Credibility of Crime Allegations*

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Abstract. The lack of hard evidence in allegations about sexual misconduct makes it difficult to separate true allegations from false ones. We provide a model in which victims and potential libelers face the same costs and benefits from making an allegation, but the tendency for perpetrators of sexual misconduct to engage in repeat offenses allows semi-separation to occur, which lends credibility to such allegations. Our model also explains why reports about sexual misconduct are often delayed, and why the public rationally assigns less credibility to these delayed reports.

Keywords. corroboration; repeat offenses; delayed reporting; encouragement effect; information escrow

JEL Classification. K14; K42; D82

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1. Introduction

Recent scandals of sexual crimes and misconduct have gripped the headlines and spawned a nascent movement to raise consciousness about a serious problem that used to be underreported. The stories of Bill Cosby, Larry Nassar, Harvey Weinstein, and many others share some striking similarities. First, the conducts involved were mostly not violent in nature so that clear-cut hard evidence is lacking.[1] Second, the same person repeatedly offended multiple victims. Third, no arrest or prosecution was made upon the first allegation against the offender. Fourth, many allegations were made years after the alleged incidents.

The Bill Cosby trial stemmed from an allegation made by Andrea Constand in 2005 alleging that Bill Cosby, a comedian, drugged and raped her in 2004. This was the first public rape allegation against Cosby. No charge was brought against him at the time. Within the same year, three additional similar allegations against Bill Cosby arose. Still no arrest was made. A new wave of allegations surfaced in 2014 and 2015, with over 50 women alleging sexual crimes that happened from 1965 to 2008. Bill Cosby was arrested and charged in 2015 and was convicted of three counts of aggravated indecent assault in 2018.[2]

The Jerry Sandusky sexual abuse case is another notable example. Over a hundred incidents of abuse of children were alleged over time against the former football coach, but the first report in 2008 was met with disbelief. The state attorney general told the accuser in 2008 that the authorities needed more victims to charge Sandusky—that is, to overcome the grand jury's doubt of a possibly false accusation. Sandusky was not arrested until the second report came from a witness in 2010, reporting an incident that happened more than ten years before.[3]

An estimated 64 to 96 percent of sexual crime victims do not report the crimes committed against them (Fisher et al., 2000; Perkins and Klaus, 1996). A major reason for this reluctance to report is that victims think their reports will be met with suspicion or outright disbelief (Jordan, 2004). When the crimes do not produce hard evidence, there is

[1] According to End Violence Against Women's research, "most sexual assaults are committed by someone who is known to the victim, who does not use a weapon or severe physical violence, and who does not inflict visible injuries on the victim." See `http://www.evawintl.org/mad.aspx`.

[2] Details of this case were widely reported in newspapers. We obtained our sources mostly from the Wikipedia article, "Bill Cosby Sexual Assault Allegations."

[3] See the October 19, 2012, story, "Sandusky Victim 1 Steps Out of Shadows, Says Justice Took Too Long," *20/20*, ABC News.

a classic asymmetric information problem: a true victim cannot easily separate himself or herself from a libeler who makes a false accusation. A libeler can be motivated by a grudge, political motives, publicity, or potential financial gains. In 2006, three Duke athletes were accused of sexual assault, which was found baseless in court. In 2014, *Rolling Stone* published an article, "A Rape on Campus," accusing several University of Virginia students of gang rape. The magazine had to retract the article in its entirety because the rape allegation was discredited. But not all false reporting is eventually rebuked. For allegations that do not present enough winning probability for the prosecutor to bring charges, there is no judgment from the jury whether or not they are true. No wonder so-called estimates of the percentage of false accusations among all reports range widely from 1.5 to 90 percent in the empirical literature (Lonsway, Archambault and Lisak, 2009).

While the percentage of false accusations is unclear, the potential of a report being false has to be the reason why sexual crime reports are not assigned a perfect credibility. Absent the possible existence of false accusers, the authorities would simply bring all cases to court and the jury would be able to always convict beyond doubt. This is clearly not the reality. An investigator in Burlington, Vermont's sex crimes unit, Tom Tremblay, said "unlike any other crime I responded to in my career, there was always this thought that a rape report was a false report."[4] Understanding the circumstances that lends credibility to sexual crime allegations is important in the fight against these crimes.

This article studies the incentives to allege a crime by victims or by potential libelers in a two-period setup. There are possibly multiple potential accusers who can make public but unverifiable reports against the same person. These accusers can choose whether or not to report, as well as when to report. We aim to address three major questions regarding these allegations. First, allegations of sexual crimes are often made of incidents that happened a long time ago, which we call *delayed reports*. These delayed reports can come from victims who are delaying to report a true crime, as demonstrated by the Sandusky case, or from libelers who are choosing to make false accusations long after the time of interaction with the accused. Why do delayed reports appear so often? Second, given the possibility of false accusations, how much credence should be given to allegations that are unsubstantiated by witnesses or physical evidence? Third, a delayed report is typically met with suspicion. For example, in October 2016 Trump supporters have started the hashtag #NextFakeTrumpVictim by attacking the sexual assault allegations against Donald Trump with tweets that read, for example, "Why didn't these 'victims' come forward

[4] "Why Don't Cops Believe Rape Victims?" *Slate*, June 19, 2013.

30 years ago? Could've scored a hefty sum from a billionaire." Is such skepticism justified?

A key to our analysis is that sexual crimes are often committed by recidivists, who have a tendency to engage in repeat offenses against other victims. According to the Rape, Abuse & Incest National Network (RAINN), more than half of all alleged rapists have at least one prior conviction. Taking into account the low reporting rate and the low conviction rate,[5] this statistic suggests a strong tendency for rapists to engage in repeat offenses. In addition, the medical literature suggests that "pedophilia is a sexual orientation and unlikely to change."[6] In this paper, we assume that a true victim expects a higher chance that another victim exists who may provide corroboration than a potential libeler does.

The possibility of the existence of another victim or another potential libeler produces a free-riding problem. Because a single accusation is often insufficient evidence to cause the authorities to take action, individuals have an incentive to take a wait-and-see approach and delay making an allegation until another allegation arises. In our benchmark model, an individual with relatively low reporting cost always reports immediately, whereas an individual with higher reporting cost makes a delayed report if and only if there is another report against the accused.[7]

On the surface, given that there is a higher chance of having a corroborator for a victim than for a libeler, one might suspect that a victim is more inclined to wait for others to report first in order to delay the cost of making an allegation. We argue that this reasoning is not correct, because it assumes that the potential corroborator's reporting behavior is not affected by the history he or she observes. In fact, the potential corroborator (past or future victim) is more likely to report if there has been a previous report, so the higher incentive to "break the silence" and encourage the potential corroborator to report dominates the motive to delay reporting costs for individuals with low reporting costs. This dynamic *encouragement effect* works in the opposite direction of the standard free-riding effect in public goods provision. Because guilty agents have a higher tendency of recidivism than do innocent ones, the encouragement effect figures more prominently for true victims than for potential libelers. This effect causes true victims to be less inclined to make a delayed report than do potential libelers. The fact that true victims tend to make timely crime allegations with a higher probability in turn lends credence to such allegations, allowing

[5] RAINN estimates that only 310 out of 1000 rape cases are reported, out of which 11 will get referred to prosecutors and 7 will result in a felony conviction.

[6] See "Pessimism about Pedophilia," *Harvard Mental Health Letter*, July 2010.

[7] This potential free-riding incentive is called a "first mover disadvantage" by Ayres and Unkovic (2012).

a semi-separating equilibrium to exist even when true victims and potential libelers face the same costs and benefits from making an allegation. In other words, even though allegations are unsubstantiated by hard evidence, they do contain information that may prompt the authorities into taking action.[8]

Our model also justifies the public's skepticism toward delayed reports. If there is another allegation against a person, victims or libelers who took a wait-and-see approach will no longer shy from making an allegation because corroborated reports are more convincing than a single report. But because libelers have a greater probability of taking a wait-and-see approach than victims do, the public rationally assigns less credibility to delayed reports than to undelayed ones. The public is rightly skeptical because delayed reports are more likely to have been made "opportunistically."

The communication game described in this article is different from a cheap talk game (Crawford and Sobel, 1982). Here the action of reporting carries a cost, whereas the action of not reporting does not. Reporting is directly costly for many reasons. A reporter often has to reveal facts about themselves that are not positive, such as the use of drug and alcohol, which can lead to social stigma, suspension from school, or loss of scholarships.[9] The reporter faces possible retaliation from the accused. Investigations are emotionally and physically exhausting themselves. The easier thing to be do is to not allege a sexual crime.

In order to highlight the difficulties in separating truthful allegations from fake ones, we purposefully avoid the traditional channel of signaling arising from payoff differences. Both a true victim and a potential libeler in our model have the same costs of reporting and the same payoffs from the authorities' decisions.[10] In this sense, our model is different from a standard signaling game (Spence, 1973). In our model, different types (victim or libeler) would behave in exactly the same way if they are sure that another victim or libeler does not exist. It is the assumption that victims and libelers expect different probabilities that another accuser may exist that causes their equilibrium strategies to be different.

[8] This information comes from equilibrium inference, which may not constitute evidence that is admissible in court. However, it may be sufficient to induce the authorities to conduct further investigations that lead to arrest or prosecution.

[9] An accuser of rape at Brigham Young University was suspended because of the revelation that she used illegal drugs. See "At Brigham Young, A Cost in Reporting a Rape," *The New York Times*, April 26, 2016.

[10] In Chandrasekhar, Golub and Yang (2017), different types have the same costs and benefits from taking a signaling action (asking for help), and partial separation is achieved in equilibrium because the distribution of benefits are different for different types.

This article is related to Chassang and Miquel (2016), a study of unverifiable reporting by whistleblowers. They take a mechanism design approach, in which the cost of reporting arises endogenously as retaliation from the accused. In their model there is a single monitor who may potentially report on inappropriate behavior of an agent. Our article focuses more on the incentive issues that arise when possibly more than one victim (or more than one libeler) can make allegations against the same agent in a dynamic setting. We adopt a reduced-form approach by taking the distribution of reporting costs as given, but there is discounting in reporting costs if accusers make delayed reports. For sexual harassment in the workplace, the exogenous reporting costs in our model may reflect the possibility of retaliation by the accused or by the employer,[11] and these costs can be substantially lower if the accuser has left the firm by the time he or she makes a delayed report.

Daughety and Reinganum (2011) study a dynamic model of victims choosing when to file a lawsuit. Similar to part of our intuition in our corroboration equilibrium, a plaintiff has a wait and see incentive in their model because each benefits from a lawsuit filed by another plaintiff. However, their focus is the endogenous settlement behavior of the defendant who uses settlement to discourage follow-on lawsuits. Credibility of the plaintiffs is not an issue in their paper.

Chamley and Gale (1994) study a model of endogenous delay in a framework in which there is informational externality but no payoff externality. They show that potential investors may delay their projects in the hope of learning about the existence of other potential investors. Their model also exhibits clustering in investment decisions, similar to the appearance of follow-on reports after the first allegation is made in our model. In our model of allegations about sexual crimes, the externality involved is a direct payoff externality coming from the possibility of corroboration. Delay may also occur in the investment game of Gale (1995), because the benefit of investing increases in the number of investors and investing early before the others is money-losing initially. He finds that in some equilibrium there is an encouragement effect: investing early encourages others to invest. The literature on the dynamic provision of public goods (e.g., Fershtman and Nitzan 1991; Marx and Matthews 2000) also focuses on payoff externalities, but the existence of other players is not taken to be uncertain in that literature or in Gale (1995). Furthermore, our article analyzes how the endogenous timing of reporting behavior affects the credibility of these reports, which is not an issue in the dynamic public goods provision problem.

[11] In a sample of 86 state workers studied by Loy and Stewart (1984), 62 percent reported retaliation by their employers following their responses to harassment.

In Section 2 of the article, we lay out the setup of our signaling game. Section 3 analyzes the equilibrium we are most interested in—a corroboration equilibrium in which multiple reports may happen on the equilibrium path and some reports may be delayed. We provide a brief discussion of other types of equilibria in Section 4. In Section 5, we extend the benchmark model in different ways and discuss how these modifications affect the analysis and our main conclusions. Our formal model provides a framework to study a recently developed reporting system of sexual crimes: the online *information escrow* (Ayres and Unkovic 2012). Such an analysis is developed in Section 6 of the article. An information escrow allows people to place allegations into an escrow on the condition that the allegations are transferred to the authorities if and only if a pre-specified number of allegations are lodged against the same person. A system, using a pre-specfied number of two, called the "Callisto reporting system," has been developed into operation and is adopted by eight universities by 2017.[12] The basic idea is that information escrows can remove victims' incentive to wait for corroboration. We point out, however, that the credibility of two reports from a Callisto system is lower than the credibility of two reports outside a Callisto system. Depending on the standard of credibility expected by the authorities to take action, forcing all reports to go through the Callisto system may sometimes cause victims to be less forthcoming in reporting crimes than without the Callisto system.

2. The Model

An agent A is active for two periods. Agent A can be of two types: "guilty" or "innocent." Guilty A hurts a person (and therefore breaks the law) with independent probability p in each period. If A is innocent, a potential libeler holding a grudge against A appears with independent probability q in each period. In the model the behavior of A is non-strategic.[13] The focus of our analysis is the behavior of victims and potential libelers. The existence of victims and the existence of potential libelers are mutually exclusive.[14]

Suppose A is a guilty type. For $t = 1, 2$, let V_t represent the victim hurt by A in period

[12] Further information about this system is available at `https://www.projectcallisto.org/`.

[13] In Section 5.4, we discuss the case where the guilty agent strategically chooses whether or not to commit a crime in each period and the innocent one strategically chooses whether or not to exercise caution to avoid libel. The qualitative results remain the same. We present the details of this extension in a Supplementary Appendix available at `https://sites.google.com/site/researchoffrancesxu/`.

[14] A more natural story is to let a guilty agent face both victims and potential libelers and an innocent one face only potential libelers. This will not change the logic and the qualitative results of the paper, as will be discussed in Section 5.4.

t. If V_1 and V_2 do not exist, then nothing happens in this model. Because crimes are perpetrated in secrecy (unless there is a report of the crime), the victim of A does not know whether A had committed a similar crime before nor whether A will commit a similar crime in the future. We capture this uncertainty by assuming that V_t does not know whether she lives in period 1 or period 2. Ex ante, she assigns probability $\frac{1}{2}$ to each of these two possibilities.[15]

A victim derives utility from getting A arrested. We normalize this payoff to 1. However, reporting a crime is costly. We denote the cost of reporting by c and assume that it is an independent draw from the uniform distribution on $[0, 1]$. A victim knows her own cost c, but outsiders do not observe her c. The victim applies a discount factor $\delta < 1$ to benefits that are obtained or costs that are incurred a period later.

Victim V_1 is harmed by A in period 1 (although she does not know that she lives in period 1). She has two chances to lodge a complaint. First, she can report the crime against her immediately in period 1. Let $\alpha(c)$ represent the probability that she chooses to immediately report the crime; and let $a \equiv \mathrm{E}[\alpha(c)]$, where the expectation is taken over possible realizations of c. Thus, a is the ex ante probability that a victim will immediately report a crime in the absence of a prior report against agent A. Second, if V_1 does not report in period 1, she can lodge a delayed report at the end of period 2, after learning whether or not another victim has made a complaint against A. We let $\hat{\alpha}_1(c)$ represent the probability that V_1 lodges a delayed report in period 2 if she has learned that another complaint has been made, and let $\tilde{\alpha}_1(c)$ represent the probability that she lodges a delayed report in period 2 if no other victim has made a complaint.

Victim V_2 is harmed in period 2. She has only one chance to lodge a complaint. If no one has accused A before, then V_2 does not know whether she is V_1 or V_2. In this case, her strategy is the same as that of V_1 in period 1, i.e., she reports the crime immediately with probability $\alpha(c)$, but she will have no chance to lodge a delayed report because she lives in the last period.[16] If someone has lodged a complaint against A, then V_2 observes this report and knows that she lives in period 2. We use $\hat{\alpha}_2(c)$ to represent the probability that V_2 complains against A, knowing that there is a prior allegation against him. Any

[15] In Section 5.4, we present an extension of the model where each victim knows whether she is harmed in period 1 or period 2 to show that this uncertain timing assumption is not crucial. We maintain the uncertain timing assumption in our benchmark model for its realism.

[16] For example, we may assume that the whereabouts of agent A are no longer traceable after period 2.

complaint made against A is assumed to be public knowledge.[17]

The prior probability that A is a guilty type is μ_0. With probability $1-\mu_0$, A is innocent. An innocent A faces a potential libeler in each period with independent probability q. We let L_1 and L_2 represent the potential libelers in period 1 and period 2, respectively. These potential libelers (if they exist) hold a grudge against A and derive a payoff of 1 from getting A arrested. Their costs of lodging a complaint are independent draws from the uniform distribution on $[0,1]$, and their discount factor is δ. In other words, the payoff structure for potential libelers is identical to that for true victims. A priori, it is not obvious whether the costs and benefits of making an allegation are higher or lower for potential libelers than for true victims. We make the assumption that their payoffs are identical to highlight the difficulty of making inferences based on systematic differences in payoffs. For convenience, we will sometimes refer to potential libelers directly as libelers, even though they may not choose to make an allegation in equilibrium.

The information structure for libelers is very similar to that for victims as well. If no prior complaint has been filed against A, a libeler does not know whether she is L_1 or L_2, and she lodges a complaint immediately with probability $\beta(c)$. We define $b \equiv \mathrm{E}[\beta(c)]$. All other notations parallel those for victims: L_1 files a delayed report with probability $\hat{\beta}_1(c)$ after L_2's complaint; L_1 files a delayed complaint with probability $\tilde{\beta}_2(c)$ if L_2 does not file a complaint; and L_2 files a complaint with probability $\hat{\beta}_2(c)$ after L_1's complaint. The only difference in the information between a libeler and a victim is that the former knows A is innocent whereas the latter knows A is guilty. As a result, a libeler assigns prior probability q to the existence of another libeler, whereas a true victim assigns prior probability p to the existence of another victim. Crucially, we maintain the following assumption throughout the article:

Assumption 1. *$p > q$.*

Assumption 1 captures the fact that sexual crimes are likely to be perpetrated by repeat offenders.[18] Thus, a true victim of A should expect a high likelihood that her story can be corroborated by similar victims of A. On the other hand, the existence of potential libelers

[17] Section 5.1 considers an extension in which a report against A is observed by another accuser only with some probability.

[18] Groth, Longo and McFadin (1982) find that the majority of the sexual crime offenders had been convicted more than once for a sexual assault. Moreover, on average, they admitted to having committed two to five times as many sex crimes for which they were not apprehended.

tends to be more idiosyncratic. If a person holds a personal grudge against innocent A, this person may not assign a high probability that another person will hold a similar grudge against A.

If a report alleges that a crime happened in the same period, we call it an *undelayed report*. If a report alleges a crime a period earlier, we call it a delayed report. The decision maker (the police authorities, for example) also does not know which period she is in, and assigns prior probability $\frac{1}{2}$ to either possibility. If no one makes a complaint against A (we denote this event by ϕ), the decision maker cannot arrest A. She decides whether or not to arrest agent A after the following observable outcomes: (1) there was only one undelayed report in the current period (event r); (2) there was only one delayed report in the current period (denoted R); (3) there was only one undelayed report in the previous period and no report in the current period (event $r\phi$); (4) there was one undelayed report in the previous period and another undelayed report in the current period (event rr); and (5) there was one undelayed report in the current period followed by one delayed report (event rR). For $\mathscr{E} \in \{r, R, r\phi, rr, rR\}$, let $\mu(\mathscr{E})$ represent the decision maker's posterior belief that A is a guilty type conditional on event $\mathscr{E}$. For simplicity, we just assume that the decision maker is bound to arrest A as soon as $\mu(\mathscr{E})$ is greater than or equal to some threshold standard $\hat{\mu}$, which is taken to be exogenous.[19] The game ends at the end of period 2 or whenever A is arrested. The passage of time over a period is something that everyone can experience; so if a victim or a libeler finds that she can still report after a whole period has passed, she knows that she is in period 2. Similarly, if the decision maker knows that she can still make an arrest after a whole period has passed, she knows that she is in period 2.

The timing of the game when A is guilty is illustrated in Figure 1. The timing of the game when A is innocent is the same, with V_t replaced by L_t for $t = 1, 2$.

3. Corroboration Equilibrium with Occasional Delay

In this section, we focus on an equilibrium in which events rr and rR both appear with positive probability on the equilibrium path; that is, it is possible to observe multiple allegations against the same agent, and sometimes these allegations are delayed. In such an equilibrium, both rr and rR lead to an arrest; otherwise they will not appear in equilib-

[19] The threshold standard can be determined by the decision maker's costs of making type I and type II errors.

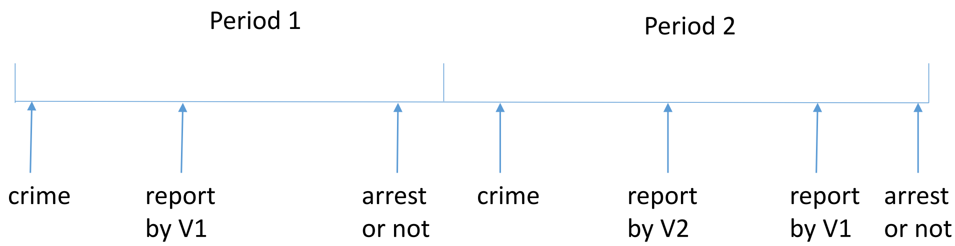

Figure 1. *The timeline when A is guilty. This figure shows the case in which A strikes a victim in each period. If there is no crime, there is no reporting decision. If there is no report, there is no arrest decision.*

rium. Moreover the events r or $r\phi$ will not lead to an arrest, because if they do, then no one will follow up with a report. Similarly, the event R does not lead to an arrest, because if it does, then one will always delay a report and rr or rR will not appear in equilibrium.

In other words, we look for an equilibrium in which A is arrested if and only if there are two allegations against him. We refer to this type of equilibrium as a "corroboration equilibrium with occasional delay," or simply a *corroboration equilibrium*.

Let $l(\mathscr{E})$ represent the likelihood ratio of event $\mathscr{E}$ (given the guilty type relative to the innocent type). For any fixed prior μ_0, there is a monotone relationship between $\mu(\mathscr{E})$ and $l(\mathscr{E})$. Thus, one can also say that the decision rule of the authorities is to arrests A as soon as $l(\mathscr{E}) \geq \hat{l}$, where $\hat{l} = \hat{\mu}(1-\mu_0)/(\mu_0(1-\hat{\mu}))$. We sometimes refer to $\hat{l}$ as the *standard of proof*. The existence of a corroboration equilibrium requires $l(rr)$ and $l(rR)$ to be greater than or equal to the standard of proof $\hat{l}$, and $l(r)$, $l(R)$, and $l(r\phi)$ to be less than $\hat{l}$. We proceed by assuming these conditions, and then verify that they indeed hold in equilibrium.

Given the above assumed conditions of the likelihood ratios, a silent victim V_1 who observes another person lodging a report against A in period 2 will surely lodge a delayed complaint, because doing so gives a payoff of 1 at a cost $c \leq 1$. Therefore, $\hat{\alpha}_1(c) = 1$ for any c. Similarly, a victim V_2 who knows of a prior complaint against A will also lodge a complaint upon being hurt. Therefore, $\hat{\alpha}_2(c) = 1$ for any c. On the other hand, a silent victim V_1 has no incentive to report against A at the end of period 2 if no other victim had come forward. Therefore, $\tilde{\alpha}_1(c) = 0$ for any c. The payoff structure of libelers is identical to the payoff structure of true victims. Thus, $\hat{\beta}_1(c) = \hat{\beta}_2(c) = 1$ and $\tilde{\beta}_1(c) = 0$ for any c.

Consider now a victim of A who is just harmed in the current period and has not seen a prior accusation against A. For convenience, we label her a *new victim* (even though she may be the second victim if the first one did not report). A new victim can entertain three possibilities:

1. Another victim does not exist (the probability of this event is $1-p$).
2. She is V_1, and another victim V_2 exists in period 2 (the probability is $\frac{1}{2}p$).
3. She is V_2, and another victim V_1 exists but did not report (the probability is $\frac{1}{2}p(1-a)$.)

The sum of these probabilities is $1-\frac{1}{2}pa$.

In the first eventuality, one report is not sufficient to arrest A because $l(r) < \hat{l}$. Therefore, reporting immediately is futile (i.e., the payoff is 0). In the second eventuality, reporting immediately will encourage the future victim V_2 to report because $\hat{\alpha}_2(c) = 1$. The discounted benefit is δ. In the third eventuality, reporting immediately will cause the past victim V_1 to come forward with a delayed report because $\hat{\alpha}_1(c) = 1$. This leads to the arrest of A in the same period, with a payoff of 1. Therefore, if the new victim has reporting cost c, the expected net payoff from reporting immediately is

$$\frac{1-p}{1-(1/2)pa}[-c] + \frac{(1/2)p}{1-(1/2)pa}[\delta - c] + \frac{(1/2)p(1-a)}{1-(1/2)pa}[1-c]. \tag{1}$$

If the new victim does not report immediately, then only in the second eventuality can she follow up with a delayed report provided that V_2 makes a complaint against A. The probability that V_2 will make a complaint conditional on this eventuality is a, and the discounted net benefit is $\delta(1-c)$. Therefore, the expected net payoff from not reporting immediately is

$$\frac{1-p}{1-(1/2)pa}[0] + \frac{(1/2)p}{1-(1/2)pa}[a\delta(1-c)] + \frac{(1/2)p(1-a)}{1-(1/2)pa}[0]. \tag{2}$$

Let $f(c,a;p)$ represent the payoff difference between reporting immediately and not reporting immediately for a new victim, given that other victims are adopting the strategies $\hat{\alpha}_1(c) = 1$, $\hat{\alpha}_2(c) = 1$, $\tilde{\alpha}_1(c) = 0$, and $\mathrm{E}[\alpha(c)] = a$:

$$f(c,a;p) = \frac{1-p}{1-(1/2)pa}[-c] + \frac{(1/2)p}{1-(1/2)pa}[\delta - c - a\delta(1-c)] + \frac{(1/2)p(1-a)}{1-(1/2)pa}[1-c]. \tag{3}$$

For any a and p, $f(\cdot,a;p)$ is strictly decreasing, with $f(0,a;p) > 0 > f(1,a;p)$. Therefore, there exists $\hat{c}(a,p)$ satisfying $f(\hat{c}(a,p),a;p) = 0$, such that the best response is to report immediately (i.e., choose $\alpha(c) = 1$) if and only if $c \leq \hat{c}(a, p)$. Because $a = \mathrm{E}[\alpha(c)]$ and the distribution of c is uniform, equilibrium requires $\hat{c}(a^*, p) = a^*$.

In a similar fashion, the payoff difference between reporting immediately and not reporting immediately for a *new libeler* (i.e., a libeler who does not observe a prior report against A) is $f(c, b; q)$. Equilibrium requires that $f(b^*, b^*; q) = 0$, with the new libeler choosing $\beta(c) = 1$ if and only if $c \leq b^*$.

Before contrasting the behavior of a new victim and a new libeler, we will first point out two important incentives reflected in the net benefit function $f(c, a; p)$: strategic substitution and the encouragement effect.

Lemma 1. *(Strategic Substitution.) The net benefit $f(c, a; p)$ of reporting immediately is decreasing in a.*

If other new victims are more likely to report immediately (a increases), then a new victim is less likely to do so ($\hat{c}(a, p)$ decreases). This strategic substitution in reporting immediately among new victims (or new libelers) reflects the public good nature of crime allegations when a single report is not sufficient to lead to arrest. Each victim who has not observed an allegation against A has an incentive to take a wait-and-see approach. If another report later comes to surface, the new victim can reduce the cost by lodging a delayed report. If no other report comes to surface, the new victim can eliminate the cost of making a futile report. The downside of this wait-and-see approach for a new victim is that A may not be arrested if (1) the new victim is V_2 and V_1 did not report, or (2) the new victim is V_1 and V_2 does not choose to be the first one to report. Both of these two events are less likely when a is higher, so the downside risk is smaller when a is higher, which explains the strategic substitution effect. The proof of Lemma 1 is in the Appendix.

Lemma 2. *(Encouragement Effect.) The net benefit $f(c, a; p)$ of reporting immediately is increasing in p.*

It may appear that the free-riding problem[20] is more severe when the other victim is more likely to exist—in equation (2) the payoff from not reporting is increasing in p. However, free-riding is not the only incentive in our setting, as the model also exhibits complementarity between the possibly two victims through an encouragement effect. First,

[20] When free-riding on the other accuser, one eventually still needs to file a report to corroborate if the other reports, but filing later saves expected reporting costs.

if a new victim is V_1, and if V_2 exists, then by reporting immediately the new victim raises the probability that the future victim V_2 will report the crime from $\mathrm{E}[\alpha(c)] = a$ to $\hat{\alpha}_2(c) = 1$. Second, if a new victim is V_2 but V_1 did not report, then by reporting immediately the new victim raises the probability that V_1 will make a delayed follow-on report from $\tilde{\alpha}_1(c) = 0$ to $\hat{\alpha}_1(c) = 1$. Lemma 2 shows that a higher chance of the existence of another victim gives more incentive for a new victim to report immediately. The proof is in the Appendix.

Lemma 2 implies that the encouragement effect is stronger for new victims than for new libelers because p is greater than q. This leads to the following result.

Proposition 1. *In a corroboration equilibrium, new victims report immediately against A with a strictly higher probability than do new libelers. Moreover, a^* increases in p and δ, and b^* increases in q and δ.*

Proof. In a corroboration equilibrium, a^* satisfies $F(a^*; p) = 0$, where

$$F(a; p) \equiv f(a, a; p) = \frac{1/2}{1-(1/2)pa}\left[-a(2-pa) + p\delta(1-a(1-a)) + p(1-a)\right]. \quad (4)$$

Since $f(c, a; p)$ is decreasing in a (Lemma 1) and in c, $F(a; p)$ is decreasing in a. Also, $F(0; p) > 0 > F(1; p)$. Hence there exists a unique $a^* \in (0, 1)$ such that $F(a^*; p) = 0$. Lemma 2 implies that $F(a; p)$ increases in p. By the implicit function theorem, an increase in p raises a^*. Because the equilibrium b^* satisfies $F(b^*; q) = 0$, $p > q$ implies $a^* > b^*$. Finally, because $F(a; p)$ increases in δ, a^* is increasing in δ. Likewise, b^* is increasing in δ. ■

The fact that $a^* > b^*$ in a corroboration equilibrium lends credibility to allegations about sexual crimes. If victims and libelers report with equal probability, the likelihood ratio of an undelayed report (event r) would be simply p/q. We can take p/q to be the "face value" of a crime allegation. However, Proposition 1 implies that the likelihood ratio in the event of an undelayed report is $pa^*/qb^* > p/q$. The additional credibility is the result of equilibrium inference, coming from the reasoning that true victims are more likely to make an undelayed report than libelers do. Furthermore, we also have the following result.

Proposition 2. *In a corroboration equilibrium, two undelayed reports against A are assigned a greater credibility than one undelayed report corroborated by a delayed report. Moreover, if $p \leq \frac{2}{3}$, we have $l(rR) > p^2/q^2$.*

Proof. Suppose agent A is guilty. The event $\mathscr{E} = rR$ is observed only when both V_1 and V_2 exist, and V_1 has cost above a^* and V_2 has cost below a^*. The probability of this event is $p^2 a^*(1-a^*)$, and the likelihood ratio is $l(rR) = p^2 a^*(1-a^*)/(q^2 b^*(1-b^*))$. The event $\mathscr{E} = rr$ is observed only when both V_1 and V_2 exist, and V_1 has cost below a^* (V_2 will always report when V_1 has reported in the earlier period). The likelihood ratio is $l(rr) = p^2 a^*/(q^2 b^*)$. By Proposition 1, $a^* > b^*$, which implies $l(rr) > l(rR)$.

From the equation $F(a^*; p) = 0$, we can verify that $a^* = \frac{1}{2}$ when $p = \frac{2}{3}$ and $\delta = 1$. Because a^* increases in p and δ (Proposition 1), $q < p \leq \frac{2}{3}$ implies $b^* < a^* < \frac{1}{2}$ for any $\delta < 1$. Hence, $b^*(1-b^*) < a^*(1-a^*)$, and we obtain $l(rR) > p^2/q^2$. ■

Proposition 2 is consistent with common attacks on the credibility of accusations that surface long after the alleged crimes. In a corroboration equilibrium, true victims are more likely than libelers to lodge an undelayed complaint against A if there is no prior complaint against him, but everyone (true victim or not) can secure an arrest of A if there is already a prior complaint. Because libelers are more likely to take a wait-and-see approach, the public rationally believes that delayed reports are more likely to be "opportunistic" and assigns less credibility to them.

If victims and libelers were non-strategic and always report, the likelihood ratio from having two reports would be p^2/q^2. Proposition 2 shows that $l(rR) > p^2/q^2$ as long as p is not too large. Because $a^* > b^*$ in our model, having a undelayed report against an agent A is strong indication that A is guilty. As long as p is not too large, so that $b^* < a^* < \frac{1}{2}$, this effect is more than enough to offset the skepticism toward a delayed report to cause rR to be more credible than two reports from non-strategic actors.

Proposition 3. *A corroboration equilibrium exists if and only if*

$$\hat{l} \in (\underline{l}^*, \overline{l}^*] \equiv \left(\frac{p(2-p)a^*}{q(2-q)b^*}, \frac{p^2 a^*(1-a^*)}{q^2 b^*(1-b^*)} \right].$$

Moreover, there exists $\overline{p}(\delta)$, which is decreasing in δ and greater than $\frac{2}{3}$, such that the range $(\underline{l}^*, \overline{l}^*]$ is non-empty for all $p \leq \overline{p}(\delta)$.

Proof. Suppose A is a guilty type. Given the strategy profile in a corroboration equilibrium, there are two possibilities that lead to the event r: (1) the current period is period 1 and V_1 reported (this happens with probability $\frac{1}{2} p a^*$); and (2) the current period is period 2, V_1 didn't exist, and V_2 reported (this happens with probability $\frac{1}{2}(1-p) p a^*$). Therefore, the probability of observing r given A is guilty is $\frac{1}{2}pa^*(2-p)$. Similarly, the probability of observing r given A is innocent is $\frac{1}{2}qb^*(2-q)$. This gives $l(r) = \underline{l}^*$. The event $r\phi$ happens if V_1 exists and makes an immediate report but V_2 does not exist, which occurs with probability $p(1-p)a^*$. The corresponding likelihood ratio is $l(r\phi) = p(1-p)a^*/(q(1-q)b^*) < \underline{l}^*$. In the proof of Proposition 2, we show that $l(rR) = \overline{l}^* < l(rr)$. The event R is off-equilibrium. We can assign an off-equilibrium belief such that $l(R) < \hat{l}$. This establishes that a corroboration equilibrium exists if and only if $\hat{l} \in (l(r), l(rR)]$.

The range $(\underline{l}^*, \overline{l}^*]$ is non-empty if and only if

$$\frac{p(1-a^*)}{2-p} > \frac{q(1-b^*)}{2-q}.$$

The left-hand-side of the above is equal to the right-hand-side when $p = q$. Because $p > q$, it suffices to show that the left-hand-side is increasing in p, which is equivalent to

$$2(1-a^*) - p(2-p)\frac{\partial a^*}{\partial p} > 0. \tag{5}$$

By implicit differentiation of (4),

$$\frac{\partial a^*}{\partial p} = \frac{(1+\delta)(1-a^*(1-a^*))}{2+(1+\delta)p(1-2a^*)} = \frac{2a^*}{p\,(2+(1+\delta)p(1-2a^*))},$$

where the second equality holds because $F(a^*; p) = 0$ implies $(1+\delta)(1-a^*(1-a^*)) = 2a^*/p$. Suppose p and δ are such that $a^* < \frac{1}{2}$. Then, we have $\partial a^*/\partial p < a^*/p$, and therefore the left-hand-side of (5) is greater than or equal to $2(1-\frac{1}{2}) - (2-p)\frac{1}{2} > 0$. By Proposition 2, we conclude that inequality (5) holds for all $p \leq \frac{2}{3}$.

This argument also shows that we must have $a^* > \frac{1}{2}$ whenever

$$h(a^*, p, \delta) \equiv 2(1-a^*) - p(2-p)\frac{(1+\delta)(1-a^*(1-a^*))}{2+(1+\delta)p(1-2a^*)} = 0.$$

For $a^* > \frac{1}{2}$, $h(a^*, p, \delta)$ is decreasing in a^*, p, and δ. By Proposition 1, this implies $H(p,\delta) \equiv h(a^*(p,\delta), p, \delta)$ is decreasing in p and δ. Thus, the locus $\overline{p}(\delta)$ that satisfies $H(\overline{p}(\delta), \delta) = 0$ is decreasing in δ, with $H(p, \delta) > 0$ for all $p < \overline{p}(\delta)$. ■

Proposition 3 states that a corroboration equilibrium exists whenever the standard of proof $\hat{l}$ falls in the range $(l(r), l(rR)]$. Because rr is more credible than rR, and r is more credible than $r\phi$, the accused agent A will be arrested if and only if there are two reports lodged against him.

The range $(l(r), l(rR)]$ may be empty, in which case a corroboration equilibrium does not exist. This may occur because, for very high values of p and δ, the event rR is even less credible than r.[21] The reason is that rR reveals that the first accuser chose to not report right away. Because libelers are more likely to take this wait-and-see approach, this brings down the belief, reflected in the ratio $(1-a^*)/(1-b^*)$. If both p and δ are close to 1, then $1-a^*$ would be close to 0, causing a undelayed report followed by a delayed report to be less credible than just one undelayed report.

Proposition 3 also establishes that the existence of a corroboration equilibrium is guaranteed whenever p or δ is not too large. Specifically, for any δ, a corroboration equilibrium always exists if $p \leq \frac{2}{3}$. Suppose, for example, that $p = 0.3$, $q = 0.1$, and $\delta = 0.8$. Then, in a corroboration equilibrium, $a^* \approx 0.22$ and $b^* \approx 0.08$. In other words, more than three-quarters of the new victims do not report the crimes against them immediately. In such an equilibrium, $l(rr) \approx 24.75$ and $l(rR) \approx 20.47$. A corroboration equilibrium exists if and only if $\hat{l} \in (7.21, 20.47]$. If victims and libelers were to always lodge a complaint immediately (e.g., if they are non-strategic), the credibility of two undelayed reports would be $l(rr) = p^2/q^2 = 9$. Thus, for $\hat{l} \in (9, 20.47]$, agent A would never get arrested if victims and libelers behaved non-strategically by always reporting immediately, but A will be arrested with some probability in the corroborated equilibrium of our model. More generally, $p \leq \frac{2}{3}$ implies $a^* < \frac{1}{2}$, and hence $a^*(1-a^*) \geq b^*(1-b^*)$. This ensures that $l(rR) \geq p^2/q^2$. The fact that true victims are more likely to make allegations against A than libelers are in a corroboration equilibrium lends credence to such allegations.

The criminal justice system is imperfect and has to strike a balance between the possibilities of punishing the innocent (type I error) and letting go the guilty (type II error). In our model, type I error occurs because libelers wrongly accuse A even though he has not broken the law. Given that there is at least one libeler, the probability that agent A will be arrested in a corroboration equilibrium is:

$$\Pr[\text{type I}] = \frac{q^2}{1-(1-q)^2}\left(1-(1-b^*)^2\right), \tag{6}$$

where the fraction is the probability that there are two potential libelers given that there is at least one, and the second term is the probability that at least one of L_1 and L_2 has a reporting cost less than b^* (which will lead to two reports because the other one will follow up). Similarly, given that there is at least one victim, the probability that the evidence

[21] For example, when $p = 0.9$, $q = 0.8$ and $\delta = 0.95$, we have $a^* \approx 0.69$ and $b^* \approx 0.59$. Then $l(r) \approx 1.21 > 1.12 \approx l(rR)$.

against him does not reach the standard of proof in a corroboration equilibrium is:

$$\Pr[\text{type II}] = \frac{p^2}{1-(1-p)^2}(1-a^*)^2 + \frac{2p(1-p)}{1-(1-p)^2}. \tag{7}$$

The first term is the conditional probability that neither V_1 nor V_2 lodges a complaint. The second term is the conditional probability that A has hurt only one victim, so the evidence is never sufficient to reach the threshold regardless of whether the victim lodges a complaint or not.

Proposition 4. *In a corroboration equilibrium, the probability of type I error increases in q and δ, and the probability of type II error decreases in p and δ.*

Proof. From equation (6), the probability of type I error increases in q and in b^*. Proposition 1 establishes that b^* increases in q and δ. Therefore, Pr[type I] increases in q δ. From equation (7), Pr[type II] decreases in p and in a^*. Because a^* increases in p and δ, Pr[type II] decreases in p and δ. ∎

An increase in the probability of repeat offense p by a guilty agent A has two effects on the probability of his getting away with punishment. The first effect is mechanical: a higher p raises the chance that there are two victims to report his crime. The second effect works through the response of the victims: a victim who expects the existence of another victim is more likely to report the crime through the encouragement effect. Both effects tend to reduce the probability of not having A arrested.

In a corroboration equilibrium, new victims face a trade-off between encouraging others to report the crime and delaying to pay the cost of reporting. Greater patience δ makes the latter option less attractive and hence increases the probability that they report immediately. When people are more forthcoming in making an allegation against A, the probability of type I error increases and the probability of type II error decreases.

We may also consider the effects of reporting costs on reporting behavior and on the probabilities of type I and type II errors. Suppose the cost of reporting is uniformly distributed on $[0, \bar{c}]$, with $\bar{c} \leq 1$. An increase in $\bar{c}$ represents a first-order stochastic increase in reporting cost. In a corroboration equilibrium, if the strategy is for a new victim to lodge a complaint against A if and only if her reporting cost is lower than some critical value $\hat{c}$, then $a = \mathrm{E}[\alpha(c)] = \hat{c}/\bar{c}$, and therefore the critical type must have cost $\bar{c}a$. The equilibrium value of a is given by the indifference condition:

$$f(\bar{c}a, a; p) = \frac{(1/2)}{1-(1/2)pa}\left[-\bar{c}a(2-pa) + p\delta(1-a(1-\bar{c}a)) + p(1-a)\right] = 0.$$

The payoff difference $f(\bar{c}a, a; p)$ is single-crossing from above in a and is decreasing in $\bar{c}$. Therefore, we have $\partial a^*/\partial \bar{c} < 0$. Not surprisingly, a stochastic increase in reporting cost causes people to be less forthcoming in making an allegation. This reduces the probability of type I error but raises the probability of type II error.

4. Other Types of Equilibria

4.1. Other equilibria with a corroboration flavor

In the previous section, we focus on the corroboration equilibrium, in which agent A is arrested if and only if there are two reports against him. The corroboration equilibrium, provided that it exists, is not the only equilibrium in our model. Multiple equilibria exist because beliefs are self-confirming. For example, if rR does not lead to arrest, then no one has an incentive to make a delayed report. Because rR does not occur in equilibrium in this case, we can assign off-equilibrium beliefs such that rR is not credible enough to cause an arrest, hence confirming the equilibrium construction. In this subsection, we consider two other types of equilibria in which corroboration is a necessary (but not sufficient) condition for making an arrest. In the first type, agent A is arrested only when both reports against him are undelayed. We call this an rr-equilibrium. In the second type, agent A is arrested only when one report is undelayed and the other is delayed. We call this an rR-equilibrium.

In an rr-equilibrium, the event rR does not lead to an arrest. Therefore, a silent V_1 who has not reported in period 1 has no incentive to file a delayed report against A upon learning that V_2 has reported. Unlike in a corroboration equilibrium, we therefore have $\hat{\alpha}_1(c) = 0$ for all c. On the other hand, as in a corroboration equilibrium, we still have $\tilde{\alpha}_1(c) = 0$ (V_1 will not report in period 2 if no one reports against A) and $\hat{\alpha}_2(c) = 1$ (V_2 will report if she learns that V_1 has already made a report) in an rr-equilibrium.

We continue to use a to denote the probability of reporting right away by a new victim, and will use a_{rr} to denote its equilibrium value. Likewise, b_{rr} is the equilibrium probability of reporting immediately by a new libeler. In an rr-equilibrium, reporting immediately gives a new victim a payoff of

$$\frac{(1/2)p}{1-(1/2)pa}\delta - c.$$

Not reporting gives her a payoff of 0, as delaying the report will certainly lead to no arrest. The equilibrium probability of a new victim reporting right away when there is no prior report is the unique solution for a to:

$$F_{rr}(a;p) \equiv \frac{(1/2)p}{1-(1/2)pa}\delta - a = 0. \tag{8}$$

Comparing (8) to (4) in the earlier section, we see that both the benefit from reporting immediately and the benefit from delaying to report are smaller in an rr-equilibrium than in a corroboration equilibrium. Moreover, using (8), we obtain

$$F(a_{rr};p) = \frac{(1/2)p(1-a_{rr})}{1-(1/2)pa_{rr}} - \frac{(1/2)p}{1-(1/2)pa_{rr}}\delta a_{rr}(1-a_{rr}) > 0.$$

This implies $a_{rr} < a^*$, because $F(\cdot;p)$ is single-crossing from above. Therefore, the overall effect of not allowing corroboration with delay as sufficient ground for arrest is to discourage new victims from making a report immediately, as it removes the chance that an immediate report will encourage past victims who did not report to come forward by filing delayed reports.

Consider next an rR-equilibrium. In such an equilibrium, because a second undelayed report will not lead to arrest, we have $\hat{\alpha}_2(c) = 0$ (whereas we still have $\hat{\alpha}_1(c) = 1$ and $\tilde{\alpha}_1(c) = 0$, as in a corroboration equilibrium). The payoff to a new victim from reporting immediately reporting is

$$\frac{(1/2)p(1-a)}{1-(1/2)pa} - c,$$

which comes from the possibility that V_1 exists but has not reported. On the other hand, not reporting gives a new victim a payoff of

$$\frac{(1/2)p}{1-(1/2)pa}a\delta(1-c),$$

which comes from the possibility of reporting later if V_2 exists and makes a report. Let a_{rR} be the equilibrium probability that a new victim reports immediately, and let b_{rR} be the equilibrium probability that a new libeler reports immediately. Then, a_{rR} is given by the unique solution for a to the following equality:

$$F_{rR}(a;p) \equiv \frac{(1/2)p(1-a)}{1-(1/2)pa} - a - \frac{(1/2)p}{1-(1/2)pa}a\delta(1-a) = 0. \tag{9}$$

Comparing (9) to corresponding equation (4) that characterizes a^* in a corroboration equilibrium, because the payoff from reporting immediately is reduced but the payoff from not reporting remains unchanged, we have $a_{rR} < a^*$.

Proposition 5. *(a) There exists a non-empty interval $(\underline{l}_{rr}, \bar{l}_{rr}]$ such that an rr-equilibrium exists if and only if $\hat{l}$ is in that interval. In this equilibrium, $b_{rr} < a_{rr} < a^*$. Moreover, $\bar{l}_{rr} > \bar{l}^*$; and if $p \leq \frac{2}{3}$ then $\underline{l}_{rr} > \underline{l}^*$.*

(b) There exists a non-empty interval $(\underline{l}_{rR}, \bar{l}_{rR}]$ such that an rR-equilibrium exists if and only if $\hat{l}$ is in that interval. In this equilibrium, $b_{rR} < a_{rR} < a^*$. Moreover, $\bar{l}_{rR} > \bar{l}^*$; and if $p \leq \frac{2}{3}$ then $\underline{l}_{rR} > \underline{l}^*$

The proof of Proposition 5 is in the Appendix. In both the rr-equilibrium and the rR-equilibrium, new victims are less likely to report immediately compared to the case in a corroboration equilibrium. Furthermore, because $\hat{\alpha}_1(c) = 0$ in an rr-equilibrium and $\hat{\alpha}_2(c) = 0$ in an rR-equilibrium (these two quantities are both equal to 1 in a corroboration equilibrium), the overall probability that a victim or a libeler will make an allegation is lower compared to that in a corroboration equilibrium.

Compared to a corroboration equilibrium, an rr-equilibrium and an rR-equilibrium both reduce type I error but increase type II error, for two reasons: (1) each reduces the set of events under which A is arrested; and (2) the probability that a new victim or new libeler will report immediately is lower. On the other hand, Proposition 5 also shows that arrests in an rr-equilibrium or an rR-equilibrium are more credible than the event rR in a corroboration equilibrium (assuming p is not too large). Thus, even if the standard of proof $\hat{l}$ is so high that a corroboration equilibrium does not exist, it is still possible that the model will admit an rr-equilibrium or an rR-equilibrium.

The event rR is off the equilibrium path in an rr-equilibrium, and likewise for the event rr in an rR-equilibrium. Standard refinements are not sufficient to rule out these two types of equilibria. Nevertheless, because both rr and rR are observed in reality, we believe that the corroboration equilibrium is the most relevant equilibrium to focus on.

4.2. Lower standard of proof and no-corroboration equilibrium

The probabilities of type I and type II errors can be affected by the standard of proof $\hat{l}$. Consider the case where one report against agent A is sufficient to lead to arrest. In such a case, no one will have an incentive to file a second report against the same person; so rr and rR are off-equilibrium events. We call this type of equilibrium a *no-corroboration equilibrium*. The existence of a no-corroboration equilibrium requires $l(r) \geq \hat{l}$ and $l(R) \geq \hat{l}$. Because the event r is sufficient for arrest, the event $r\phi$ is irrelevant. We first assume that these conditions hold, and subsequently verify that this is true for some values of $\hat{l}$.

Suppose agent A is guilty. If a victim of A has seen a prior accusation against him, there is no point for her to report because one report is sufficient to punish A. Therefore $\hat{\alpha}_1(c) = \hat{\alpha}_2(c) = 0$ for all c. On the other hand, if a silent victim V_1 observes no one coming forward to complain against A in period 2, she will make a delayed report because the event R is sufficient to lead to arrest. This means that we have $\tilde{\alpha}_1(c) = 1$ in a no-corroboration equilibrium.

For a new victim (who does not see a prior accusation against A), the payoff from reporting immediately is $1-c$. The payoff from not reporting immediately is

$$\frac{(1/2)p}{1-(1/2)pa}[\delta(a+(1-a)(1-c))] + \frac{(1/2)(1-p)}{1-(1/2)pa}[\delta(1-c)] + \frac{(1/2)p(1-a)}{1-(1/2)pa}[1]. \quad (10)$$

The first fraction is the conditional probability that this victim is V_1 and V_2 exists. With probability a, V_2 reports the crime and V_1 gets δ; and with probability $1-a$, V_2 does not report the crime and V_1 lodges a delayed report and gets $\delta(1-c)$. The second fraction is the conditional probability that she is V_1 and V_2 does not exist. In this case, she lodges a delayed report at the end of period 2 and gets $\delta(1-c)$. The final term is the conditional probability that she is V_2 and V_1 exists but did not report. If she does not report, V_1 will lodge a delayed report and V_2 gets 1.

Let $f_{nc}(c,a;p)$ represent the difference between $1-c$ and (10), and define $F_{nc}(a;p) \equiv f_{nc}(a,a;p)$. We have:

$$F_{nc}(a;p) = \frac{(1/2)}{1-(1/2)pa}\left[(1-a)(2-pa) - p\delta\left(1-a(1-a)\right) - (1-p)\delta(1-a) - p(1-a)\right].$$

Because $F_{nc}(0;p) > 0 > F_{nc}(1;p)$ and $F_{nc}(\cdot;p)$ is single-crossing from above, there exists a unique a_{nc} such that $F_{nc}(a_{nc};p) = 0$. In a no-corroboration equilibrium, the strategy of a new victim is $\alpha(c) = 1$ (i.e., report immediately) if and only if $c \leq a_{nc}$. Similarly, the strategy of a libeler who sees no prior report against A is $\beta(c) = 1$ if and only if $c \leq b_{nc}$, where $F_{nc}(b_{nc};q) = 0$.

Proposition 6. *A no-corroboration equilibrium exists if and only if*

$$\hat{l} \leq \bar{l}_{nc} \equiv \frac{pa_{nc}(2-pa_{nc})}{qb_{nc}(2-qb_{nc})}.$$

Comparing the outcome in a no-corroboration equilibrium to that in a corroboration equilibrium: (a) the probability that a new accuser will lodge a undelayed report is higher (i.e., $a_{nc} > a^*$ and $b_{nc} > b^*$); (b) the probability of convicting an innocent A is higher; and (c) the probability of acquitting a guilty A is lower.

Proof. A no-corroboration equilibrium exists only if the standard of proof is lower than the likelihood ratio corresponding to event r, i.e., $\hat{l} \leq l(r) = \bar{l}_{nc}$. Lemma 3 in the Appendix establishes that $l(R) \geq l(r)$. Hence, $l(r) \geq \hat{l}$ implies $l(R) \geq \hat{l}$. Because rr and rR are off-equilibrium events, we can assign off-equilibrium beliefs such that $l(rr) \geq \hat{l}$ and $l(rR) \geq \hat{l}$. Given these beliefs, there is no profitable deviation from the strategy profile of a no-corroboration equilibrium.

Evaluate $F_{nc}(a;p)$ at $a = a^*$, and use the fact that $F(a^*;p) = 0$, we obtain

$$F_{nc}(a^*;p) = \frac{1/2}{1-(1/2)pa^*}\left[2 - pa^* - (1-p)\delta(1-a^*) - 2p(1-a^*)\right] > 0.$$

Because $F_{nc}(a;p)$ is single-crossing from above, we must have $a_{nc} > a^*$. A similar argument shows that $b_{nc} > b^*$.

If there are two libelers, L_1 either makes a undelayed report or a delayed report in a no-corroboration equilibrium. If there is only one libeler and this libeler is L_2, she makes a undelayed report with probability b_{nc}. Therefore, the overall probability of type I error in a no-corroboration equilibrium is

$$\frac{q^2}{1-(1-q)^2} + \frac{2q(1-q)}{1-(1-q)^2}\left(\frac{1}{2} + \frac{1}{2}b_{nc}\right),$$

which is greater than (6). Similarly, the probability of type II error is

$$\frac{2p(1-p)}{1-(1-p)^2}\left(\frac{1}{2}(1-a_{nc})\right),$$

which is less than (7). ■

Note that $F_{nc}(a;p)$ is decreasing in p. This implies that $\partial a_{nc}/\partial p < 0$. Hence, $p > q$ implies $a_{nc} < b_{nc}$. In a no-corroboration equilibrium, there is no "encouragement effect" to motivate a new victim to report immediately in order to induce a future or past victim to report. As a result, only the free-rider effect is present, and the free-rider effect is stronger the more likely that another victim exists. Hence a new victim has a higher incentive to free ride than a new libeler does and, as a result, reports with a lower probability. This implies that a no-corroboration equilibrium exists only if the standard of proof $\hat{l}$ is so low that one will be arrested based on a single report even if the victim and the libeler have the same pooling behavior (i.e., as if they were non-strategic).

Corollary 1. *A no-corroboration equilibrium exists only if* $\hat{l} < p/q$.

Proof. We show that $\bar{l}_{nc} < p/q$. Because $a_{nc}(2-pa_{nc})/(b_{nc}(2-qb_{nc}))$ is equal to 1 when $p = q$, it suffices to show that $a_{nc}(2 - pa_{nc})$ decreases in p, which is true because the derivative is equal to $-a_{nc}^2 + 2(1-pa_{nc})\partial a_{nc}/\partial p$, which is negative. ■

With a lower standard of proof, it is not surprising that both true victims and libelers are more forthcoming in lodging complaints about A—we have $a_{nc} > a^*$ and $b_{nc} > b^*$. The advantage is that a guilty agent is more likely to be punished; the disadvantage is that it comes with a much higher chance of type I error.

There exist other types of equilibria with a no-corroboration flavor. In all such equilibria, agent A is sometimes arrested when there is only one report (delayed or not) against him. In the first type, which we call an r-equilibrium, agent A is arrested in event r but not in event R. In the second type, which we call an R-equilibrium, agent A is arrested in event R but not in event r. The key features of these equilibria are quite similar to those for the no-corroboration equilibrium described in Proposition 6. We summarize these features in the following proposition.

Proposition 7. *In an r-equilibrium, new victims report immediately with a lower probability than do new libelers. In an R-equilibrium, neither new victims nor new libelers ever report immediately. Each of these two types of equilibria exists only if the standard of proof $\hat{l}$ is below p/q.*

Allowing only one report to lead to arrest eliminates the encouragement effect for new victims to report immediately. Proposition 7 shows that an r-equilibrium and an R-equilibrium share the same feature that a victim reports right away with a lower probability than a libeler when there is no prior report. This adverse selection of accusers in turn implies that the standard of proof has to be so low that the public is willing to arrest someone based on a single report while knowing that a libeler is more active in reporting than a victim (i.e., lower than p/q). Because such standard of proof seems to us to be an implausibly low standard, and because we do observe multiple allegations (rr or rR) in reality, we choose to focus on the corroboration equilibrium in the remainder of this article.

5. Model Extensions

5.1. Partially unobservable reports

In the benchmark model, any allegation against A is public knowledge. In reality, it is possible that a report made by one accuser is not observed by another accuser. The observability of a report depends, for example, on how famous the accusers or the accused are. When a celebrity is involved, an allegation gets more media coverage and is thus more visible to other potential accusers.

In this subsection, we modify the model by assuming that V_2 does not observe a prior report by V_1 with some probability $\epsilon \in (0,1)$. Similarly, V_1 does not observe a report made by V_2 in period 2 with the same probability ϵ. On the other hand, the reports are always visible to the authorities responsible for making an arrest.

For a new victim, the payoff from reporting immediately is:

$$\frac{(1/2)p}{1-(1/2)pa(1-\epsilon)}[\delta(1-\epsilon)-c]+\frac{(1/2)p(1-a)}{1-(1/2)pa(1-\epsilon)}[1-\epsilon-c]+\frac{(1/2)pa\epsilon}{1-(1/2)pa(1-\epsilon)}[1-c].$$

If the new victim is V_1 and V_2 exists, there is some chance that V_2 will not see her report; so the payoff is only $\delta(1-\epsilon)$. If the new victim is V_2 and V_1 has not reported, then by reporting immediately V_2 can encourage V_1 to make a delayed report with probability $1-\epsilon$. If the new victim is V_2 and she does not observe the prior report by V_1, then V_2 can secure A's arrest by reporting immediately; so the payoff is 1.

The payoff from not reporting immediately for the new victim is:

$$\frac{(1/2)p}{1-(1/2)pa(1-\epsilon)}[a(1-\epsilon)\delta(1-c)],$$

because a silent victim V_1 will observe a report by V_2 with probability $a(1-\epsilon)$ and get a payoff $\delta(1-c)$ if V_2 exists.

Taking the difference between these two payoffs, the equilibrium probability of reporting right away by the new victim, denoted a_{par}, is the solution of a to the following equation:

$$\frac{1/2}{1-(1/2)pa(1-\epsilon)}\Big((1-\epsilon)\big[-a(2-pa)+p\delta(1-a(1-a))+p(1-a)\big]-\epsilon a(2-p)\Big)=0.$$

The term in square brackets is equal to 0 at $a=a^*$ (the equilibrium probability in the benchmark model). Because the left-hand-side is single-crossing from above in a and is negative at $a = a^*$, we have $a_{par} < a^*$. As partial observability reduces the strength of the encouragement effect, a victim is less likely to come forward in making a fresh allegation. The same logic applies to a libeler. Given that ϵ tends to be smaller when the accused is more famous, both new victims and new libelers will report more against a more famous person.[22]

5.2. Serial dependence

A key assumption of our model is that $p > q$. In the benchmark model without serial dependence, $p > q$ embodies two conceptually separate assumptions: (1a) the probability that a victim exists given A is guilty is higher than the probability that a libeler exists given A is innocent; and (1b) the probability that a victim assigns to the event that another victim exists is higher than the probability that a libeler assigns to the event that another libeler exists. Even if (1a) does not hold, (1b) may still hold provided that we introduce serial dependence in the probability that A hurts or offends another person across the two periods—for example, if guilty agents have a greater tendency to be repeat offenders. We emphasize that our results are mainly driven by (1b) rather than (1a).

To see this point more clearly, we abandon the independence assumption in the benchmark model and consider the following correlation structure:

Guilty A

	V_1	no V_1
V_2	$p\lambda_g$	$(1-p)\lambda_g$
no V_2	$(1-p)\lambda_g$	$1-(2-p)\lambda_g$

Innocent A

	L_1	no L_1
L_2	$q\lambda_i$	$(1-q)\lambda_i$
no L_2	$(1-q)\lambda_i$	$1-(2-q)\lambda_i$

The entry in each cell represents the probability of the corresponding combination. For example, if A is guilty, the probability that both V_1 and V_2 exist is $p\lambda_g \in (0,1)$. Note that the marginal probability that V_1 exists is λ_g, and the marginal probability that V_2 exists is also λ_g. Conditional on one victim's existence, the probability that another victim exists is p. A higher value of p indicates a higher degree of correlation across the two periods. As we mention in the introduction, many sexual crimes are perpetrated by repeat offenders. On the other hand, if an innocent agent inadvertently offends another person, there is no presumption that this will happen again in the next period. We can capture this difference by the assumption that $p > q$. If $\lambda_g = \lambda_i$ and $p > q$, then (1a) does not hold but (1b) does.

[22] A caveat is that a more famous person tends to be more powerful, which may imply a higher threat of retaliation and thus a higher cost of reporting against him.

From the perspective of a new victim, the probability that another victim exists is p. Therefore, the expected payoffs from reporting immediately and from not reporting immediately are identical to (1) and (2), respectively, of the benchmark model. It follows that her equilibrium probability of reporting immediately is the same a^* of Section 3. Similarly, a new libeler reports immediately with probability b^*. In this modified model with correlation, the event rR is observed with probability $p\lambda_g a^*(1-a^*)$ when the state is "guilty," and is observed with probability $q\lambda_i b^*(1-b^*)$ when the state is "innocent." So,

$$l(rR) = \frac{p\lambda_g a^*(1-a^*)}{q\lambda_i b^*(1-b^*)}.$$

The event r is observed under two possibilities when the state is "guilty": (1) the current period is period 1 and V_1 reported (this happens with probability $\frac{1}{2}\lambda_g a^*$); or (2) the current period is period 2, V_1 didn't exist and V_2 reported (this happens with probability $\frac{1}{2}(1-p)\lambda_g a^*$). Therefore the corresponding likelihood ratio is:

$$l(r) = \frac{\lambda_g(2-p)a^*}{\lambda_i(2-q)b^*}.$$

A corroboration equilibrium exists if and only if $\hat{l} \in (l(r), l(rR)]$.

In the case of $\lambda_g = \lambda_i$, a report in a setup with a single period cannot have any information value because there is no difference between the two states. However, with correlation across periods, a report in a corroboration equilibrium has some level of credibility as long as $p > q$, even when $\lambda_g = \lambda_i$. The tendency of a guilty agent to be a recidivist causes a new victim to expect that another (past or future) victim may be present to corroborate her report. Thus the encouragement effect causes her to report immediately with a greater probability than does a libeler, which in turn lends credence to her report.

5.3. Delay of the initial report

In our benchmark model, a delayed report is always preceded by a undelayed report in a corroboration equilibrium. In reality, sometimes even the first report against an accused is significantly delayed. For example, the first two allegations of sexual assault (almost simultaneously in 2016) against Larry Nassar, a former physician of the USA Gymnastics team, were delayed for 16 years and 17 years, respectively. The alleged crimes happened when the accusers were 18 and 15 years old, so a large part of the time of silence were spent when the accusers were adults. This means the delay had to do with something more than just the immaturity of the accusers. In this section, we show that the delay of the first report can be an equilibrium outcome if we also allow V_1 to report in the second period before V_2 can.

In Figure 2, we modify the timeline of the benchmark model by allowing V_1 to have a chance to make a delayed report in period 2 before she learns about the existence of another report against A. If V_1 does not utilize this chance, she still has another chance to make a delayed report after V_2 has her chance to report. The timeline for potential libelers is modified in a similar manner.

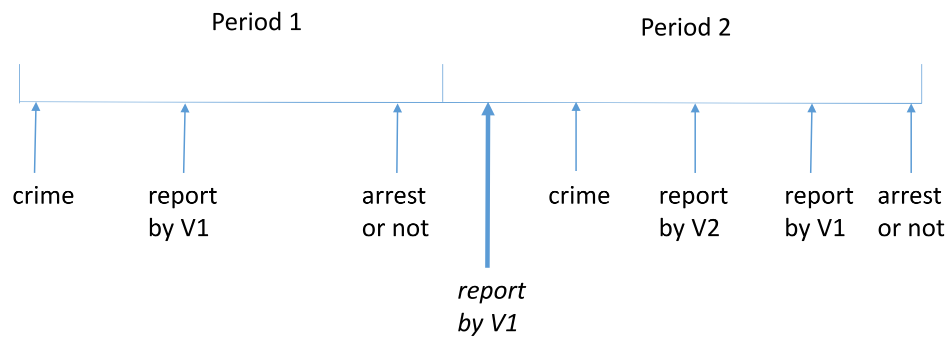

Figure 2. *The modified timeline when A is guilty. Victim V_1 can make a delayed report in period 2 before knowing whether V_2 reports or not. If V_2 reports, V_1 will have another chance to make a delayed report before the end of period 2 provided that she has not already done so.*

In this modified setting, if V_1 reports in period 2 followed by V_2's report, we denote the event by Rr. If V_1 reports in period 2 and there is no report by V_2, we denote the event by $R\phi$. We will focus on a corroboration equilibrium in which agent A is arrested if and only if there are two reports against him (i.e., in the events rr, rR, or Rr).

By the time of second period, V_1 already knows that he is V_1. If she has not yet reported, by reporting in period 2, she will get payoff $p-c$ because with probability p, V_2 exists and will follow up with a report. By not reporting in period 2, V_1 will get $pa(1-c)$ because V_2 will report with probability a, after which V_1 can follow up with a report. Therefore, the cutoff type (denoted $\hat{c}_g$) of V_1 who is indifferent between reporting and not reporting in period 2 before V_2's turn to report is determined by $p-\hat{c}_g = pa(1-\hat{c}_g)$, which gives

$$\hat{c}_g(a) = \frac{p(1-a)}{1-pa}.$$

Any V_1 whose cost is below $\hat{c}_g(a)$ will report in period 2 if she has not reported before. The subscript g denotes the state that A is guilty. Similarly, for the state that A is innocent,

$\hat{c}_i(b) = q(1-b)/(1-qb)$.

There are two cases to consider: (a) $\hat{c}_g(a) > a$; and (b) $\hat{c}_g(a) \le a$. However, only case (a) is relevant;[23] we therefore focus on case (a). In this case, some types of victim with $c \in (a, \hat{c}_g(a)]$ will choose not to report immediately but wait until period 2 to lead with a delayed report.

Consider a new victim who has not seen a prior report. There are three possibilities:

1. Another victim does not exist (the probability of this event is $1-p$).
2. She is V_1, and another victim V_2 exists in period 2 (the probability is $\frac{1}{2}p$).
3. She is V_2, and another victim V_1 exists but did not report (the probability is $\frac{1}{2}p(1-\hat{c}_g(a))$.)

The expected net payoff from reporting immediately is:

$$\frac{1-p}{1-(1/2)p\hat{c}_g(a)}[-c] + \frac{(1/2)p}{1-(1/2)p\hat{c}_g(a)}[\delta - c] + \frac{(1/2)p(1-\hat{c}_g(a))}{1-(1/2)p\hat{c}_g(a)}[1-c].$$

A victim V_1 with cost $c < \hat{c}_g(a)$ will report in period 2 prior to V_2 does if V_1 does not report immediately. For such V_1, her expected net payoff from not reporting immediately is:

$$\frac{(1/2)p}{1-(1/2)p\hat{c}_g(a)}[\delta(1-c)] + \frac{(1/2)(1-p)}{1-(1/2)p\hat{c}_g(a)}[-\delta c].$$

By the same logic as in the benchmark model, the equilibrium probability that a new victim will report immediately, denoted a_{del} is the solution in a to the following equation:

$$F_{del}(a;p) \equiv \frac{1/2}{1-(1/2)p\hat{c}_g(a)}\left[-a(2-p\hat{c}_g(a)) + p\delta a + p(1-\hat{c}_g(a)) + (1-p)\delta a\right] = 0.$$

It is straightforward to show that a unique $a_{del} \in (0,1)$ exists, and that a_{del} increases in p and δ.

Proposition 8. *Suppose V_1 can make a delayed report in period 2 before V_2 has her chance to report. Then, in a corroboration equilibrium, (a) V_1 reports immediately in period 1 if $c \le a_{del}$; (b) V_1 makes a delayed report in period 2 before V_2 has her chance to report if*

[23] In case (b), $c > a$ implies $c > \hat{c}_g(a)$. Any type who does not report immediately when she is a new victim will choose to wait in period 2 rather than leading with a delayed report. Then the condition that determines the equilibrium value of a is the same as in the benchmark model, i.e., a satisfies $F(a;p) = 0$. But because $\delta < 1$, $F(a;p) = 0$ implies $p(1-a+a^2) > a$, which contradicts $\hat{c}_g(a) \le a$.

$c \in (a_{del}, \hat{c}_g(a_{del})]$; and (c) V_1 makes a delayed report in period 2 after observing that V_2 has reported if $c > \hat{c}_g(a_{del})$. Compared to the corroboration equilibrium in the benchmark model, $a_{del} < a^* < \hat{c}_g(a_{del})$.

Proof. Suppose $\delta = 1$. Then the option for V_1 to make a delayed report before knowing V_2 has reported or not has no value to V_1 because there is no discounting. This implies $a_{del} = \hat{c}_g(a_{del}) = a^*$ for $\delta = 1$. Now, $a_{del} - \hat{c}_g(a_{del})$ is increasing in δ because a_{del} increases in δ. Thus, $a_{del} - \hat{c}_g(a_{del}) < 0$ for all $\delta < 1$. Furthermore, because $\hat{c}_g(a_{del})$ decreases in δ whereas a^* increases in δ, we have $\hat{c}_g(a_{del}) > a^*$ for all $\delta < 1$.

For any $\delta < 1$, the condition $F_{del}(a_{del}; p) = 0$ can be written as:

$$-a(2 - p\hat{c}_g(a_{del})) + \delta a_{del} + p(1 - \hat{c}_g(a_{del})) = 0.$$

The fact that $\hat{c}_g(a_{del}) > a_{del}$ implies

$$-a(2 - pa_{del}) + \delta a_{del} + p(1 - a_{del}) > 0.$$

Moreover, $\hat{c}_g(a) > a$ if and only if $a < p(1 - a + a^2)$. This implies that

$$-a(2 - pa_{del}) + p\delta(1 - a_{del} + a_{del}^2) + p(1 - a_{del}) > 0,$$

which is equivalent to $F(a_{del}; p) > 0$. As $F(\cdot; p)$ is single-crossing from above, we obtain $a_{del} < a^*$. ■

This corroboration equilibrium exists if and only if

$$\max\{l(r), l(R\phi), l(r\phi)\} < \min\{l(rr), l(Rr), l(rR)\}.$$

For example, when $p = 0.3$, $q = 0.1$, and $\delta = 0.8$, we have $a_{del} \approx 0.199$, $\hat{c}_g(a_{del}) \approx 0.256$, $b_{del} \approx 0.076$ and $\hat{c}_i(b_{del}) \approx 0.093$. In this case, $\max\{l(r), l(R\phi), l(r\phi)\} = l(r) \approx 2.89$ and $\min\{l(rr), l(Rr), l(rR)\} = l(Rr) \approx 30.176$. Therefore, $l(r) < l(Rr)$ and the corroboration equilibrium exists for $\hat{l} \in (l(r), l(Rr)]$. Compared to the benchmark model in which $a^* \approx 0.22$ and $b^* \approx 0.08$, V_1 (or L_1) in the benchmark model is less likely to report in period 1, but is more likely to have reported in period 2 before V_2 (or L_2) chooses to report.

5.4. Relaxing other model restrictions

We have made a number of modeling choices in the benchmark model to make it simple and transparent: there are only two victims (or two libelers); agent A is not strategic; a guilty agent does not face potential libelers; and accusers initially do not know which period they are in. These restrictions can be relaxed without altering our main conclusions. In this subsection, we briefly describe how to modify the model by allowing for different assumptions, leaving the full descriptions of these various extensions to the online Supplementary Appendix.

More victims. Increasing the number of victims or libelers affects the incentive to make a crime allegation through both the encouragement effect and strategic substitution effect. We illustrate this point by showing that having more potential victims does not necessarily reduce the probability that a new victim will lodge an immediate report, because the encouragement effect may sometimes outweigh the free-riding effect to cause these victims to be more forthcoming in making an allegation.

Consider the following simple modification of the benchmark model. In period 1, guilty agent A hurts one victim with probability p. In period 2, he hurts *two* victims with probability p. Similarly, an innocent agent A offends one person with probability q in period 1, and another two persons with probability q in period 2. We study a corroboration equilibrium in which at least two accusations against A (rr or rR) are needed before the authorities will arrest him.

The key difference from the benchmark model is that a victim who learns that there is a prior report against A does not necessarily report against him (i.e., $\hat{\alpha}_2(c) \neq 1$), because she may count on the other victim in period 2 to file a report. In the Supplementary Appendix, we show that $\hat{\alpha}_2(c) = 1$ if and only if $c \leq \frac{1}{2}$.

Given such strategy by V_2, there are two opposing effects on the incentive of a new victim to report immediately. First, if a victim is V_1, she is worried that the two victims in period 2 may not corroborate her allegation because these two victims free-ride on each other (the probability that at least one of these two victims will corroborate V_1's report is only $\frac{3}{4}$), which reduces her incentive to report immediately. On the other hand, if a victim is V_2, lodging a complaint immediately may lead to an arrest if it is corroborated by a contemporary victim, even if V_1 does not exist. This second effect raises the payoff from reporting immediately. Which of these two effects dominates will depend on parameter values. It is not the case that having more potential victims always causes each new victim to be less forthcoming in lodging a complaint.

Agent is strategic. The model can be generalized to allow the guilty type and the innocent type to be strategic. Let p denote the probability that an opportunity arises in each period for a guilty agent to commit a crime. We can allow him to choose whether or not to commit the crime given the opportunity to do so. The original main setup is therefore an extreme case where the guilty agent commits the crime whenever the opportunity is available.

Suppose the payoff from committing a crime for a guilty agent A (when there is an opportunity to do so) is π, which is uniformly distributed on $[0,1]$, while the cost of being arrested is 1. In a corroboration equilibrium, A will always commit the crime when the first opportunity arises, because he can always avoid arrest by refraining from committing the second crime. If the opportunity for a second crime indeed comes up (and if the first victim has not made a report), A will hurt the second victim if and only if π is sufficiently high. Thus, from a new victim's perspective, the probability that a second victim exists is not p, but p times the probability that A will strike again given the opportunity. Despite these differences with the main setup, the incentives of the victims are qualitatively the same. Specifically, we still have strategic substitution and the encouragement effect: (1) the more the other potential victim will lead with an undelayed report, the less likely this victim will lead, and (2) the more likely an opportunity will arise for a future crime, the more a victim is willing to lead.

In the same vein, we can allow an innocent agent to strategically choose whether or not to avoid being libeled at a cost. For example, a professor may find a student's performance bad enough to warrant failing the course (which happens with exogenous probability q), but at the expense of his conscience he can still choose to let her pass to avoid the libeling incentive. A boss may find a worker's performance bad enough to warrant dismissal but at the expense of lower productivity he can still choose to let her stay to avoid the libeling incentive. One can easily see the parallel with the case of the guilty type. The probability of the innocent agent to bend over backward to avoid being libeled depends endogenously on the probability that a potential libeler leads with a libel. A libel will cause the innocent one to always consciously avoid offending anyone in the future.

In the Supplementary Appendix, we show that $p > q$ implies that a true victim leads with an allegation with a higher probability than does a potential libeler, so the main results of our paper still hold when the guilty agent and the innocent one are both strategic.

Guilty agent faces both victims and libelers. It is natural that libelers may exist for not just an innocent agent, but also for a guilty one. In this alternative model, a true victim knows that A is guilty, but a libeler is not sure about the type of A. A libeler only acts upon her own libeling incentive.

This alternative setup actually provides another justification for our main assumption, namely, that a victim expects the chance of a potential corroborator to be higher than a libeler does. Here is why. Both a victim and a libeler expect there to be the same chance of a potential libeler being out there. But a victim's private information tells her that the chance of a true victim being out there is higher than what an uninformed libeler thinks. Therefore, the encouragement effect is stronger for a victim than for a libeler and the main results carry through: a new victim leads with a higher probability than a new libeler and a delayed report is met with suspicion in a corroboration equilibrium. The details are provided in the Supplementary Appendix.

Accusers know which period they are in. In the main setup, a victim is not sure whether she is the early one that gets hurt or the later one that gets hurt. In this extension, we let them know the timing (although such an assumption is less realistic in our view), to show that the main qualitative results carry through. For $t = 1, 2$, let V_t denote the victim hurt by A in period t who knows that she is hurt in period t. Just as in the main setup, the crucial strategic variables are the probability of leading with an undelayed report. Here, since new victims V_1 and V_2 are distinctive individuals with knowledge of the calendar time, we denote their probability of reporting immediately by a_1 and a_2, respectively. Similarly, we have b_1 for a new first-period libeler and b_2 for a new second-period libeler.

In the Supplementary Appendix, we show that, just as in the main setup, both the net benefits of reporting immediately of the new V_1 and new V_2 are decreasing in the probabilities of leading (a_1 and a_2) by the other victim and increasing in the probability (p) of the existence of the other victim. That is, we have the same strategic substitution and encouragement effect. It is straightforward to show that the equilibrium values of a_1 and a_2 cannot both decrease in p. Indeed, we show that when p is not too large, both a_1 and a_2 increase in p. In this case, we have $a_t > b_t$ for $t = 1, 2$ in a corroboration equilibrium of this alternative model.

6. Callisto Reporting System

An online sexual assault reporting system called Callisto has been adopted by eight universities by late 2017. This reporting system allows a student to log a report into the system under the precondition that it will only be released to the school if another student names the same perpetrator, an option called "match." The system also allows reporting to the school authority directly, but the system does not allow any potential reporter to see other reports in the system. The non-profit organization that founded this system believes that sexual assault is prevalent on campus, the reporting rate is low, and repeat offenders are not stopped.[24] The Callisto reporting system falls into the definition of an "information escrow" by Ayres and Uncokiv (2012), because Callisto allows people to transmit information to it under seal and only have the information forwarded under pre-specified conditions.[25]

In this section, we examine the outcome assuming that a school uses Callisto as the reporting channel while keeping the basic setup the same. The action choice for the school is to investigate and discipline the accused or not. We assume that an infinitesimally small cost is incurred when one enters a report into the system, and cost c is incurred when the report is submitted to the school authority because only then the potentially unflattering conduct of the accuser is known and the emotionally exhausting investigation begins.

The Callisto system potentially can create three distinguishable events to the school in our two period setup: (1) no report (denoted ϕ); (2) two reports and both are not delayed (rr); and (3) two reports and one of which is delayed (rR). Any time when only one report is in the system, the system shows no report to the school. To give reporters strict incentive to report, either rr or rR should lead to an investigation and possibly disciplinary action. For there to be an interesting issue, no report from the Callisto system should lead to no action by the school. We focus on the corroboration equilibrium, in which both rr and rR cause the school to take investigative or disciplinary action. This requires $\hat{l} \leq l(rr)$ and $\hat{l} \leq l(rR)$.

First, observe that for a victim or a libeler, using the "match" option is better than reporting directly to the school through the Callisto system. If there is already another corroborating report, then it makes no difference. If there has not been one, then using the "match" option can avoid wasting the reporting cost or can delay the reporting cost if the corroborating report comes in the future. Second, logging the complaint into the system right away is better than waiting to log it later, as long as the chance of having a corroborator is not infinitesimally small. Therefore, in any corroboration equilibrium, a

[24] See the Callisto website, `https://www.projectcallisto.org/what-we-do/`.

[25] Sometimes, journalists perform a role that is similar to an information escrow. They do not publish a story until they have gathered a few allegations from different sources. For example, *The New York Times* broke the story on Harvey Weinstein in October 2017 after gathering allegation from multiple women. The accusers were not paying the cost of publicly accusing Harvey Weinstein until several pieces of corroboration were available and the news article was published.

victim or a libeler logs the complaint into Callisto with no delay. This means that the event rr occurs with probability p^2 if the accused is guilty, or with probability q^2 if the accused is innocent.

Because the event rR is off the equilibrium path, the reports are only submitted to the school when the event is rr. The likelihood ratio corresponding to this event is $l(rr) = p^2/q^2$. For this event to be sufficient for the school to take action, we must have $\hat{l} \leq p^2/q^2$. The only other possible observable event on the equilibrium path is ϕ. The likelihood ratio corresponding to this event is $l(\phi) = (1-p^2)/(1-q^2)$, which has to be less than $\hat{l}$ in a corroboration equilibrium. Because rR is off-equilibrium, we can assign an off-equilibrium belief such that $\hat{l} \leq l(rR)$. This establishes the following result.

Proposition 9. *Under a Callisto reporting system, a corroboration equilibrium exists if and only if*

$$\hat{l} \in (\underline{l}_{Cal}, \bar{l}_{Cal}] \equiv \left(\frac{1-p^2}{1-q^2}, \frac{p^2}{q^2} \right].$$

Because of the stronger incentive to report by both victims and libelers, the equilibrium probability of reporting immediately satisfies $a_{Cal} = 1 > a^*$ and $b_{Cal} = 1 > b^*$. However, because $a_{Cal} = b_{Cal}$ whereas $a^* > b^*$, two reports (rr) from the Callisto system do not carry the same level of credibility as two reports (rr) without the Callisto system. In fact, two reports (rr) in the Callisto system may even carry less credibility than the event rR without the Callisto system if p is not very large. By Proposition 2, if $p \leq \frac{2}{3}$ then $l(rR)$ in the benchmark model is greater than $\bar{l}_{Cal}$. Therefore, if $p \leq \frac{2}{3}$ and $\hat{l} \in (\bar{l}_{Cal}, \bar{l}^*]$, the standard of proof is so high that victims have no incentive to pay the infinitesimally small cost of lodging a complaint, knowing that even two reports are not sufficient to cause the school to take action under the Callisto system. On the other hand, the same standard of proof will induce a positive equilibrium probability of reporting a^* without the Callisto system. In other words, adopting the Callisto system can potentially backfire if maintaining credibility of the allegations is a serious concern.

7. Conclusion

Many allegations about sexual crimes and misconduct are difficult to handle because they often leave behind no physical evidence. Victims usually do not have hard evidence to prove the existence of the crime, which gives libelers ample opportunities to fake as victims. This article shows that, despite this difficulty, allegations without hard evidence have a certain level of credibility. First, an allegation proves the existence of an individual who has the intention of either a victim or a libeler. This fact alone carries some credibility because a true criminal has a higher chance of facing such an individual than an innocent person does. Second, the tendency of sexual criminals to repeatedly offend gives a victim more confidence about the existence of another potential corroborator than a libeler. As a result, in a corroboration equilibrium a victim is more motivated to encourage other potential corroborators by leading with a first report against the accused than a libeler is against an innocent person. This difference in equilibrium behavior boosts the credibility of an undelayed report while reducing the credibility of a follow-up report that alleges a crime occurring a long time ago.

The interpreter of crime allegations in our model is the police and the prosecution team, who can take into account the entire history of reports to reach a decision of whether to search, arrest or prosecute. For cases of less severe sexual harassment, the decision maker may be the human resources department of the employer company, which may also use Bayesian inference to reach a decision on whether the accused should be punished or not. We would like to caution that our setup does not directly apply to the decision of the trial judge or jury because current U.S. law largely forbids a trial from including "prior bad acts," "reputation," or "opinion" testimonies into consideration, due to the federal rule of evidence Rule 404.

Absent in our model is the settlement between the accused and the accuser, and the confidentiality clauses typical in settlement agreement. This clearly played a role in the suppression of some public allegations of crimes and misconducts. Neither do we consider fully the possible behavioral responses by the agent being accused. In the main model, we simply assume that the agent's behavior is non-strategic. In Section 5.4, we briefly discuss an extension in which an agent will exercise caution and strategically decide whether to engage in a second crime if there is a prior allegation against him. Nevertheless, he always chooses to commit the first crime because one allegation is not sufficient to lead to an arrest. More realistically, there are significant costs to an agent when he is publicly accused, such as loss of reputation, even if the accusation does not constitute sufficient evidence to cause an arrest. A public allegation may also cause other potential victims to take more caution against the agent. Our extended model does not fully capture these deterrence effects arising from crime allegations. Incorporating these more realistic features into our model is an agenda for further research.

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Appendix

Proof of Lemma 1. Take derivative of $f(c,a;p)$ in equation (3) with respect to a to get

$$\frac{\partial f}{\partial a} = \frac{(1/2)p}{1-(1/2)pa}\left[f(c,a;p) - \delta(1-c) - (1-c)\right],$$

which is negative because $f(c,a;p) < 1-c$. ∎

Proof of Lemma 2. Take derivative of equation (3) respect to p to get

$$\begin{aligned}\frac{\partial f}{\partial p} &= \frac{1}{1-(1/2)pa}\left[\frac{1}{2}af(c,a;p) + c + \frac{1}{2}(\delta - c - a\delta(1-c)) + \frac{1}{2}(1-a)(1-c)\right]\\ &> \frac{(1/2)a}{1-(1/2)pa}\left[f(c,a;p) + c + \delta(1-a(1-c)) + (1-a)(1-c)\right],\end{aligned}$$

which is positive because $f(c,a;p) > -c$. ∎

Proof of Proposition 5. (a) We have shown in the text that $a_{rr} < a^*$. Note also that b_{rr} satisfies $F_{rr}(b_{rr};q) = 0$. Because $F_{rr}(a;p)$ is single-crossing from above in a and increasing in p, $q < p$ implies $b_{rr} < a_{rr}$.

In an rr-equilibrium, event rr occurs with probability $p^2 a_{rr}$. The corresponding likelihood ratio is $l(rr) = p^2 a_{rr}/(q^2 b_{rr})$. Two events lead to the event r. Either the current period is period 1 and V_1 reports (this happens with probability $\frac{1}{2}pa_{rr}$), or the current period is period 2 and V_1 either did not exist or did not report while V_2 reports (this happens with probability $\frac{1}{2}(1-pa_{rr})pa_{rr}$). Therefore, $l(r) = p(2-pa_{rr})a_{rr}/(q(2-qb_{rr})b_{rr})$. Substituting $a_{rr} = p\delta/(2-pa_{rr})$ and $b_{rr} = q\delta/(2-qb_{rr})$, we obtain $l(r) = p^2/q^2$. Therefore, an rr-equilibrium exists if

$$\hat{l} \in (\underline{l}_{rr}, \bar{l}_{rr}] \equiv \left(\frac{p^2}{q^2}, \frac{p^2 a_{rr}}{q^2 b_{rr}}\right].$$

The event $r\phi$ occurs when V_1 exists and makes a report, but V_2 does not exist. The corresponding likelihood ratio is $l(r\phi) = p(1-p)a_{rr}/(q(1-q)b_{rr}) < \underline{l}_{rr}$. The events R and rR are off-equilibrium, and we can assign off-equilibrium beliefs such that their corresponding likelihood ratios are below the standard of proof.

Because $a_{rr} > b_{rr}$, it is obvious that the interval $(\underline{l}_{rr}, \bar{l}_{rr}]$ is non-empty. To establish that $\bar{l}_{rr} > \bar{l}^*$, we show

$$\frac{a_{rr}}{b_{rr}} > \frac{a^*(1-a^*)}{b^*(1-b^*)}.$$

Because these two sides are equal when $p = q$, it suffices to show that $a^*(1-a^*)/a_{rr}$ decreases in p, which requires

$$\frac{1-2a^*}{a^*(1-a^*)}\frac{\partial a^*}{\partial p} < \frac{1}{a_{rr}}\frac{\partial a_{rr}}{\partial p}.$$

If $a^* \geq \frac{1}{2}$, then the above condition is satisfied. So, assume $a^* < \frac{1}{2}$. In this case, the above condition is equivalent to

$$\frac{1-2a^*}{(1-a^*)(2+(1+\delta)p(1-2a^*))} < \frac{1}{2-2pa_{rr}},$$

which holds for all $a < \frac{1}{2}$.

Finally, we establish that $p \leq \frac{2}{3}$ implies $\underline{l}_{rr} > \underline{l}^*$. Because the latter is equivalent to

$$\frac{(2-p)a^*}{(2-q)b^*} < \frac{p}{q},$$

it is sufficient to establish that $(2-p)a^*/p$ decreases in p, i.e.,

$$-2a^* + (2-p)p\frac{\partial a^*}{\partial p} = -2a^* + (2-p)\frac{2a^*}{2+(1+\delta)p(1-2a^*)} < 0.$$

This inequality holds because $p \leq \frac{2}{3}$ implies $a^* < \frac{1}{2}$.

(b) We have shown in the text that $a_{rR} < a^*$. As in part (a) of the proof, $q < p$ implies $b_{rR} < a_{rR}$.

In an rR-equilibrium, the likelihood ratio corresponding to event rR is $l(rR) = p^2 a_{rR}(1-a_{rR})/(q^2 b_{rR}(1-b_{rR}))$, and the likelihood ratio corresponding to event r is $l(r) = p(2-p)a_{rR}/(q(2-q)b_{rR})$. The event $r\phi$ occurs whenever V_1 exists and makes a report (because V_2 does not report as rr does not lead to arrest). The corresponding likelihood ratio is $l(r\phi) = pa_{rR}/(qb_{rR}) > l(r)$. An rR-equilibrium exists if

$$\hat{l} \in (\underline{l}_{rR}, \bar{l}_{rR}] \equiv \left(\frac{pa_{rR}}{qb_{rR}}, \frac{p^2 a_{rR}(1-a_{rR})}{q^2 b_{rR}(1-b_{rR})}\right].$$

The events R and rr are off-equilibrium, and we can assign off-equilibrium beliefs such that their corresponding likelihood ratios are below the standard of proof.

To show that the interval $(\underline{l}_{rR}, \bar{l}_{rR}]$ is non-empty, we need to show that $p(1-a_{rR}) > q(1-b_{rR})$. It suffices to show that the left-hand-side of this inequality is increasing in p, which requires

$$1 - a_{rR} - p\frac{\partial a_{rR}}{\partial p} = 1 - a_{rR} - \frac{2a_{rR}}{2+(1+\delta)p(1-2a_{rR})} > 0.$$

It is straightforward to verify that $F_{rR}(\frac{1}{2}; p) < 0$. As $F_{rR}(\cdot; p)$ is single-crossing from above, we have $a_{rR} < \frac{1}{2}$, which implies that the above displayed inequality condition holds.

Next we show that

$$\frac{a^*(1-a^*)}{b^*(1-b^*)} < \frac{a_{rR}(1-a_{rR})}{b_{rR}(1-b_{rR})}.$$

It is sufficient to show that $(a^*(1-a^*))/(a_{rR}(1-a_{rR}))$ decreases in p, i.e.,

$$\frac{1-2a^*}{a^*(1-a^*)}\frac{\partial a^*}{\partial p} - \frac{1-2a_{rR}}{a_{rR}(1-a_{rR})}\frac{\partial a_{rR}}{\partial p} < 0.$$

Plugging in the partial derivatives, this is equivalent to

$$\frac{1-2a^*}{(1-a^*)(2+(1+\delta)p(1-2a^*))} - \frac{1-2a_{rR}}{(1-a_{rR})(2+(1+\delta)p(1-2a_{rR}))} < 0,$$

which reduces to

$$(1+\delta)p(1-2a^*)(1-2a_{rR})(a^*-a_{rR}) < 2(a^*-a_{rR}).$$

Because $a^* > a_{rR}$, the above inequality is true. This establishes that $\bar{l}^* < \bar{l}_{rR}$.

Finally, we show that $p \leq \frac{2}{3}$ implies

$$\frac{(2-p)a^*}{(2-b)b^*} < \frac{a_{rR}}{b_{rR}}.$$

It suffices to show that $(2-p)a^*/a_{rR}$ decreases in p, which is equivalent to

$$-1 + \frac{4(2-p)(1+\delta)(a^*-a_{rR})}{(2+(1+\delta)p(1-2a^*))(2+(1+\delta)p(1-2a_{rR}))} < 0.$$

The left-hand-side is increasing in δ. Therefore, it is sufficient to establish that

$$-1 + \frac{2(2-p)(a^*-a_{rR})}{(1+p(1-2a^*))(1+p(1-2a_{rR}))} < 0.$$

From equations (4) and (9), we obtain

$$2(a^*-a_{rR}) = p\delta - p(1+\delta)(a^*(1-a^*) - a_{rR}(1-a_{rR})) < p\delta,$$

because $p \leq \frac{2}{3}$ implies $a^* < \frac{1}{2}$. Hence, $2(2-p)(a^*-a_{rR}) < 1$, which establishes that $\underline{l}^* < \underline{l}_{rR}$. ■

Proof of Proposition 7. (a) Let E denote the set of events $\mathscr{E}$ such that $l(\mathscr{E}) \geq \hat{l}$ (i.e., the set of events that lead to an arrest). In an r-equilibrium, $r \in E$ and $R \notin E$. If $r \in E$, then it does not matter whether any of $r\phi$, rr and rR is in E. The events $r\phi$ and rr will not appear because the game ends right after r. The event rR is off equilibrium because within a period after r no one has incentive to make a delayed report.

In an r-equilibrium, reporting immediately gives a new victim $1-c$. Not reporting gives her $\frac{1}{2}pa\delta/(1-\frac{1}{2}pa)$ (when the victim is V_1 and V_2 exists and reports with probability a). The equilibrium probability of reporting right away, denoted a_r is defined by the solution to the following equation:

$$F_r(a;p) \equiv 1-a-\frac{(1/2)pa}{1-(1/2)pa}\delta = 0.$$

A new libeler reports right away with probability b_r, which satisfies $F_r(b_r;q) = 0$. As $F_r(a;p)$ is single-crossing from above in a and is decreasing in p, a_r is decreasing in p. From this we obtain $a_r < b_r$.

The event r occurs when either V_1 reports immediately (which happens with probability pa_r), or when V_2 reports immediately if V_1 does not report (which happens with probability $(1-pa_r)pa_r$). The corresponding likelihood ratio is $l(r) = (2-pa_r)pa_r/((2-qb_r)qb_r)$. Thus, an r-equilibrium exists if and only if

$$\hat{l} \leq \bar{l}_r \equiv \frac{(2-pa_r)pa_r}{(2-qb_r)qb_r}.$$

The event R is off equilibrium, and we can assign off-equilibrium beliefs such that $l(R) < \hat{l}$. Note that $\bar{l}_r < p/q$ if and only if $(2-pa_r)a_r/((2-qb_r)b_r) < 1$. This condition is true because $p > q$ and $(2-pa_r)a_r$ is decreasing in p.

(b) We next consider an R-equilibrium, in which $R \in E$ but $r \notin E$. If $r \notin E$, then $r\phi$ is not in E. Otherwise, after r, no one (victim or libeler) will report. So the belief after $r\phi$ should be the same as the belief after r, which forms a contradiction. It follows that there are only four possible types of R-equilibrium:

(i) $r \notin E$, $R \in E$, $rr \in E$, $rR \in E$.

(ii) $r \notin E$, $R \in E$, $rr \notin E$, $rR \in E$.

(iii) $r \notin E$, $R \in E$, $rr \in E$, $rR \notin E$.

(iv) $r \notin E$, $R \in E$, $rr \notin E$, $rR \notin E$.

Consider case (i). For a new victim, reporting immediately gives a payoff of

$$\frac{(1/2)pa}{1-(1/2)pa}\delta+\frac{(1/2)p(1-a)}{1-(1/2)pa}-c.$$

Not reporting gives payoff of

$$\frac{(1/2)pa}{1-(1/2)pa}\delta(1-c)+\frac{(1/2)p(1-a)}{1-(1/2)pa}+\frac{(1/2)(1-pa)}{1-(1/2)pa}\delta(1-c),$$

because any V_1 can delay reporting to achieve an arrest even if V_2 does not exist. Thus, not reporting immediately dominates reporting immediately even when $c=0$. It follows that the equilibrium probabilities of reporting immediately by new victims and new libelers are $a_R=b_R=0$. Only event R occurs in equilibrium; rr and rR are off-equilibrium events. The likelihood ratio associated with event R is p/q. Thus, an R-equilibrium exists if and only if

$$\hat{l}\leq\bar{l}_R\equiv\frac{p}{q}.$$

In case (ii), the payoff from reporting immediately is smaller than that in case (i) (because the first term of that payoff becomes 0 when rr does not lead to arrest), but the payoff from not reporting immediately remains the same as that in case (i). It follows that not reporting immediately still dominates reporting immediately. The equilibrium probabilities of reporting immediately are $a_R=b_R=0$, and this equilibrium exists if and only if $\hat{l}\leq p/q$.

In case (iii), the payoff difference between reporting immediately and not reporting immediately for a new victim is

$$f_R(c,a;p)\equiv\left(\frac{(1/2)pa}{1-(1/2)pa}\delta-c\right)-\left(\frac{(1/2)p(1-a)}{1-(1/2)pa}+\frac{(1/2)(1-pa)}{1-(1/2)pa}\delta(1-c)\right).$$

Thus, $f_R(a,a;p)=0$ if and only if

$$pa\delta-a(2-pa)-p(1-a)-(1-pa)\delta(1-a)=0.$$

The left-hand-side of the above is convex in a and is negative at $a=0$ and at $a=1$. Therefore, $f_R(a,a;p)<0$ for all $a\in[0,1]$. The only equilibrium probabilities of reporting consistent with this case are $a_R=b_R=0$, and this equilibrium exists if and only if $\hat{l}\leq p/q$.

In case (iv), the payoff from reporting immediately is smaller than that in case (iii), but the payoff from not reporting immediately remains the same as that in case (iii). It follows that not reporting immediately still dominates reporting immediately. The equilibrium probabilities of reporting immediately are $a_R = b_R = 0$, and this equilibrium exists if and only if $\hat{l} \le p/q$. ∎

Lemma 3. *In a no-corroboration equilibrium, $l(R) > l(r)$.*

Proof. We first provide an upper bound to $\partial a_{nc}/\partial p$. By implicit differentiation,

$$\frac{\partial a_{nc}}{\partial p} = -\frac{1 - a_{nc}^2 + \delta a_{nc}^2}{2 + 2p\delta a_{nc} - 2pa_{nc} - \delta}.$$

This expression is decreasing in δ; evaluating it at $\delta = 0$ gives the following upper bound:

$$\frac{\partial a_{nc}}{\partial p} \le -\frac{1 - a_{nc}^2}{2(1 - pa_{nc})}.$$

The likelihood ratio corresponding to event R is

$$l(R) = \frac{p(1 - a_{nc})(1 - pa_{nc})}{q(1 - b_{nc})(1 - qb_{nc})}.$$

Hence, $l(R) > l(r)$ if and only if

$$\frac{(1 - a_{nc})(1 - pa_{nc})}{a_{nc}(2 - pa_{nc})} > \frac{(1 - b_{nc})(1 - qb_{nc})}{b_{nc}(2 - qb_{nc})}.$$

The derivative of the left-hand-side with respect to p has the same sign as:

$$-a_{nc}^2(1 - a_{nc}) - \left(a_{nc}(1 + p - 2pa_{nc})(2 - pa_{nc}) + 2(1 - pa_{nc})^2(1 - a_{nc})\right)\frac{\partial a_{nc}}{\partial p}.$$

Using the upper bound for $\partial a_{nc}/\partial p$, the above expression is greater than

$$\frac{1 - a_{nc}}{2(1 - pa_{nc})}\left(a_{nc}(1 - a_{nc})(1 + p)(2 - pa_{nc}) + 2(1 - pa_{nc})^2\right),$$

which is positive. Hence, $p > q$ implies $l(R) > l(r)$. ∎