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A field-experiment testing the impact of a warrant service prioritization strategy for police patrol officers

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Abstract

The objective of this experiment was to test the efficacy of providing prioritized warrant lists to patrol officers. A field experiment was carried out with the Greensboro (NC) Police Department. Warrant risk profiles were calculated from an analysis of historical offending; historical risk factors were used to implement prospective risk assessment for committing a violent crime while having an outstanding warrant issued during the field experiment. During the period from March 01, through July 31, 2019, people with warrants were randomly allocated to treatment or control. Outcomes included: number of warrants served, time to service, and average risk score of warrants served. Prioritization was not effective in promoting additional warrant service. No differences were found in the risk scores of people served. However, assessment of time to service suggested that warrants were served more quickly during the experimental period. Implementation of warrant prioritization had limited impacts; the process evaluation demonstrated the difficulty in modifying police patrol behaviors.

Keywords Warrants, Policing, Police strategy

Introduction

The regulation of search and seizure must balance state and individual interests created during the criminal investigative process (Slobogin, 1991). The Fourth Amendment to the U.S. Constitution authorizes arrest with a warrant when based upon probably cause and supported by oath or affirmation (Bar-Gill & Friedman, 2012). In the United States warrants can be issued for both misdemeanor and felony offenses (Bohlen & Shulman, 1927). Warrant backlogs have been noted as the "Achilles heel of law enforcement"; thousands of unserved warrants overwhelm a law enforcement agency's ability to successfully carry out this important function (Committee on the Judiciary, 2000). Service of these warrants requires considerable effort and resources by law enforcement agencies (Goldkamp, 2012). Little is known, however, about how agencies can prioritize these large warrant backlogs to both increase service and increase public safety.

This article reports on a field experiment that tested the utility of a prioritized warrant list designed to improve the efficiency and effectiveness of warrant service by patrol officers. Testing the efficacy of warrant service prioritization for patrol officers was comprised of the following components that included both historical data analysis and a field-based randomized control trial:

- Warrant prioritization: Using historical data, a model was constructed to predict the likelihood that a person would be arrested for a violent crime after a warrant was issued. A gradient boosted trees algorithm, based on analysis of 341,950 warrants (correspond-

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ing to 248,398 individuals) issued between January 1, 2013 and October 15, 2016, were used to determine this risk score.

- Agency implementation: Patrol officers in one large law enforcement agency were provided a spatially-referenced and prioritized warrant list via an intranet site developed to support the experiment. The intranet site provided officers a centralized place to identify outstanding warrants that were of high priority for service. It also served as a place where officers could log information about the warrant service (or attempted service).
- Randomization: Half the prioritized warrant list was suppressed from the officer view. The group of warrants that were suppressed from view were held as the control comparison.
- Evaluation: We explored the impact of the prioritization on likelihood of service, speed of service, and risk of warrants served. Interviews and focus groups with officers were conducted to understand how information and technology developed by the project was integrated into operations.

In the following section we explore three issues related to warrant service: (1) characteristics of outstanding warrants and warrant service at a state and national level, (2) the relationship between warrants and public safety, and (3) if proactive police activities can have meaningful impacts on the volume or type of warrants served. Despite being a persistent law enforcement problem, there has been relatively little research on this issue. There are considerable gaps in both our understanding of warrant issuance and police response to warrant service. Critically, there is little known about what agencies can do to best manage the volume of warrants issued in a way that maximizes public safety.

Literature review

Characteristics of outstanding warrants and warrant service

Knowledge about warrant issuance and service is hampered by the decentralized systems capturing warrant data and the difficulty of accessing these data for research and evaluation purposes. Unlike other measures of policing and criminal justice activity there is no central repository to understand warrant issuance or service. National information on criminal incidents, for example, can be tracked through efforts such as the Uniform Crime Reporting Program or the National Incident-Based Reporting System (Federal Bureau of Investigation, 2019). Unfortunately, no centralized service exists for understanding law enforcement and courts use of warrants.

Some efforts have been made to centralize warrant information for law enforcement practitioners. At a national level, warrant data are stored in the National Criminal Information Center's (NCIC) wanted persons database. Analysis of NCIC warrant data from all jurisdictions in the US found that 1.95 million warrants were active on a single, day in April 2011. About half of those warrants were issued within the last two years; 20% were issued more than five years prior (Bierie, 2014). Approximately 60% of all outstanding warrants were bench warrants related to probation/parole violations, bail violations, failure to appear, failure to comply, or related court-processing violations (Bierie, 2014). The extensive use of warrants for non-compliance with court proceedings has been associated with racial and ethnic disparities unconstitutional policing behaviors (Sekhon, 2018).

Research exploring correlates of warrant service have been limited. Craun and Tiedt (2017) examined all NCIC warrants entered between January 1, 2014 to September 14, 2014 and found that the average number of days from warrant issuance to warrant service was 31.7 days. Warrants related to child pornography, sex crimes, assault, kidnapping, and homicide had significantly higher chances of being served. They also found that warrants with subject's addresses were served significantly faster than warrants without addresses.

Understanding warrant service based on NCIC data, however, comes with a considerable limitation: warrants are entered by each responsible agency and there is no requirement that warrants be submitted to NCIC. Furthermore, warrants are generally only entered if the responsible agency is willing to fund extradition, if necessary ("NCIC 2000 Operating Manual," 2000). Therefore, the warrant information captured in NCIC is a subset of all outstanding warrants and it remains unknown how well NCIC warrants track with the universe of warrants to be served by law enforcement. The limitations of NCIC have led some to suggest that NCIC needs to be supplanted by a national active warrant registry that is publicly accessible (Bierie, 2015). Calls for more transparency around warrant issuance have also been made in an effort reduce racial and ethnic biases and disparity (The Policing Project, 2023).

Studies conducted using state-level data are few, but those that have been done, have investigated warrant characteristics, backlogs, and time to service. In Kentucky, the warrant backlog increased by about 28,000 per year, year-over-year (Hager et al., 2005). Guynes and Wolff's (2004), assessing six months of warrant data issued in Montgomery County, MD, found that warrants were predominantly issued for failure to appear (FTA, 59.8%) and violation of terms of probation (12.1%). The underlying charges for these FTA and probation violation

warrants were predominately related to traffic offenses or DUIs. Outstanding warrants for crimes against persons or property were relatively low at 1.6 and 4.9%, respectively (Guynes & Wolff, 2004).

The service of warrants has been associated with numerous characteristics. For example, Hager et al. (2005) found a strong relationship between the seriousness of the offense and the days until service. The median days to serve a warrant for a capital offense was 7 days, 23 days for felony A offenses, and 155 days for misdemeanor B offenses. Johnson et al. (2015) identified case- and person-level characteristics that influenced time to service. Out of the 11 characteristics analyzed, six were found to be associated with time to service.[1] Warrants took longer to serve when the defendant was male (1.3×), Hispanic (1.7×), or lived outside the county that issued the warrant (2.1×). Warrants associated with felonies were served about 26% faster than warrants from misdemeanor cases; cases with higher bond amounts were served faster than warrants with lower bond amounts. Instanter warrants were generally served 35% faster than warrants stemming from a violation. Two additional predictors were marginally significant: older defendants were served faster than younger defendants and those with more prior arrests were served slower than those with less.

Warrants, public safety, and the role of law enforcement

The theoretical framework for understanding how, why, and law enforcement's impact on the service of warrants is underdeveloped. A strong body of evidence suggests that focused deterrence strategies can be effective at reducing crime (Braga & Pierce, 2005; Engel et al., 2011; Fox & Novak, 2018). Within a focused deterrence framework, the presence of an outstanding warrant service may serve as an important indicator for risk of future offending and may, therefore, serve as a useful indicator for law enforcement action. Unfortunately, little research has established the characteristics associated with a warrant that indicates higher, or lower, levels of risk for future offending. As described above, the majority of warrants are issued for minor infractions related to court operations.

Research linking warrant service with public safety outcomes is limited, but some evidence suggests that focusing police resources on apprehending individuals with warrants may improve public safety. Dunford (1990) considered the impact of issuing warrants as part of domestic violence incidents and found that when warrants were issued recidivism was lower. Homant et al. (2007) evaluated a program focused on serving warrants for offenses related to drinking and driving. They found that the program increased the service of warrants but could not draw conclusions about its broader impact on drunk driving offending or highway safety. Notably absent from existing research is a framework for agencies to use to prioritize which warrants should be prioritized for service to improve key public safety indicators. Previous studies have narrowly focused on warrants for specific types of crimes.

More broadly, the last few years have seen widespread (McCarthy, 2022) calls for police reform especially as related to police use of force (Subramanian & Arzy, 2021). Some reform efforts have focused on an overall reduction on enforcement-focused police-community contacts. Communities have made efforts to reduce police involvement in traffic safety (Thorn, 2021), reduced the presence of law enforcement in schools (Beckett, 2020), and implemented non-law enforcement crisis response teams to address the often co-occurring and long-term challenges related to drug use, mental health, and homelessness (Westervelt, 2020). High profile cases of mistaken identity (Ebrahimji, 2022), mistaken households (Rosenblatt, 2017), and unjustified use of force during warrant service (Bowman, 2022) have also highlighted the need for warrant service reform. The current work explores one opportunity for reforming warrant service by focusing on people with warrants that are at highest risk for violent offending while deprioritizing warrants that have lower risks to public safety.

Law enforcement strategies for warrant service

The process law enforcement officers use to prioritize warrant service has been attributed to three factors: (1) protection of the community based on perceived risk of a person's future dangerousness, (2) blameworthiness, and (3) practical constraints around capacity to serve warrants (Johnson et al., 2015). Unfortunately, existing research has not fully explored how agencies can improve the service of warrants within this existing framework. Warrant squads (i.e., dedicated personnel focused on warrant service) are common in law enforcement, but evaluations of this approach are rare and dated. Whitecomb and Rossman (1984) evaluated a felony warrant apprehension team implemented by the New York State Police. They found evidence that the warrant squad approach increased the proportion of warrants served, reduced time to service, and was cost effective.

[1] Defendant's gender, race, ethnicity, age, the number of prior arrests, whether the case was criminal (vs civil), whether the case was for a felony (vs misdemeanor), whether the crime was against a person, the bond amount, whether the defendant was known to reside within the jurisdiction, and whether the warrant was an instanter warrant (vs a warrant for a continuation for a case).

Fugitive safe surrender (FSS) programs are operated at both federal and local/regional levels and some evidence suggest that these can be an effective method of clearing warrant backlogs (Cahill, 2012; Flannery & Kretschmar, 2012). Some agencies have explored warrant service via mail as a cost-effective method of serving low level warrants. Limited research has found this approach to be effective (Born et al., 1991) but some note the risk for exploitation (United States Courts, 2014). Gould (1982) assessed a holistic approach to warrant service that coordinated efforts by the court, sheriff, and municipal police and found fewer warrants were issued and more of the issued warrants were served.

We were unable to locate any research that specifically focused on how police patrol practices could be optimized to improve warrant service. As the largest workgroup within policing, there are potential benefits of using patrol officers to serve warrants. Nevertheless, unallocated patrol time, in which warrants could be served, is often limited. Service of warrants by patrol officers must be further contextualized by how officers arrive in a situation in which a warrant could be served. Broadly, warrant service may be intentional (i.e., the officer(s) go out with the intention of serving a specific warrant for a specific person) or incidental (i.e., an outstanding warrant is discovered secondary to some other reason for a police-community interaction). We were unable to locate any research that disaggregated the relative proportion of warrants served intentionally versus incidental to other contact, although research has suggested that the majority of warrants are for administrative violations of court proceedings (Sekhon, 2018) and therefore may be of lower priority for patrol resources. Research addressing how to optimize warrant attempts by patrol is needed for efficient allocation of resources.

Finally, it is worth considering non-law enforcement strategies to reduce the volume of warrants issued. Scholars have noted that many warrants issued are for failure-to-appear that may result from misunderstanding or confusion, rather than willful disregard for court proceedings. Strategies such as behavior nudges, reminding defendants of their court dates, and extending court access and hours, have been demonstrated effective at reducing missed court appearances (Bernal, 2017; Fishbane et al., 2020). Although preliminary, this work suggests that the persistent problem of warrant service should be addressed through a variety of strategies.

Technology in law enforcement agencies

As described in the next section, our experiment focused on facilitating warrant service for patrol officers through a technology platform that improved access to warrant information. Although the experiment focused on improving warrant service, the ability to achieve change can must be set within a larger framework of technology adoption in law enforcement agencies. In this section we explore two related concepts. First, are there agency characteristics that facilitate technology adoption? Second, how is technology effectiveness assessed and how do these perceptions of effectiveness impact adoption?

There is some evidence that characteristics related to the agency and characteristics related to policing strategy are related to technology adoption although this relationship has received little empirical attention. Technology adoption has been associated with a variety of agency and community context characteristics: mobile camera adoption has been correlated with agency size, crime levels, and size of geography served (Schuck, 2016); computerized crime mapping with 'cosmopolitanness' (Weisburd & Lum, 2006); web-based crime mapping with agency size and length of recruit training (Leong & Chan, 2012); and crime analysis with agency command structure, number of specialized units, and number of formalized policies (Randol, 2014). Hendrix et al. (2017) found that community-oriented policing and hot spots policing strategies were associated with the adoption of geographic information systems, social media, and license plate readers. Together, these studies tell us that technology adoption within law enforcement agencies may be conditional upon characteristics of those agencies. Agencies that are larger, and have more financial resources and human capital, appear to be earlier and more consistent adopters of technology.

The effectiveness of technology in policing can be broadly classified into two categories: improvements to technical efficiency and increases in operational effectiveness (Hatry, 2014; Taylor Griffiths et al., 2014). Outcomes associated with technical efficiency aim primarily at improving the cost, time, or resources need to achieve an outcome such as the use of computerized records management systems to improve the efficiency in filing reports (Rutgers & van der Meer, 2010). Effectiveness outcomes are focused on improving desired outcomes. These outcome domains are not independent as technology may make an agency both more efficient and more effective. Nevertheless, Lum et al. (2016) found that agency staff tended to be highly focused on outcomes associated with technical efficiency and were less concerned with outcomes associated with effectiveness.

Critically, the adoption of technology, by itself, does not guarantee successful or optimal use of technology. Goodhue and Thompson (1995) task-technology-fit (TTF) theory suggests that for technology to be effective it must be utilized, and it must show good fit for the tasks it is supposed to be supporting. Using a TTF framework, Ioimo and Aronson (2016) argued that technology must

be directly relevant to officer's daily activity. Technology aimed at creating new officer activities, or technology that supports non-core activities, will be less effective. More broadly, this suggests that technology should not drive changes in police strategy or activities. Instead, organizations need to identify and implement technology that supports their activities.

Gaps in existing research

Bringing these divergent streams of research together suggests that the exact extent of the warrant backlog problem is difficult to assess due to poor availability of data. Nevertheless, even a cursory observation of available evidence suggests that the volume of outstanding warrants are a persistent problem for law enforcement agencies. Despite the persistence of this problem, little is known about how to improve the efficiency of warrant service, especially as related to the service of warrants by patrol officers. Technology (in the form of predictive analytics and better warrant information access) may improve the efficiency with which warrants are served, but the adoption of technology within law enforcement agencies is complex. This additional information, by itself, may be insufficient to meaningfully impact policing operations.

The current study aimed to address several of these limitations. Outstanding warrants were prioritized using a machine learning technique to identify individuals that were most likely to engage in violent crimes. This information was disseminated to officers via a custom intranet-based dashboard. A multi-method evaluation was conducted to determine if warrants could effectively be prioritized in a way that encouraged service by patrol officers and improve public safety.

Research questions

The goal of this research was to assess the effectiveness of producing prioritized warrant lists for patrol officers. Outcomes were focused on four areas: time to warrant service, volume of warrant service, risk score of persons served, and impact of warrant service on officer activity. A randomized controlled experiment was conducted. However, the presence of historical data prior to our field experiment allows us to frame questions that are pre- and during intervention as well as treatment versus control.

Time to service

- R1a. Are people with warrants assigned to the treatment condition served more quickly than people assigned to the control condition?
- R1b. Are people with warrants with a higher priority score served more quickly than people with warrants with a lower priority score?
- R2. Has the time between warrant issuance and warrant service decreased after implementation of the warrant prioritization tool?

Number of warrants served

- R3. Are people with warrants assigned to treatment more likely to be served than people with warrants assigned to control?
- R4. Has the number of warrants served increased after the implementation of the field experiment?

Risk score of persons served

- R5. Was the average risk score of warrants served higher for persons assigned to treatment versus persons assigned to control?

Traffic stops and self-initiated activity

- R6. Did implementation of the field experiment reduce proactive police patrol activities such as (a) traffic stops or (b) other self-initiated activity?

Methods

This was a multiphase project including (1) analysis of historical data to determine risk factors associated with new offending after a warrant was issued, (2) a field experiment testing the implementation of a web-based platform that prioritized warrants for service, and (3) a process evaluation to assess the changes brought about by warrant prioritization.

The field experiment was conducted in Greensboro, NC, the third most populous city in the state. Residential population is estimated to be more than 294,000 with considerable growth in recent years. The population is predominantly White (48%) and African American (41%). People of Hispanic or Latino heritage, regardless of race, comprised approximately 7.5% of the population. Median household income was $46,702 in 2018 dollars with approximately 19% of people living in poverty (U.S. Census Bureau, 2018). The Greensboro Police Department (GPD) is a full service municipal law enforcement agency with 674 sworn staff and 113 civilian staff organized into four patrol districts, investigations, and specialty units (Greensboro Police Department, 2017).

Warrant service in GPD was similar to many other mid-sized agencies. Until two years prior to the experiment, the agency staffed a warrant squad tasked exclusively with serving warrants. Due to staffing and budget constraints, the warrant squad was disbanded. High priority warrant service was coordinated between detectives and agency's tactical team. Lower priority warrants were served by patrol as time allowed, or secondary to incidental contact between officers and warrant holders. GPD command staff hoped that the experiment could prompt more warrant service from patrol officer and ease some of the 'friction' caused by multiple data systems that were not conducive to use by officers in the field.

Experimental design

To support the experiment, a web-based tool (WOMBAT) was developed to serve four main purposes: (1) access and process daily warrant updates from North Carolina Statewide Warrant Repository (NCAWARE), (2) assign people with warrants to treatment or control conditions, (3) serve as a place for entering data needed for risk scoring, (4) communicate prioritized warrant information to patrol officers in the field, and (5) inform executive staff and patrol supervisors about the volume of warrants served by each officer and patrol team.

Patrol officers were able to access WOMBAT through department computers (including mobile data terminals located in patrol cars). The field experiment was conducted from March 01, 2019 through July 31, 2019. From March 01 through June 02, the experiment was conducted in two of four GPD districts (Districts 1 and 4). On June 03, the remaining districts (Districts 2 and 3) were brought into the experiment. Due to the short implementation in Districts 2 and 3, our analysis is restricted to Districts 1 and 4.[2] There were 180 officers assigned to Districts 1 and 4 during the experimental period.

Deployment within the districts was conducted in stages as officer training opportunities became available. Training of patrol officers and their first-line supervisors was conducted by a GPD captain. The content of the training was developed collaboratively between the research team and the GPD to ensure that system features were documented correctly. Training was done in person during routine start-of-week briefings and occurred over a three-week period in March 2019. The training (typically 30 min) demonstrated the WOMBAT platform and explained expectations for officer data entry during warrant service.

The deployment of WOMBAT was combined with an increased communication of the importance of warrant service by agency executive staff. Throughout the duration of the experiment, all officers were periodically prompted, through agency email, by agency executive staff to conduct warrant service. To facilitate this action, approximately 60 days into the field experiment, a warrant service report was developed and incorporated into WOMBAT. The report provided information on the number of warrants served by patrol squad and the number of warrant attempts recorded in WOMBAT. These reports were sent by the GPD captain to patrol supervisors.

Data

Historical criminal history

Historical criminal history data were provided by the North Carolina Administrative Office of the Court (NCAOC). These data were used to identify risk factors for new arrests after a warrant was issued. NCAOC provided the research team with an extract NCAWARE data. The main benefit of using the NCAWARE data was the availability of record-level identifiers that linked events to individuals and grouped warrants and criminal history events to a single unique person record.

Warrant data

On a daily basis, WOMBAT received an update on warrant information from the NCAWARE. WOMBAT parsed the updates to existing warrants and identified all newly issued warrants and new people with warrants. Random assignment to treatment or control condition occurred at the person level. Warrants for existing person-records were linked to that person but retained their original treatment/control assignment.

Contemporary criminal history and risk scoring

Risk scoring individuals with warrants was a two-step process. A GPD representative entered criminal history data in WOMBAT. Information used in the risk scoring included misdemeanor charges and convictions, felony charges and convictions, and charges and convictions that included a violent offense. These data were retrieved from CJLEADS by a GPD representative and manually keyed into WOMBAT.[3] Once these data were entered, WOMBAT used predefined risk predictions identified

[2] The two districts where the primary experiment was conducted were selected as a matter of convenience and organizational control. These two districts fell under the command of one Deputy Chief. A sensitivity analysis was conducted including all districts and no noteworthy differences were found to the main results presented here.

[3] CJLEADS is North Carolina's centralized repository for information about offenders.

in Phase I to calculate a risk score. These scores were assigned to a person-record.[4]

Focus groups and interviews

The process evaluation was designed to assess how the implementation of WOMBAT affected officers' work. Semi-structured interviews and focus groups were conducted over two days in July 2019. Discussions were conducted with (1) officers who had used WOMBAT; (2) officers who had not used WOMBAT; (3) patrol supervisors of squads who had some use of WOMBAT; (4) patrol supervisors with less use of WOMBAT; (5) a member of command staff; and (6) a data entry clerk responsible for entering criminal history data in WOMBAT. A total of nine GPD personnel were involved in group or individual interviews. Personnel for each group were purposively sampled to represent desired user types. A member of the GPD command staff reached out to individuals to determine their interest in participating. Two members of the research team lead the discussion; one team member was primarily responsible for note taking.

Randomization

Randomization to treatment or control was made systematically and automatically in WOMBAT without intervention from project or GPD personnel. Randomization to treatment or control condition was made at the person level[5] and was conducted after the record's address was geocoded but prior to the entry of criminal history data and risk scoring. After geocoding, a record was assigned a random number between 1 and 100. If their random number was 50 or less, they were assigned to the control group. If the number was 51 and above, they were assigned to treatment.

Measures and analytical strategies

The first analysis we conducted was on historical criminal history and warrant data to develop the risk classification models. The outcome of interest was arrest for a violent offense after a warrant for arrest is issued (for any reason).

Historical risk predictions

After data cleaning (including removing duplicate records), the analysis dataset contained 341,950 warrants (corresponding to 248,398 individuals) issued between January 1, 2013 and October 15, 2016. For the classification task, a gradient boosted trees algorithm was used to predict the outcome. For its flexibility, we used the XGBoost python package (xgboost 0.6a2). Six time frames were used to summarize criminal history information (counts of events during last 6-month, one year, two-year, five-year, ten-year, all-time) for six variables: counts of charges and convictions for misdemeanors, felonies, and violent crimes. The outcome variable was arrest for a violent crime after warrant issuance.

To determine which time range of variables was most predictive of the outcome, models were created with each time-frame subset of variables and evaluated using cross-validation with the Area Under the Receiver Operating Characteristic (AUCROC) curve. Using all criminal history available provided the most accurate model and that subset of variables were used in the final model. For the field experiment, raw model predictions were converted to risk scores. The risk score was the percentile of that predicted value out of all predicted values. For example, the model may output a predicted probability of 0.11, a score that is lower than 97% of all output predicted values. Thus, their risk score would be 3 (representing the 3rd percentile of all output scores). These percentile-based risk scores were displayed for users as part of the field experiment. More information on the predictive models used to develop the risk scoring can be found in Appendix A.

Impact of experiment

Evaluation of the experiment was conducted in several stages and included experimental (comparisons between treatment and control groups) and quasi-experimental (pre- and during-experiment) comparisons. To better contextualize the impact of the experiment and warrant prioritization approach, interviews and focus groups were conducted. We explore the impact of the experiment among the following domains:

1. Random assignment to treatment or control conditions was made at the person level. The effectiveness of the random assignment in producing equivalency was checked by comparing number of warrants, risk score, and demographics.
2. Potential tradeoffs between warrant service and other officer activity were examined using regression

[4] Data in NCAWARE can be organized into person-, warrant-, and case-level information. For the purposes of this analysis, we were interested in person- and warrant-level information. Randomization to treatment or control occurred at the person level. Analyses presented in this report are done at the person- or warrant-level, depending on the research question. The term "process" is a more general category of events from which warrants were identified. For consistency, we use the term warrants throughout.

[5] We considered an alternative approach of randomizing warrant service prioritization at the officer-level. However, this approach was found to be impractical. Patrol is organized around strong work groups. Contamination of the control-assigned officers was determined to be an unacceptable risk unless we could randomize entire patrol teams. Although this was possible, it would have meant we would need to adjust the experiment every time personnel changed teams.

models to examine changes in traffic stops, pedestrian stops, and directed patrols before and during the experimental period.
3. The impact of warrant prioritization on characteristics of warrant service such as time between warrant issuance and warrant service, number of warrants served, and the risk score of the warrant served. Analyses compared treatment and control during the experimental period and pre/during comparison using historical data. Comparison between treatment and control groups on time to service was explored through survival analysis.
4. Results of the interview and focus groups were examined to assess the impact of warrant service and prioritization on patrol officers.

Results

Assessment of randomness

Analyses were conducted to determine if the random assignment protocol was effective at producing equivalent treatment and control groups along the following dimensions: number of warrants per person, risk score, age, race, and sex. Comparison between treatment and control on the number of processes per person, risk score, and age were compared using t-tests. Sex and race were coded as categorical variables; evaluation of the significance between treatment and control groups was made using Pearson Chi-Square. Table 1 summarizes the results.

No statistically significant differences between treatment and control group were found in the number of processes per person ($t = 0.34$, $p = 0.73$) or risk scores ($t = -0.49$, $p = 0.62$). There was a small but significant difference between age of people in control (mean = 33.26) versus treatment (mean = 34.64; $t = -1.98$, $p = 0.05$). No significant differences were found between treatment and control on race ($\chi^2 = 0.79$, $p = 0.67$) or sex ($\chi^2 = 0.44$, $p = 0.51$).

Treatment vs. Control analyses represent warrants that were issued between experiment start (March 01, 2019) and experiment end (July 31, 2019), inclusive of both dates. Actions (e.g., warrant service or warrant recall) outside of these dates were not included. The warrants that were pre-loaded into the system (from January 1, 2019 through February 28, 2019) were not included in this analysis because of the difficulty of classifying their time at risk. Although they were allocated to treatment or control, these pre-loaded warrants were up to two months old before the experiment started. Therefore, the number of warrants and persons included will be less than those described in the allocation statistics in following tables. Although we excluded these warrants from the main analysis, we conducted additional tests on these cases.

Number of warrants served (pre/during)

We conducted analyses that considered the impact of the warrant prioritization project, overall, on the number of warrants served by GPD. This ignored the treatment and control allocation, and instead explored the potential total impact of WOMBAT implementation and the agency's focus on warrant service (Table 2). Number of warrants, by week, were calculated from the NCAWARE data. These were warrants served by GPD, regardless of assigned agency.[6] Negative binomial regression models were conducted. The intervention period was modeled with a binary indicator variable for the weeks while the experiment was in the field. Models included controls for month (Appendix A). The experimental period was not associated with changes in warrant service activity.

Officers have a finite amount of time to spend on proactive activity, so we assessed whether officers substituted attempted warrant service for other kinds of proactive activity. We analyzed traffic stops independently from other officer activities that were likely to be proactive. The modeling strategy was consistent with the evaluation of warrants served, described above. Models for traffic stops, suggested no change in activity comparing pre- and during-experiment periods. Models of other proactive activity suggests less activity during the experiment relative to the pre-intervention period. However, given no apparent change in warrant service, it is difficult to suggest that officers were conducting warrant service in place of other proactive activity.

Additional sensitivity analyses are presented in Appendix B. These models help to disaggregate some of the alternative model specifications that could have been made based on project implementation. These results did not change any of the substantive conclusions described above.

Number of warrants served (treatment vs. control)

We sought to determine if more warrants were being served when assigned to the treatment condition (Table 3). No differences were found on the number of warrants served ($z = 0.14$, $p = 0.89$) between treatment and control assignment.

[6] Unlike previous the analyses, the impact on warrant service ignores the assigned agency/district of the process/warrant. Instead, we calculated all service activity conducted by officers.

Table 1 Comparison of treatment and control allocations

Variable	Assignment	N	Mean	(SD)	t (p)
Number of processes per person	Control	641	1.43	1.09	0.34 (0.73)
	Treatment	620	1.41	1.09	
Average risk score	Control	641	39.01	28.02	− 0.49 (0.62)
	Treatment	620	39.77	27.09	
Age	Control	637[a]	33.26	11.96	− 1.98 (0.05)
	Treatment	619	34.64	12.83	
Variable	**Assignment**	**Group**	**N**	**% (Total)**	**Chi-square (p)**
Race[b]	Control	Black	464	37	0.79 (0.67)
		White	139	11	
		Other	38	3	
	Treatment	Black	439	35	
		White	147	3	
		Other	34	12	
Sex[b]	Control	Female	197	16	0.44 (0.51)
		Male	444	35	
	Treatment	Female	179	14	
		Male	441	35	

[a] N for age does not match N for other characteristics due to missing data

[b] Difference assessed using Pearson Chi-Square

Table 2 Impact of experiment on warrant service, traffic stops, and proactive activity

Model	B	SE	z	P	95% CI	
Outcome 1: N Warrants Served	0.07	0.09	0.76	0.45	− 0.14	0.28
Outcome 2: N Traffic Stops	− 0.13	0.08	− 1.67	0.10	− 0.29	0.02
Outcome 3: N Other Proactive Activity	− 0.23	0.08	− 2.94	< 0.01	− 0.38	− 0.08

Models specified as negative binomial regression. Unit of analysis was weekly counts of activity. Comparison is between weeks pre-intervention and weeks during the intervention. Outcome 1 included controls for month. Outcomes 2 and 3 included controls for month and year. Information on warrants served was determined through data downloaded from NCAWARE. Number of traffic stops and proactive activity was based on calls for service data maintained by the GPD

Number of warrants served per person served (treatment vs. control)

During the experimental period, 488 people were served (control n = 215; treatment n = 202). From this, we tested whether there were differences in the number of outstanding warrants per person between the treatment and control groups. We hypothesized that officers may be more likely to attempt service on individuals with more outstanding warrants. On average, the individuals assigned to treatment, and whose warrants were served, had fewer warrants than the control group, but this difference was not significant (t = 0.32, p = 0.75) (Table 4).

Time to service (treatment vs. control)

Differences in time to service between the treatment (mean days at risk = 49.4; median days at risk if served = 18) and control groups (mean days at risk = 49.1; median days at risk if served = 17) were evaluated through survival analysis (Table 1). Log-rank tests between the survival distributions of the treatment and control groups revealed no significant differences (z = 0.08, p = 0.78). A Cox proportional hazards model with a binary treatment/control indicator was fit to the data; group assignment was non-significant (β = − 0.02; 95% CI = (−0.19,0.14)) and resulted in an underfit model (concordance = 0.50) (Table 5).

Table 3 Number of warrants issued and served

Assignment	N (Warrants)	N (Warrants served)	% Served	SE	z (p)
Control	666	299	45	0.25	0.14 (0.89)
Treatment	611	262	43	0.26	

Unit of analysis was at the process (warrant) level. Comparison is between cases assigned to treatment and control

Table 4 Number of warrants served per person served

Assignment	N (People Served)	Mean number of warrants	SD	t (p)
Control	215	1.39	1.19	0.43 (0.67)
Treatment	202	1.35	0.91	

Unit of analysis was at the person level. Comparison is between cases assigned to treatment and control

Table 5 Time to service, treatment vs control comparison

Assignment	Mean time at risk (days)	Median (days, if served)
Control	49.1	17
Treatment	49.4	18

Unit of analysis was at the process level. Comparison is between processes assigned to treatment and control

Table 6 Time to service, pre/during comparison

Assignment	Mean time at risk (days)	Median (days, if served)	N	% Served
Pre	247	36	4410	40
During	58	14	1537	32

Unit of analysis was the warrant. Comparison is between warrants issued from January 1, 2018 to February 28, 2019 (pre-experiment) and March 01, 2019 through July 31, 2019 (during experiment)

[a] Due to the unequal length time tracked during the pre-experimental time and during-experimental time, we would expect the mean days to be longer for the pre-experimental group

Time to service (pre/during)

Differences in time to service between the pre-intervention and during-intervention periods were evaluated through survival analysis (Table 6).

This analysis was conducted on the subset of warrants that were assigned to districts 1 and 4 and were served by GPD. Log-rank tests between the survival distributions of the treatment and control groups revealed significant differences ($z = 29.24$, $p < 0.001$). A Cox proportional hazards model with a binary pre-during indicator was fit to the data, with the during group assignment resulting in a significant coefficient estimate ($\beta = 0.29$; $\exp(\beta) = 1.33$; 95% CI = [0.18, 0.39]) and underfit model (concordance = 0.53). The exponentiated coefficient indicates that warrants during the experimental period were served 33% faster (hazard ratio of 1.33). A plot of the smoothed survival function is presented in Fig. 1.

Differences in risk score (treatment vs. control)

This analysis assessed if the people served by GPD varied in risk score based on their assignment to treatment or control (Table 7). A reasonable hypothesis would be that the risk scores of people served should be higher for those in the treatment group, compared with the control group, if officers were using WOMBAT to identify higher priority people for warrant service. Although the risk scores of people served at least one warrant was higher when assigned to treatment, the difference was not significant ($t = -0.77$, $p = 0.44$).

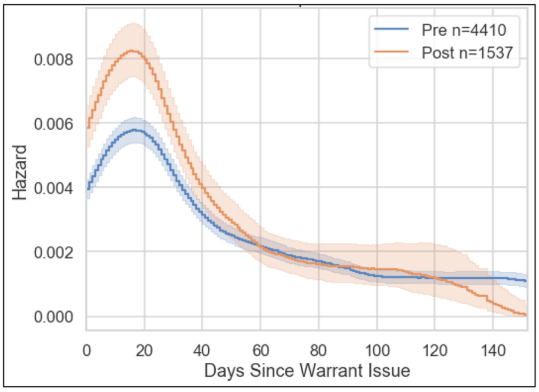
A note on power

A consistent story emerging from these analyses was that intentional warrant service was low, and the implementation of WOMBAT and risk prioritization scores did not change these behaviors. To understand what kind of impact would have been needed to be detectable, several steps were taken. For comparing the percent of warrants served between treatment and control (Table 3), we calculated the pooled standard errors to determine the plausible effect size that would have been detectable.[7] Results suggest a pooled standard error of 2.8% suggesting a detectable effect would have required an 11–12% change in warrant service. Thus, we can rule out a medium effect but not a small effect of the warrant improvement process.

Post hoc power was calculated for the results presented in Tables 4 (number of warrants served per person served) and 7 (risk scores). Using the means, standard deviations, and counts reported in those tables, achieved power was found to be 0.10 for the comparison presented in Table 4 and 0.19 for the comparison presented in Table 7.

This achieved power was substantially less than what was anticipated during our a prior power analysis conducted prior to conducting the experiment. In that a prior analysis we determined that a sample size of approximately 400 would be adequate to identify a small ($d = 0.2$) effect of the treatment improving the likelihood

[7] We thank an anonymous peer reviewer for the recommendation and guidance on presenting information related to power and detectable effect size.



Note: Smooth hazard function of time to warrant service for warrants issued pre- and post- experiment.

Fig. 1 Smooth hazard function, pre/during experiment. Smooth hazard function of time to warrant service for warrants issued pre- and post-experiment

Table 7 Risk scores

Assignment	N	Mean score	SD	t (p)
Control	215	41.55	28.51	− 0.77 (0.44)
Treatment	202	43.67	27.48	

Unit of analysis was at the process level. Comparison is between cases assigned to treatment and control

of a warrant being served. It is clear that this was not achieved, despite meeting target sample size estimates.

Process evaluation

The process evaluation was conducted three weeks after the conclusion of the field experiment. The process evaluation was conducted through interviews and focus groups with officers from the GPD. The discussions were structured into four sessions: command staff, system manager, "active" users in patrol, non-users in patrol, and patrol supervisors. Focus group sessions were conducted in-person and lasted approximately one hour. Each session was attended by three researchers, two primarily leading the discussion and one dedicated to taking notes. Following the conclusion of the focus group, the note taker would complete their notes and send them to the other researchers to add additional comments. The three researchers involved in the focus groups developed the first set of thematic findings. These thematic findings were then reviewed by the other project team members. Finally, we shared the thematic findings with GPD command staff to ensure that information provided during the focus group sessions were accurately interpreted.

The process evaluation identified the need to be clear in intention when discussing warrant service. Reason for warrant service fell into two categories: (1) intentional warrant service and (2) incidental warrant service. Deliberate warrant service is where warrant service or attempted service is conducted with the goal of serving that warrant. Incidental warrant service occurs as officers go through other routine activities that bring them in contact with members of the public. Critically, it is not deliberate; it is a by-product of other officer activity.

Intentional warrant service is not an agency-wide, and consistent, priority: We heard repeatedly that warrant service was not a priority for officers. Instead, officers and command staff prioritized other activities, such as hot spots policing, for their proactive patrol time. In the past, the agency had a warrants squad with dedicated personnel. Some reported that disbanding of this group signaled that proactive warrant service was not a priority. The implementation of WOMBAT was not perceived as a renewed focus on warrant service. The limited use of WOMBAT demonstrated that intentional warrant service was limited.

Intentional warrant service is perceived as time/resource intensive and inefficient: Three issues were reported explaining why warrant service was not more prevalent. First, officers and first-line supervisors reported that they did not have time to conduct warrant service. Existing workload and staffing levels do not leave sufficient proactive time to peruse warrant service. Second, warrant service was perceived as burdensome. Officers must check multiple systems to identify potential warrants worth serving. Additionally, the agency practice generally suggests that warrant service attempts should be conducted by two officers. Third, attempted warrant service was highly prone to failure. One officer stated that attempted service failed 95% of the time.[8] Much of these failed service attempts were due to people not being home and bad addresses.

Technology fragmentation hurts perceived efficiency: Officers reported that there were multiple systems they had to consult when serving warrants. To some, WOMBAT added to the technology overload rather than mitigating challenges of existing systems.

The experiment may have been noticeable to officers: Some officers reported not seeing warrants in WOMBAT that they knew to be outstanding. This may have been because half the warrants were suppressed to serve as the control or because older warrants were not placed into the Officer View. Officers reported concern over these missing warrants and questioned overall reliability of the system.

[8] Based on data submitted through WOMBAT, warrant service was successful in 19% of attempts.

WOMBAT helped fill important gaps, and officers had suggestions for enhancements: Officers reported that the system was very easy to use, and they appreciated that they did not need login information to access the system. Despite challenges with address accuracy, users reported that the mapped view of outstanding warrants was a valuable feature. For future development, officers reported that they would like to include date of birth and a photo of the person with a warrant. Officers also reported that they would have liked the ability to add or update address information.

Discussion

There are considerable practical challenges for using NCAWARE for proactive policing operations. During the project, many officers reported that NCAWARE was difficult and time consuming to operate, especially while in the field. WOMBAT addressed many of these usability issues by improving accessibility and providing officers with more actionable information. Nevertheless, we observed that measurable use of WOMBAT was low.[9] We took considerable efforts to facilitate WOMBAT adoption including (1) designing an easy-to-use system, (2) engaging command staff in promoting adoption, (3) providing tailored end-user training, and (4) producing customized reports on officer actions that were disseminated to officers. Despite these efforts, we found that warrant service activity was still low throughout the department. Interviews and focus groups with officers suggested that warrant service was still perceived to be low priority and that there was insufficient time available for proactive activity. Turning back to Goodhue and Thompson (1995) and task-technology-fit theory, this result is not overly surprising given what was heard during interviews and focus groups. Although technology may be able to overcome challenges with data access and information about warrants, it is unable to fully address the main challenge of limited time and perceived de-prioritization by the agency.

We found no evidence that risk score was associated with warrant service. Results suggest that intentional warrant service was low, both within WOMBAT and as an overall agency strategy. It would appear, that to a large extent, most warrant service is incidental to other officer activity. Given these characteristics of warrant service, it was not surprising that risk score was not predictive of warrant service. Unfortunately, a technical solution to prioritizing warrant service, and providing that information in more efficient ways, cannot overcome organizational realities that limit intentional warrant service.

Both qualitative and quantitative evidence suggested that warrant service was inefficient. Notes provided by officers indicate that bad addresses and no answers were repeated challenges on efficient warrant service. Of the 81 notes filed by officers through WOMBAT, 39 (48%) were related to bad address information. Notes on 36 cases (44%) indicated that the officer got no answer or was unable to locate the subject. There may be room for considerably improving efficiency if additional research, or outside datasets, were attached to warrant information. Information outside of NCAWARE, such as those contained in public records aggregators could contribute to improved accuracy of residential address.

Our discussion with multiple agencies identified varying patterns in the recording of attempted warrant services within NCAWARE. Although officers have the capability to report failed warrant service attempts, many indicated that it was cumbersome to do so. We found that agencies reported wide variability in procedures dictating if this activity should be reported in NCAWARE.

Taken together, the results of this experiment are mixed. Officers did not appear to serve more warrants (when comparing either treatment vs. control or pre vs. during) after the implementation of WOMBAT. Comparing treatment vs. control assignment, the warrants served were not associated with higher risk individuals nor were there differences in the number of warrants served per person. We did find, however, that warrants issued during the experimental period were served more quickly relative to the warrants served in the previous year. Warrant issuance date was available in the main officer view of WOMBAT, which may have contributed to focus on newer warrants (instead of focusing on more risky warrants like we had intended). The focus on newer warrants would be consistent with our qualitative work where officers reported little interest in going after "stale" warrants.

From a practical perspective, results suggest that patrol officers do not consider intentional warrant service to be a high priority activity. The process of serving warrants is challenging because it is time intensive, failure prone, and not perceived to be important by command staff. Most warrant service is incidental to other police-community contacts such as traffic stops or pedestrian stops. Results suggest that both traffic and pedestrian stops were declining in the agency over the analysis period. This suggests that we would expect lower levels of warrant service as this officer proactive activity decreases. Additional research is needed to better understand how intentional warrant service can be promoted and reinforced in an agency.

The results of this experiment are consistent with Goodhue's (1995) TTF Theory. The implementation of

[9] Measurable use would include logging services, attempted services, or case/address notes. Other activity, such as just reviewing records or outstanding warrants, could not be measured.

WOMBAT may have been a good 'fit' for increasing the success and effectiveness of warrant service, but intentional warrant service was not a prioritized activity. It is no surprise then that the implementation of WOMBAT did not spur measurable increases in warrant service. Increasing intentional warrant service among patrol officers would require that the agency define this activity as a key performance measure and allow officers the time and resources necessary to conduct warrant service attempts.

Finally, it is worth discussing this experiment in the context of current efforts to reduce warrant issuance and service, more generally (Lerner, 2021). Research has found that sanctions associated with warrants can create long-term cyclical problems by repeatedly bring people into contact with the criminal justice system (Brett, 2020). The harms associated with prolonged criminal justice involvement have been found to be disproportionally damaging to people of ethnic and racial minority groups (The Sentencing Project, 2018). There have been considerable calls for major reforms to the warrant issuance and service process (see, for example, Figler, 2020), some of which have called for considerable reduction in the use of warrants for failure to appear (The Policing Project, 2023). Evidence-based strategies could be used to better prioritize warrant service to balance public safety with individual harms.

Limitations and avenues for future research

Because of the structure of this implementation and evaluation, we are unable to disentangle the impact of the warrant prioritization from the broader impact of prioritization, warrant data availability, and agency focus on warrant service. Because of this, we cannot say that the prioritization scores, independent of the data availability and leadership focus, had an impact on warrant service.

There were several challenges in using the historical data to forecast risk profiles. Research has established that a considerable amount of crime is never reported to the police and, of the crime reported to the police, only a small percentage is solved through arrest. These two characteristics mean that the inputs for our predictive models were censored and undercounted events.

There were limitations on our ability to identify unique people within the state warrant data which may have resulted in multiple records in WOMBAT for a single person. Matching process records to person records required the each to have the same name and address. If the name was different (perhaps due to typographical errors) or if the address changed between the previous warrant and the new warrant, a new person record would be generated in WOMBAT.

Our evaluation period was relatively short. The challenges of managing a patrol-focused field experiment necessitated these constraints. Importing and coding warrant data was resource intensive for the agency. Our inability to rollout WOMBAT to the entire agency, for a longer period, almost certainly contributed to the low warrant service rate. Additionally, it may have created a situation where officers perceived the focus on warrants to be temporary.

Adoption of WOMBAT by field officers was low. Officers reported that this was due to limited organizational emphasis on warrant service and lack of sufficient staffing. Future policing technology research must go beyond simply building tools and technologies that can improve officer effectives. Additional work must be done to understand the organizational context surrounding implementation. Technology that contributes to workload, or only assists for work activities that are perceived as low priority, will not be readily adopted by field officers.

Finally, the experiment and evaluation may have had unintended consequences on the perceived utility of the WOMBAT platform. Officers reported being aware of warrant information suppressed from WOMBAT. This may have negatively affected perceptions of system reliability. Additionally, we became aware of the inaccurate address situation early in the project. Bad addresses are a well-known limitation of warrant service. Nevertheless, to protect the experiment, we did not allow reassignment of warrants once they were assigned to a place.

Conclusion

Despite the public safety value of improved warrant service efficiency, little is known about how officers approach the need to serve a volume of warrants that far outstrips capacity. Our work was the first experiment designed to capitalize on advances in police data systems and technology and predictive modeling with the goal of improving the efficiency and effectiveness of warrant service. Multiple analyses found that this approach had minimal impact on warrant service. Results suggested that this was likely due to an implementation failure.

Appendix A: Regression models, full results

See Tables 8, 9 and 10.

Table 8 Count model of warrant service

Variable	B	SE	z	P	95% Confidence interval	
Intervention	0.07	0.11	0.66	0.51	− 0.14	0.28
February	− 0.03	0.16	− 0.17	0.86	− 0.33	0.28
March	0.05	0.16	0.30	0.76	− 0.28	0.37
April	0.22	0.15	1.38	0.17	− 0.09	0.52
May	− 0.05	0.16	− 0.28	0.78	− 0.37	0.28
June	0.23	0.16	1.46	0.14	− 0.08	0.54
July	0.12	0.15	1.10	0.27	− 0.13	0.45
August	0.07	0.16	0.63	0.53	− 0.21	0.41
September	0.05	0.19	0.29	0.77	− 0.32	0.43
October	− 0.12	0.18	− 0.64	0.52	− 0.47	0.24
November	0.01	0.19	0.03	0.98	− 0.37	0.38
December	− 0.12	0.18	− 0.64	0.52	− 0.47	0.24
Constant	3.78	0.11	35.48	0.00	3.57	3.99
Log Alpha	− 2.53	0.19			− 2.92	− 2.15
Alpha	0.08	0.02			0.05	0.12

Number of observations = 86

Wald $\chi^2(12) = 18.63$

Prob > $\chi^2 = 0.10$

Table 9 Count model of traffic stops

Variable	B	SE	z	P	95% Confidence interval	
Intervention	− 0.13	0.08	− 1.67	0.096	− 0.29	0.02
Year 2015	− 0.48	0.05	− 10.26	< 0.001	− 0.57	− 0.38
Year 2016	− 0.84	0.05	− 17.63	< 0.001	− 0.94	− 0.75
Year 2017	− 0.75	0.04	− 21.26	< 0.001	− 0.82	− 0.68
Year 2018	− 0.85	0.03	− 25.89	< 0.001	− 0.91	− 0.78
Year 2019	− 0.71	0.05	− 12.95	< 0.001	− 0.82	− 0.60
February	0.00	0.06	0.03	0.974	− 0.11	0.11
March	− 0.06	0.05	− 1.22	0.222	− 0.16	0.04
April	− 0.24	0.06	− 3.92	< 0.001	− 0.36	− 0.12
May	− 0.23	0.05	− 4.11	< 0.001	− 0.33	− 0.12
June	− 0.12	0.05	− 2.32	0.020	− 0.23	− 0.02
July	− 0.09	0.05	− 1.71	0.087	− 0.19	0.01
August	− 0.17	0.05	− 3.32	0.001	− 0.27	− 0.07
September	− 0.29	0.06	− 4.60	< 0.001	− 0.41	− 0.16
October	− 0.32	0.05	− 5.86	< 0.001	− 0.42	− 0.21
November	− 0.29	0.08	− 3.59	< 0.001	− 0.46	− 0.13
December	− 0.38	0.09	− 4.11	< 0.001	− 0.56	− 0.20
Constant	6.35	0.04	153.06	< 0.001	6.27	6.43
Log Alpha	− 2.93	0.11			− 3.14	− 2.71
Alpha	0.05	0.01			0.04	0.07

Number of observations = 299

Wald χ^2 (12) = 1007.0

Prob > χ^2 = < 0.001

Table 10 Count model of other proactive activity

Variable	B	SE	z	P	95% Confidence interval	
Intervention	− 0.23	0.08	− 2.94	0.003	− 0.38	− 0.08
Year 2015	− 0.51	0.04	− 12.31	< 0.001	− 0.59	− 0.43
Year 2016	− 0.61	0.04	− 15.30	< 0.001	− 0.69	− 0.53
Year 2017	− 0.54	0.03	− 16.03	< 0.001	− 0.60	− 0.47
Year 2018	− 0.73	0.04	− 20.53	< 0.001	− 0.80	− 0.66
Year 2019	− 0.62	0.06	− 10.85	< 0.001	− 0.73	− 0.51
February	0.10	0.05	1.90	0.057	0.00	0.21
March	0.08	0.06	1.35	0.177	− 0.04	0.21
April	0.15	0.07	2.30	0.021	0.02	0.28
May	0.15	0.06	2.71	0.007	0.04	0.26
June	0.15	0.06	2.65	0.008	0.04	0.27
July	0.06	0.05	1.26	0.209	− 0.04	0.16
August	0.10	0.06	1.77	0.077	− 0.01	0.21
September	0.05	0.06	0.73	0.463	− 0.08	0.17
October	0.03	0.06	0.55	0.584	− 0.09	0.15
November	− 0.03	0.06	− 0.59	0.555	− 0.15	0.08
December	− 0.09	0.07	− 1.41	0.160	− 0.23	0.04
Constant	5.18	0.05	111.77	0.000	5.09	5.27
Log Alpha	− 3.46	0.12			− 3.69	− 3.23
Alpha	0.03	0.00			0.03	0.04

Number of observations = 299

Wald $\chi^2(12) = 598.4$

Prob > χ^2 = < 0.001

Appendix B: Sensitivity analysis

The main results compare the treatment versus control during the experimental period or the pre-experimental period versus during-experimental period. In both instances, the analysis omits warrants issued during a small block of time between the pre-phase and the experimental phase, which we refer to as the backlog. The backlog cases were made available to officers to ensure that there were cases available to officers on the first day of the field experiment. We graphically demonstrate the experiment time periods in Appendix Fig. 2.

Weekly count of warrant service plotted. Data were disaggregated into the three phases for sensitivity analysis. Warrants in the "backlog" and "experimental" phases were assigned to treatment or control. Warrants in the "pre-experiment" were not assigned to treatment or control and were not available in WOMBAT.

Events in the backlog do not fit cleanly into the pre-experiment or experimental periods. Cases in the backlog could have been active for up to two months before the experiment started. Therefore, we would not necessarily expect to see faster service for these cases. Given that the global significance test approached traditional $p < 0.05$ levels, we conducted post-hoc testing to determine if there were significant differences between groups (results not tabled). Although results of post-hoc testing suggested significant differences between several groups, these did not hold out once correction for familywise error rates were applied. Test of differences between groups in the number of warrants served, per person suggested no differences between groups.

A Cox proportional hazards model with a binary indicator for (1) pre-experiment ($\beta = -0.48$; $\exp(\beta) = 0.62$; 95% CI = [− 0.64, − 0.32]), (2) during experiment ($\beta = 0.5$; $\exp(\beta) = 1.65$; 95% CI = [0.34, 0.65]), and (3) treatment/control assignment ($\beta = 0.01$; $\exp(\beta) = 1.01$; 95% CI = [− 0.12, 0.14]). Indicators for per-experiment and during experiment were significant at the $p < 0.01$ level. Consistent with the primary analysis, warrants appear to have been served more quickly during the experiment, but there were still no differences between treatment and control assignment.

However, plotting the hazard function for each group suggests that the distribution of events does not meet the assumption of proportional hazards. Because of this, we are reluctant to draw too many conclusions from this analysis and include it for descriptive purposes only. Comparing the risk score of people served, by group, there were no significant differences between groups. We were unable to

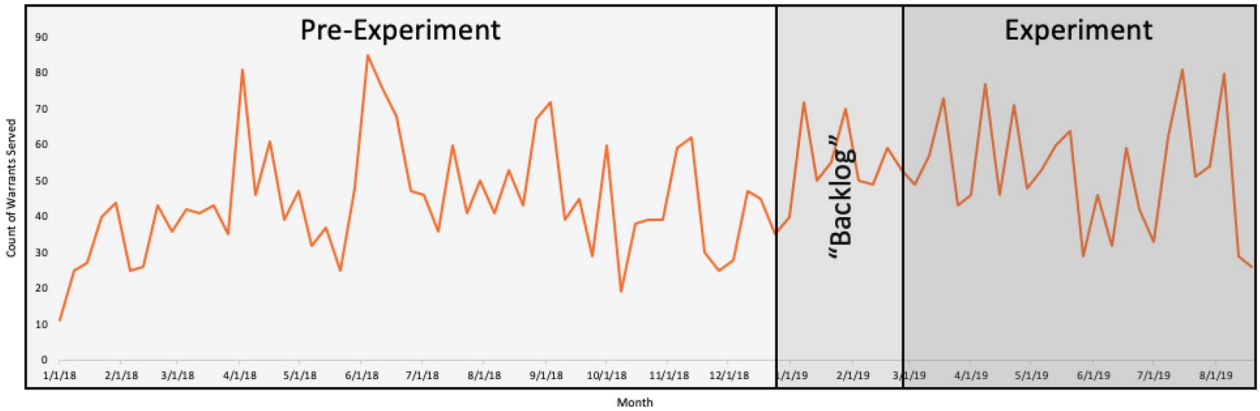


Fig. 2 Experimental phases

identify any significant differences between treatment and control group, even after disaggregating by backlog versus experimental period cases.

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Availability of data and materials
Data from this project are available through the National Archive of Criminal Justice Data.

Declarations

Competing interests
The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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