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Abstract:

This study examines the rates of data production for US law enforcement agencies deploying Body Worn Camera and DashCam systems. Analysis estimates that local law enforcement agencies can reasonably expect to produce 33.9 individual video files, totaling 11.1 hours of video, and (depending on the video capture quality) requiring between 10-20 gigabytes of storage space per officer, per month. The study also demonstrates that video file production rates from existing DashCam systems can be an effective benchmark when considering the implementation of a Body Worn Camera system. Finally, the study finds that of all implementation policies examined, only two policies demonstrated significant positive impact on video capture rates: 1) if officers were required to inform citizen of camera in operation, and 2) if officers were allowed to view footage prior to making a shift report.

Headings:

Public records -- Government information

Public records -- Management

Electronic government information

Body Worn Cameras

DashCams

Law Enforcement Records

MEASURING THE IMPACT OF BODY WORN CAMERAS (BWC) ON DATA MANAGEMENT AND RECORD RETENTION FOR LAW ENFORCEMENT AGENCIES

by
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1.0 INTRODUCTION

In the past year, interest in equipping Law Enforcement Officers (LEOs) with Body Worn Cameras (BWCs) has increased significantly. In the wake of the shooting of Michael Brown on August 9, 2014 and the subsequent press coverage of the Ferguson Police Department's mismanagement of the case, police departments nationwide have undergone increased scrutiny for excessive use of force by LEOs.[1] This has led to an increase in the number of law enforcement agencies considering the implementation of BWC programs as a method of curbing excessive use of force and promoting the transparency of law enforcement in general.[2] BWC technology has received wide public interest in the past few years after US District Court Judge Shira Scheindlin issued a directive to the NYPD to begin a pilot BWC program as part of her judgment against its 'stop-and-frisk' policy on August 11, 2013.[3] In 2012, relatively few police departments across America had implemented or piloted a BWC program; 2014, however, saw a large increase in the number of police chiefs interested in pursuing such programs, culminating in President Barak Obama's proposal to provide $263 million to match state funding for

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[1] Harwell, Drew. (2014, December 03). "The Body-Camera Industry Is 'Feeling Phenomenal' after Ferguson." *The Washington Post*. Retrieved April 25, 2015 from http://www.washingtonpost.com/blogs/wonkblog/wp/2014/12/03/the-body-camera-industry-is-feeling-phenomenal-after-ferguson/

[2] Police Executive Research Forum, U.S. Justice Department. (2014). *Implementing a Body-Worn Camera Program: Recommendations and Lessons Learned.* (2).

[3] Blake, Aaron. (2013, August 12). "Judge Says New York's 'Stop And Frisk' Law Unconstitutional". *The Washington Post*. Retrieved May 13, 2015 from http://www.washingtonpost.com/blogs/post-politics/wp/2013/08/12/judge-says-new-yorks-stop-and-frisk-law-unconstitutional/

police BWC systems, possibly deploying 50,000 devices in three years.[4] In response to the growing interest, the Police Executive Research Forum (PERF) published policy recommendations in September 2014 to help Police Chiefs around the nation implement BWC programs.[5] In its survey of 500 law enforcement agencies, PERF found that only 25% (n=64) of those responding (n=254) had implemented a BWC pilot as of July 2013.[6] Although accurate estimates of the number of law enforcement agencies that have initiated BWC programs are not available, the Federal Bureau of Justic Statistics estimates that between 4,000 and 6,000 US law enforcement agencies are planning to adopt or have already adopted BWCs as of May 2015.[7]

Despite the broad interest in BWC technology by the public, lawmakers, and police administrators, there are relatively few empirical studies on BWC programs. According to White, only five empirical studies were available on the impacts of BWC on Law Enforcement as of September 2013.[8] Developing research in this area, however, has increased over the last two years; a review conducted by George Mason University identified 12 empirical studies and 30 ongoing research projects as of early 2015 (many replicating previous studies).[9] Although preliminary research suggests the

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[4] The White House, Office of the Press Secretary. (2014). *FACT SHEET: Strengthening Community Policing*. Retrieved from http://www.whitehouse.gov/the-press-office/2014/12/01/fact-sheet-strengthening-community-policing

[5] Police Executive Research Forum. "Implementing a Body Worn Camera Program." (2).

[6] Ibid. (5).

[7] Reaves, B. (2015). **"**Local Police Departments, 2013: Personnel, Policies, And Practices." Bureau of Justice Statistics. Retrieved from http://www.bjs.gov/index.cfm?ty=pbdetail&iid=5279

[8] White, Michael D. (2014). "Police Officer Body-Worn Cameras: Assessing the Evidence." Washington, DC: Office of Community Oriented Policing Services. Retrieved from https://ojpdiagnosticcenter.org/sites/default/files/spotlight/download/Police%20Officer%20Body-Worn%20Cameras.pdf. (6).

[9] Lum, C., Koper, C.S., Merola, L.M., Scherer, A., and Reioux, A. (2015). "Existing and Ongoing BodyWorn Camera Research: Knowledge gaps and opportunities." Report for the Laura and John Arnold Foundation. Fairfax, VA: Center for Evidence-Based Crime Policy, George Mason University. (8).

implementation of BWC programs have a positive correlation with the reduction of use of force and reduction of citizen complaints, it has little to say on the implementation of the programs themselves or the impact on IT resources, which remains one of the largest concerns by agencies that are considering deployment of a BWC program.[10]

The literature often cites the difficulties of assessing costs of implementation and maintenance of BWC programs. Many of the practical concerns for implementation remain unanswered. How long should law enforcement agencies retain BWC data? What are the costs of the resulting data storage? What are the costs of maintenance of local servers vs. cloud storage? What is the demand on new and existing staff? Too often, policy makers have adopted policy language without fully considering the practical limitations that such policies might incur. Some police departments have chosen a data retention period of 6 months, while Oakland (CA) PD has adopted a permanent retention period. It is impossible to keep all data forever. Indexing, description, and retention of data can contribute to significant labor costs, and longer retention of data implies significant increases to the cost of storage.

The current ability to calculate costs based on file/data creation is very difficult because of a lack of valid metric data. One report from the Mesa Police Department in Arizona estimates 2327 files produced on average per month for a pilot study of 50 officers, resulting in an average of 47 files per officer per month.[11] Conversely, the experiences of Greensboro, NC suggest that 250 officers have produced more than 40,000 files in a seven-month period, resulting in an average of 22.8 video files per

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[10] Police Executive Research Forum. "Implementing a Body Worn Camera Program." (19).
[11] MPD (Mesa Police Department). (2013). "On-Officer Body Camera System: Program Evaluation and Recommendations." Mesa, AZ: Mesa Police Department.

officer per month.[12] Furthermore, while some anecdotal accounts provide estimations for number of hours, number of files, or storage size required—each presenting a particular challenge to IT and data curation experts—none considers them collectively. Knowing the average number of files produced in a month does not allow us to estimate how much data storage is required for those files, nor does it shed light on the total length of the video collection, factors both impacted by the cameras' capture bitrate and compression. These gaps in knowledge result in uncertainty for policy makers and significant challenges for law enforcement administration, as they are unable to predict how costly the programs are beyond the initial equipment investment.

Three facets of video data storage (number of files, size of storage and length of video) demand IT resources, each with a different impact. For the purposes of the following research, the term *IT resources* is used generically to refer to all costs associated with these systems throughout the lifecycle of a BWC record, from creation to eventual disposal. This includes the primary costs for the hardware/software procurement and human labor required for maintenance of the system as well as secondary or unintended costs that occur because of the existence of the records themselves (e.g. costs related to video ingestion, metadata creation, retrieval of records, or labor required for redaction).

Each of the following facets poses different demands on these IT resources. First, the number of files stored in a collection directly influences the difficulty of information retrieval, and the number of files produced per officer significantly increases the labor required for description and, at larger scales, may create challenges for reliable recall of

[12] Ibid. (32).

records. Second, the storage size of the collection (in gigabytes for instance) translates into a direct cost for storage media, but the average file size of video produced per officer contributes to secondary costs incurred during record ingestion (i.e. a larger file will take longer to upload) and costs associated with fulfillment of a record request (e.g. physical media required). Finally, the length of video (in hours) produced per officer will have a direct impact on the costs associated with review (i.e. how much irrelevant footage must be reviewed to find a segment of interest) and secondary impact on costs related to video redaction required as a result of record requests.

Little is known about how BWC systems will contribute to each of these data demands, and no study to date has provided a comprehensive picture of the video production statistics of all three facets. Production estimates for these facets in BWC technology have varied wildly, in part, because news articles typically focus on one statistic (storage space) without the context of the other related facets. Reporting on a single facet ignores other contributing factors and can ultimately lead to inaccurate, anecdotal predictions. For example, ten one hour-long video files offer very different challenges and implications than a single video file that is ten hours long, even though the data storage required will be virtually identical. The primary goal of this study is to fill in these gaps, aggregating all three statistics into a reliable estimate that law enforcement agencies can use to weigh the impacts of BWC policies on IT resources (both primary and secondary).

A major determinant for the number of videos produced will be the number of officers equipped with cameras. However, as the Rialto, CA study demonstrated, policy choices (i.e. officer discretion or voluntary assignment) can have a direct impact on the

adoption rate of the technology (and subsequently the amount of data produced).[13] Therefore, the secondary goal of this study is to investigate whether differences in policy choices and agency characteristics result in different data production statistics. In order to inform policy makers and IT professionals of the real projected costs of a BWC program, valid metrics must be created and analyzed in relation to the different possible policies for program implementation. The practical outcomes of this study provide a method of estimating how great an impact BWC systems might have on IT resources in an organization on a per officer, per month basis, and provide a list of policy points that have a significant impact on the feasibility of a BWC program.

Finally, existing infrastructure already exists for IT solutions for video storage collected through police department's DashCams. To date, no study has compared the outputs of BWC programs and DashCam programs. Collecting relevant metrics from existing full-scale DashCam programs may allow us to infer baseline statistics for full-scale BWC programs. The final goal of this study explores whether such a correlation exists. These findings will be particularly useful for those agencies who already deploy DashCam systems and are interested in implementing a BWC program.

Initial research suggests that BWC programs offer significant social benefits, and the political expediency of deploying such programs as an answer to growing concerns from the public creates a strong motivation for police departments to adopt BWC programs. Confirming the validity of these social benefits, however, is outside the scope

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[13] Farrar, Tony. (2013). "Self-awareness to being watched and socially-desirable behavior: A field experiment on the effect of body-worn cameras on police use-of-force." The Police Foundation. Retrieved from http://www.policefoundation.org/publication/self-awareness-to-being-watched-and-socially-desirable-behavior-a-field-experiment-on-the-effect-of-body-worn-cameras-on-police-use-of-force/

of this analysis. Given the assumed benefits of increasing the transparency of modern policing and the frequency with which public officials have called for their deployment, this study assumes that adoption of BWC programs will be widespread in the near future. It attempts to provide a more granular look at the practicalities of implementation, mapping out the choices that have the greatest impact on infrastructure demands and estimating the magnitude of that impact on resources.

2.0 LITERATURE REVIEW

As the latest example of a camera technology used to support law enforcement and security efforts, the discussion of the impacts of BWC on IT resources should start by considering its predecessors: DashCams and CCTV. The intended uses of these three camera technologies within law enforcement are similar—either as a crime deterrent, method of evidence collection, or as a tool for increasing transparency of law enforcement generally. This review will explore the development and deployment of camera technology for the use of law enforcement, examining the similar causes for adoption and contrast the different challenges that each of these systems has had on technical implementation.

2.1 The Rise of CCTV

The deployment of camera technology by law enforcement agencies has steadily increased since the 1960s, when the technology was first adopted to monitor crowds and regulate traffic lights with statically mounted CCTV systems. In 1960, the London Metropolitan police deployed static pan-tilt cameras in Trafalgar Square during a high-profile visit by the Royal Family of Thailand to Parliament, and again a year later to monitor revelers during Guy Fawkes Night.[14] The primary purpose of these systems was

[14] Norris, C., McCahill, M., & Wood, D. (2004). Editorial. "The Growth of CCTV: a global perspective on the international diffusion of video surveillance in publicly accessible space." *Surveillance & Society*. (*110*).

to augment law enforcement, increasing monitoring capabilities in support of traditional ground police work.[15] Since the uses were typically temporary instead of a long-term approach to policing, maintenance of the resulting records (camera footage) was negligible. While early uses of CCTV were limited to policing crowds and providing security surveillance for high profile events, Norris et al. argue that wide-scale adoption of CCTV increased after 1993 when "the fuzzy CCTV images of toddler Jamie Bulger being led away from a Merseyside shopping mall by his two ten-year old killers placed CCTV in the spotlight."[16] While CCTV did not prevent Bulger's death, Norris et al. argue that it did comfort the public with the belief that the killers would soon be caught, increasing the public's faith in law enforcement's execution of the law.[17] In UK, public anxiety led to the steady increase in public funds provided for CCTV system acquisition with proponents citing crime deterrence and evidence production as valuable outcomes.[18]

The value of CCTV as a crime deterrent is based on rational choice theory, which posits that "potential offenders make purposeful, rational (albeit bounded) decisions to commit crimes after weighing the potential costs and benefits of the crime in question."[19] Research on the impact of CCTV on crime deterrence has demonstrated mixed results. Studies have shown that CCTV reduces the fear of crime,[20] but it does not have the same effect as a deterrent for all types of crime (e.g. reducing occurrences of theft but having

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[15] Ibid. (110).
[16] Ibid. (111).
[17] Ibid. (113).
[18] Goold, Benjamin J. (2004). "CCTV and Policing: Public Area Surveillance and Police Practices in Britain." New York: Oxford University Press. (34).
[19] La Vigne, N., Lowry, S., Markman, J., and Dwyer, A.. (2011). "Evaluating the Use of Public Surveillance Cameras for Crime Control and Prevention." Washington, DC: Office of Community Oriented Policing Services. Retrieved from http://www.cops.usdoj.gov/Publications/e071112381_EvalPublicSurveillance.pdf.(4).
[20] Ratcliffe, Jerry. (2006). "Video Surveillance of Public Places." Washington, D.C.: U.S. Department of Justice, Office of Community Oriented Policing Services. (3).

little effect on violent crime).[21] Evaluation of CCTV as an effective crime deterrent is also mixed; a meta-study conducted by the Office of Community Oriented Policing Services (COPS) found that about half (n=22) of studies conducted on CCTV use in downtown areas found that CCTV placements reduced crime rates relative to controls.[22] Other studies remain critical, claiming that CCTV systems simply displace crime to other unmonitored areas.[23] Regardless of the outcomes, the UK has steadily increased its use of CCTV cameras as a method of crime deterrence and evidence collection by both the private sector and law enforcement to the point where Richard Thomas, the UK Information Commissioner in 2004, argued that Britain was "sleepwalking into a surveillance society."[24]

CCTV can be used to capture evidence of a crime, but this is a secondary purpose of such systems; the primary purpose is to serve as a deterrent or to allow a security team to actively identify and prevent developing security threats. However, the intended uses (both primary and secondary) of the camera footage have direct implications for the storage systems that support them. CCTV has several key limitations. It is not mobile and therefore, the context of the evidence it captures is not flexible—used to survey everything, not document a discrete thing. While advances in CCTV (e.g. motion detection and face recognition) have resulted in systems capable of more granular, event-driven capture, many systems still do not discriminate what they record. CCTV is most

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[21] Welsh, Brian, and Farrington, David. (2004). "Surveillance for Crime Prevention in Public Space: Results and Policy Choices in Britain and America." Criminology and Public Policy 3(3): 497–526. (498).

[22] La Vigne, et al. "Evaluating the Use of Public Cameras." (6).

[23] Gill, Martin, and Spriggs, Angela. (2005). "Assessing the Impact of CCTV." Home Office Research Study 292. Retrieved from www.homeoffice.gov.uk/rds/pdfs05/hors292.pdf.

[24] Ford, J. (2004, August 16). "Beware Rise of Big Brother State, Warns Data Watchdog." The Times. Retrieved from http://www.thetimes.co.uk/tto/news/uk/article1927810.ece.

powerful when deployed in an array with many vantage points overlapping to achieve comprehensive surveillance, requiring many cameras to achieve desired outcomes.[25] This significantly increases the canvas of the area surveyed and means that these systems capture far more evidence than is required for the primary purpose. For example, a CCTV array may capture video of all persons approaching the entrance of a government building, but will invariably capture additional trivial details (like who bought a hotdog from the nearby street vendor, or how frequently passersby discarded cigarette butts). This wider scope significantly increases the chance for video evidence to have secondary purposes beyond those originally envisioned by designers. A system required to serve these unknown secondary purposes may be required to retain records for far longer, creating data storage and retrieval challenges.

Law enforcement agencies have addressed many of the data storage and management challenges for CCTV, but a brief discussion of these challenges is useful because they differ slightly from those created in DashCam and BWC systems. Unsurprisingly, the increase in the number of vantage points necessary to secure a location significantly increases the amount of footage produced by the system, also incurring data storage challenges. Law enforcement uses CCTV in two ways: actively in support of a manned security monitoring station, or passively in unmanned security surveillance.[26] In the first case, footage may have little value past a relatively short retention period to support the official record provided by human security agents, but passive monitoring increases the value of keeping the record for a longer period due to the lack of active annotation of contextual events that transpire during video capture. In

[25] La Vigne, et al. "Evaluating the Use of Public Cameras." (20).
[26] Ibid. (23).

terms of record storage and retention, CCTV has some technological advantages over BWC or DashCam systems. Frequently, static camera installations are hardwired into storage systems, and transfer between video capture and storage is seamless. Furthermore, retention for CCTV is frequently automated (whether accomplished with revolving magnetic tape or digitally) as systems simply overwrite expired footage. This means that storage requirements remain relatively static depending on the number of cameras deployed.

2.2 Deploying DashCam Systems

While the US has been slower than the UK to adopt broad deployment of CCTV cameras, it has aggressively adopted in-car systems (DashCams) mounted in patrol vehicles. Like their CCTV cousin, DashCams were first used in 1960 when the Connecticut State Police installed a video camera and tripod in the front seat of a patrol cruiser.[27] In the 1990s, the DashCam saw increased use in America's war on drugs as a method for documenting consent to a search for suspected drug traffickers during interdiction stops.[28] Like the proliferation of CCTV technology, widespread deployment of DashCam systems was a response to public outcry. Allegations that law enforcement agencies were using racial profiling increased public distrust of law enforcement; a 1999 Gallup poll reported that 59% of Americans (regardless of race) believed that racial profiling was widespread, and 81% of Americans disapproved of the practice.[29]

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[27] International Association of Chiefs of Police. (2004). "The impact of video evidence on modern policing: Research and best practices from the IACP study on in-car cameras." Alexandria, VA: International Association of Chiefs of Police. (5).

[28] Ibid.

[29] Newport, Frank. (1999). "Racial profiling is seen as widespread, particularly among Young Black Men." Gallup.

Simultaneously, assaults against officers were on the rise and state and legislative bodies began to require detailed documentation of all traffic stops.[30] COPS advocated the deployment of DashCams as the solution, and between 2002 and 2004, provided more than $21 million in grants to aid state police and highway patrol agencies in the purchase of DashCam systems.[31] During this period, the number of DashCams installed on state patrol vehicles rose from 3,400 (11%) to 17,500 (74%).[32] Although initially some law enforcement agencies resisted implementation, by 2003 implementation was widely embraced as instrumental to policing.[33]

While both CCTV and DashCam systems saw large deployment rates at the same time, DashCams were received far more favorably by the public. A 2004 IACP survey found that 94% of the public indicated that they did support and approve of the use of DashCams by law enforcement agencies.[34] In addition, 93% of the police-misconduct cases using DashCam evidence resulted in officer exoneration and 58% of prosecutors reported reductions in time spent in court when prosecuting with DashCam evidence. Similar to CCTV, officers reported feeling like monitoring systems made them more careful to follow proper protocol and increased awareness of how they were treating suspects/citizens.[35] DashCams have demonstrated substantial value to the agencies using them including enhancing officer safety, improving agency accountability, improving citizen compliance, and increasing the quality in documentation of interactions between

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[30] International Association of Chiefs of Police. "Impact of Video Evidence." (5).
[31] Ibid. (2).
[32] Ibid. (6).
[33] Ibid. (22).
[34] 71% also indicated they should be informed when they are being videotaped. Ibid. (20).
[35] Goold, B. J. (2002). "Public area surveillance and police work: the impact of CCTV on police behaviour and autonomy." *Surveillance & Society, 1*(2), 191-203.

officers and citizens.[36] In contrast to the use of CCTV—whose primary function is to surveil the actions of members of the public only—DashCams are situated more objectively, recording actions of the public and law enforcement alike.

DashCam systems present different challenges for data management than does CCTV. First, DashCams have a far narrower scope and are less likely to capture incidental or unnecessary evidence. Most DashCams systems are designed to automatically activate when an officer turns on the car's sirens; as such, the video captured is narrowly defined to the officer's pursuit and interactions with the public once stopped. Whereas CCTV can be used as either passive or active monitoring, DashCams are always used actively as an augmentation of the police record. As such, a far greater percentage of DashCam footage is relevant as evidence or documentation than CCTV footage. Additionally, the focus on officer interactions means that DashCam footage can be used for secondary administrative purposes (e.g. officer training/review or evaluating an agency's policies/procedures). The increased likelihood for DashCam footage to have secondary value for law enforcement administration means that footage captured by DashCams may have a much longer lifecycle than footage captured by CCTV. While DashCam systems produce less data than CCTV because there are fewer cameras associated with each monitoring point, a greater percentage of the video will be evidentiary. Furthermore, even non-evidentiary DashCam video has a greater chance of being valuable for secondary purposes, increasing the need to annotate, maintain, and store these records. Finally, DashCams cannot be hardwired into storage systems, requiring human intervention to transfer information from capture to storage. This means

[36] International Association of Chiefs of Police. "Impact of Video Evidence." (6).

that unlike CCTV systems (which can be fully automated and passive), DashCams always require some amount of human labor to migrate to the storage environment.

2.3 Growing Interest in BWC Systems

DashCams have been widely adopted by agencies as an effective method of documenting traffic stops and collecting evidence.[37] While DashCam systems developed to fulfill a particular niche in modern policing, there remain significant limitations. While they have the advantage of being mobile and targeted (able to document officer/citizen interactions when they occur, where they occur), DashCams are mounted to a squad car and often only provide visual evidence. If audio support is available, its quality is often low.[38] Considering the ongoing need for transparency to the public, it is natural that agencies began to explore the possibility of equipping officers with Body Worn Cameras (BWC) as a way of addressing the limitations of DashCams. BWCs can follow officers wherever they go and capture both audio and visual feeds of whatever occurs.[39] Localized on the officer herself, the BWC captures the context as close to the officer as is currently possible with available technology.[40] While it is important not to overgeneralize and assume that the video captured *is* the experience of the officer, a BWC is able to capture a viscerally objective account of events as they occurred assuming the camera is turned on for the entirety of the event and barring camera malfunction or user error. Ultimately,

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[37] On a related note, there has been a recent trend in private citizens in countries outside the US, but US citizens are also beginning to adopt the technology as a method of collecting evidence of fault in automobile accidents. See Smith, Tim. (2015, September 25). "Dash cams: They aren't just for police anymore." The State. Retrieved from http://www.thestate.com/news/local/article36548994.html.

[38] Rickerd, Chris. (2014). "Strengthening CBP with the Use of Body-Worn Cameras." ACLU.

[39] National Institute of Justice. (2012). "A Primer on Body Worn Cameras for Law Enforcement." Washington, DC: US Department of Justice. Retrieved from https://www.justnet.org/pdf/00-Body-Worn-Cameras-508.pdf. (3).

[40] Ibid.

BWCs and DashCams share the same perceived benefits and law enforcement agencies deploy them to affect similar outcomes: an increase in police legitimacy through more accountability; an improvement in officer and citizen behavior resulting in an improvement to officer and public safety; and an increase in the quality of documentation of interactions between officers and citizens.[41]

Like the impact of the Bulger murder on deployment of CCTV and reaction against racial profiling on deployment of DashCams, BWC deployment has increased due to a public opinion flashpoint. In August 2013, BWCs drew national attention in the US after District Court Judge Shira Scheindlin issued a directive to the NYPD to begin a pilot BWC program as part of her judgment against its 'stop-and-frisk' policy.[42] Continued allegations of racial profiling and a concern over the increase in use of force incidents have led many to propose BWC technology as the solution. In 2010, David A. Harris's law review on BWCs argued, "If the presence of the camera has an effect on the behavior of police officers, making them more likely to hew to proper legal and constitutional standards, that is reason enough to move toward the use of these devices."[43] Public calls for BWC deployment became increasingly common in August 2014 after the death of Michael Brown in Ferguson, MO.[44] Law enforcement agencies considering implementation of BWC programs saw a sharp increase from 2012 to 2014.[45]

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[41] White. "Police Officer Body-Worn Cameras. (6).

[42] Santora, Marc. (2014, October 15). "Order That Police Wear Cameras Stirs Unexpected Reactions." New York Times. Retrieved from http://www.nytimes.com/2013/08/14/nyregion/order-that-police-wear-cameras-stirs- unexpected-reactions.html?_r=0.

[43] Harris, D.A. (2010). "Picture this: Body worn video devices ("head cams") as tools for ensuring Fourth Amendment compliance by police." Legal Studies Research Paper Series. Pittsburgh: University of Pittsburgh School of Law. (369)

[44] Prall, Derek. (2014, August 27). "Calls for body-worn police cameras increase." American City & County.

[45] Police Executive Research Forum. "Implementing a Body Worn Camera Program." (2).

In December 2014, President Barak Obama proposed the provision of $263 million to match state funding for police BWC systems as part of his Strengthening Community Policing initiative, with the goal of deploying 50,000 devices in three years.[46] The report specifically cites the events in Ferguson, Missouri as evidence of the need for "trust between law enforcement agencies and the people they protect." Many local governments have leapt to take advantage of these funds as a way of addressing the growing distrust of law enforcement, frequently in reaction to local tragedy. For instance, four days after video evidence surfaced in North Carolina showing Officer Michael Slager tampering with evidence after the 2015 fatal shooting of Walter Scott, Charleston Mayor Keith Summey announced that he had ordered 150 BWCs, enough to equip every officer in the city police department.[47] Within two months, the Charleson Police Department had deployed 42 cameras as a pilot test.[48] This is evidence that the adoption of BWC seems to be following a similar script to that of CCTV and DashCams; one or more high profile, nationwide tragedies result in quick adoption of a large-scale technological solution involving greater documentation.

Due to the similarities between DashCams and BWC in context of use and intended outcomes, the Police Executive Research Forum (PERF) predicts that use of BWCs by law enforcement agencies is undoubtedly a growing trend and may soon be as widely deployed as DashCam systems. Chief Parker of the Dalton Police Department (GA), interviewed in PERF's report, echoed this assessment: "Although body-worn

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[46] The White House. *FACT SHEET: Strengthening Community Policing*.

[47] Fantz, Ashley and Yan, Holly. (2015). "Dash cam video shows the moments before South Carolina police shooting." CNN. Retrieved from http://www.cnn.com/2015/04/09/us/south-carolina-police-shooting/.

[48] Knapp, Andrew. (2015, June 03). "In initial deployment, Charleston police start using 42 body-worn cameras." *The Post and Courier*. Retrieved from http://www.postandcourier.com/article/20150603/PC16/150609765.

cameras are just one tool, the quality of information that they can capture is unsurpassed. With sound policy and guidance, their evidentiary value definitely outweighs any drawbacks."[49]

Yet, as Michael White argues in his 2013 survey of current BWC research, "there have been few balanced discussions of the merits and drawbacks of police officer body-worn cameras and even fewer empirical studies of the technology in the field."[50] The first full-scale study on use of BWCs by law enforcement occurred in 2007 in the UK. The Home Office report identified an increase in evidential quality as the most significant advantage that BWCs offered law enforcement agencies, particularly in providing the capacity to capture the details justifying use of force.[51] It also reported a reduction in the "level" of hostility when officers equipped with BWC confronted subjects. The report claims that BWCs "can have a greater impact than street CCTV or vehicle-borne cameras as they can be deployed at any position within the incident."[52] In the US, three separate law enforcement agencies conducted foundational empirical studies during 2013 (Rialto, CA; Mesa, AZ; and Phoenix, AZ).[53] A study in Rialto, CA, found that shifts equipped with BWCs experienced half as many incidents of use of force, and complaints against officers dropped from 28 in the previous year to 3 during the year-long pilot.[54] A study in Mesa, AZ found that there was a 48% reduction in citizen complaints against officers equipped with cameras, and a 75% decline in complaints for excessive use of force.[55]

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[49] Ibid. (9).
[50] White. "Police Officer Body-Worn Cameras." (13).
[51] Home Office. (2007). "Guidance for the Police Use of Body-Worn Video Devices." Police and Crime Standards Directorate. (7).
[52] Ibid. (8).
[53] White. "Police Officer Body-Worn Cameras." (5).
[54] Farrar, Tony. "Self-Awareness to Being Watched."
[55] MPD (Mesa Police Department). (2013). "On-Officer Body Camera System."

Finally, a study in Phoenix, AZ argues that BWC have a "civilizing effect" on both officers and the public.[56] These findings, however, have significant methodological limitations, and White argues, "The absence of rigorous, independent studies using experimental methods has limited understanding of the impact and consequences of body-worn cameras."[57]

Research on the outcomes of equipping LEOs with BWC has been on the rise since the announcement of President Obama's Strengthening Community Policing initiative. A research survey conducted by Cynthia Lum et al. identified 12 empirical studies and 30 ongoing research projects as of early 2015.[58] Many of these studies replicate previous studies conducted by in Rialto and Phoenix. The survey concluded that the dramatic rise of interest in researching the impacts of BWCs is unprecedented: "the rapid response to research needs due to the deployment of this technology appears to be unmatched, historically. For example, despite the rapid adoption of license plate readers in policing since around 2009, this technology has still not produced a similar research response."[59] According to Lum et al, the current focus of research is trending toward

- Impact of BWCs on officer behavior
- Officer attitudes about BWCs
- Impact of BWCs on citizen behavior
- Citizen and community attitudes about BWCs
- Impact of BWCs on both criminal and internal investigations
- Impact of BWCs on police organizations
- Examination of national prevalence and use of BWCs[60]

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[56] Smart Policing. (2012). "Measuring Impacts of Police-Body Worn Cameras." Retrieved from http://www.smartpolicinginitiative.com/SPIsites/phoenix-arizona.
[57] White. "Police Officer Body-Worn Cameras." (16).
[58] Lum, et al. "Existing and Ongoing BodyWorn Camera Research." (8).
[59] Ibid. (10).
[60] Ibid. (12).

Preliminary findings from this research suggest that officers do not necessarily have negative attitudes regarding BWC implementations and BWCs may reduce excessive force complaints. Results that suggest arrest activity actually increases for officers wearing BWCs,[61] and that while stop and frisks decrease, citations increase complicate these findings, however.[62]

The increased call for equipping law enforcement officers with BWCs has raised concerns over privacy and confidentiality. For instance, since BWC footage can result in intimate details of an officer's interactions with the public and can result in capture of non-public environments (e.g. private citizen's homes). Law enforcement agencies have expressed concern that the invasive nature of BWCs could potentially discourage reports of domestic abuse or diminish the effectiveness of police informants, in both cases endangering those captured in the video.[63] Given the sensitive nature of these records, the ACLU advocates short retention periods "measured in weeks, not years."[64] The ACLU's position originates from the concern that the longer non-evidentiary video is retained, the greater likelihood that video will be used for secondary purposes that are outside the scope of the original capture. According to the ACLU, the primary concern is that BWC systems "protect the public without becoming yet another system for routine surveillance of the public, and maintain public confidence in the integrity of those privacy

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[61] Katz, C. (2013). No Title. Arizona State University, Phoenix, AZ. Funding Agency: Bureau of Justice Assistance: Smart Policing Initiative.

[62] Ready, J.T. & Young, J.T. (2015). "The impact of on-officer video cameras on police-citizen contacts: Findings from a controlled experiment in Mesa, AZ." *Journal of Experimental Criminology*, 11(3), 445-458.

[63] Police Executive Research Forum. "Implementing a Body Worn Camera Program." (32).

[64] Stanley, J. (2015). "Police Body-Mounted Cameras: With Right Policies in Place, A Win for All." ACLU. Retrieved from https://www.aclu.org/police-body-mounted-cameras-right-policies-place-win-all

protections."[65] However, studying systemic problems (like racial profiling) requires agencies to collect and maintain longitudinal data, increasing necessary retention periods. Agencies will need to balance the need to protect the public's right to privacy against the objective of making incidents of systemic abuses discoverable, ensuring that the policy objectives that motivated the implementation of a BWC system are still achieved.

Who precisely should have access to video records captured by BWC is also an open question. Law enforcement agencies have indicated BWC footage offers advantages to officers when completing end of shift reports, particularly as video evidence can corroborate and verify details in the report.[66] The ACLU, however, argues that allowing officers to view BWC video prior to shift reports may provide opportunity for tampering or misrepresentation in the officer's report.[67] Additionally, to what extent the public has access to BWC videos is still under scrutiny. Agencies that have implemented BWC pilots have found that allowing public citizens to view BWC footage prior to making a excessive force complaint has reduced the number of complaints filed.[68] Whether BWC footage is a public record discoverable by public record requests by those not present in the video depends on the statutes and record retention policies of each state. Some states have explicit policies in place for DashCam records that states could expand to include BWC records. Generally, non-evidentiary video captured by BWCs is of greater concern because states expressly define the policies for retaining and disposing of evidentiary records r criminal proceedings. For those states without explicit definition of non-evidentiary video, however, to what extent BWC video is discoverable may depend on

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[65] Ibid. (2).
[66] Police Executive Research Forum. "Implementing a Body Worn Camera Program." (33).
[67] Stanley. "Police Body-Mounted Cameras: With Right Policies in Place, A Win for All." (5).
[68] Police Executive Research Forum. "Implementing a Body Worn Camera Program." (43).

whether the governing agency classifies it as an administrative record or part of the officer's personnel file. For instance, North Carolina's public records law allows, but does not require, law enforcement agencies to withhold most law enforcement records from the public, and records gathered by a government agency regarding its employees are confidential.[69] Frayda Bluestein, Professor at UNC School of Government, illustrates the tensions that document classification has on classification of BWC videos: "Ironically, the content that is most desired – evidence of officer behavior – is the very content the law enforcement agency has the least authority to release."[70]

Officer discretion is another policy that theoretically influences the amount of data generated by these systems. In its recommendations, the ACLU asserts that "policies and technology must be designed to ensure that police cannot edit on the fly (i.e., choose which encounters to record with limitless discretion)."[71] The ACLU asserts that allowing police the freedom to turn cameras off for any reason grants them editorial rights over the record, reducing the benefit of BWC as a check on police behavior. The ACLU further advocates that recording should be continuous to limit the opportunity for officers to alter the record to suit their own purposes maliciously. Continuous capture, however, is a prohibitively outlandish policy. With a million sworn officers in the United States, continuous capture would produce approximately 40 million hours of video every week. Such a policy would convert officers into walking CCTV cameras, vastly increasing the amount of non-evidential and non-relevant footage. This removes many of the benefits that DashCam and BWC systems have over their CCTV counterparts (e.g. discrete

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[69] Bluestein, Frayda. (2015). "How Public Are Law Enforcement Vehicle or Body Camera Videos? (Not Very, in North Carolina.)." Retrieved from http://canons.sog.unc.edu/?p=7856.
[70] Ibid.
[71] Stanley. "Police Body-Mounted Cameras: With Right Policies in Place, A Win for All." (5).

capture of evidence accompanying official actions). Furthermore, proper annotation and categorization of a continuous feed video (assuming no demarcations) would significantly increase the labor required by law enforcement agencies to submit video files into the official records. Advances in automatic metadata creation (such as geolocation, context detection, etc.) may increase the feasibility of continuous feed policies. In the absence of these advances, manual intervention is required to segment video into meaningful sections adequately. A pilot program in the UK that studied continuous feed policies found that officers had developed a useful manual annotation method called "bookmarking," where officers turned cameras off and then back on quickly to indicate an event of interest.[72] It would be difficult to ensure that all officers practiced such a method uniformly, however, since it relies on human intervention and discretionary judgement. As discussed previously, there are situations (domestic violence victims and police informants) where recording interactions between an officer and the public are inappropriate. Also, members of the public may not wish to be recorded, and many states require two-party consent for electronic recording.[73] Law enforcement agencies will need to define how much discretion officers should have in the course of fulfilling their duties on a case-by-case basis as dictated by the legal context of state and local law, making a uniform discretionary policy across the US unlikely.

Examination of how law enforcement policies governing the use of BWC affects the privacy rights of the public is an area that requires more empirical study.[74] If empirical studies on the impacts of BWC on privacy are not yet conclusive, however,

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[72] The Body Worn Video Steering Group. (2013). "The Body Worn Video Steering Group guide to implementing a large scale Body Worn Video programme." (16).
[73] Stanley. "Police Body-Mounted Cameras: With Right Policies in Place, A Win for All." (8).
[74] White. "Police Officer Body-Worn Cameras." (30).

reliable estimates of its impact on IT resources are nonexistent. One of the greatest concerns law enforcement agencies have when considering implementation of a BWC program is its resource and logistical challenges.[75] While direct costs of cameras (currently $800 - $1000 per camera) are easy to calculate, the costs of data storage and information management have proven far more difficult to estimate.[76] Data management costs include the labor required to upload, categorize, review, and retrieve video, as well as the adherence to proper retention protocols for disposition of the videos at the end of their retention period. Video containing sensitive material may need redaction or splicing before distribution of requesting parties, posing significant costs to agencies. The cost of data storage is impacted by how many videos are produced, how long videos are kept, and where the videos are stored, while data management costs are impacted by aggregate number of videos produced and frequency of video requests.

2.4 Estimating the Amount of Data BWC Systems Produce

Pilot studies have demonstrated that BWC programs produce an enormous amount of video data that law enforcement agencies must manage in a secure and easily accessed repository. Chief Miller of Greensboro Police Department (NC) reported that "with 500 officers using cameras, we have already produced over 40,000 videos in just seven months," while one formula suggested that 250 officers would produce 2.3 million files in a 3 year span.[77] Increasing the number of videos stored significantly increases the probability of a public records request, which in turn significantly increases the chances that law enforcement agencies must scrub videos of information pertaining to active

[75] Ibid.
[76] Police Executive Research Forum. "Implementing a Body Worn Camera Program." (32).
[77] Ibid.

federal or state criminal cases, personal biographical information, juvenile faces, undercover officers, informants, nudity and other sensitive information. The 2013 Mesa Arizona study found that while only three public record requests required redaction services during the month-long pilot, the labor demands for administrative review and subsequent redaction were considerable. Each case of redaction required approximately 10 hours of video editing to complete; participants found that even a mild expansion of BWC deployment would require careful management of resources.[78]

Further, complicating issues, estimates for the average number of videos produced per officer, and the file size and video length of the video captured vary wildly, preventing anything but crude projections. One report from the UK estimated that the average total length of video captured per officer per shift is just 20 min.[79] Some calculations suggest officers produce on average a mere 1.5 videos per shift while a 90-day, 18-camera pilot in Phoenix, AZ produced 2300 files and 860 hours of video, doubling the UK estimate.[80] Number of videos, length of videos and file size are difficult to compare and do not produce reliable estimates for law enforcement agencies wishing to calculate the overall impact that implementing a BWC program would have on IT resources.

One explanation for the range in estimations is the difference in policies. Three key policy points significantly influence demand for IT resources: 1) what is the established retention period for non-evidential videos, 2) do officers have discretion or are they obligated to record citizen interactions, and 3) were the officers equipped with

[78] MPD (Mesa Police Department). "On-Officer Body Camera System."
[79] The Body Worn Video Steering Group. "The Body Worn Video Steering Group guide." (12).
[80] Lovell, Steve. (2013). "Body-Worn (Video) Evidence." Evidence Technology Magazine.

BWCs assigned or recruited voluntarily. PERF has found that policies range significantly. While most agencies have adopted a one-month retention period for non-evidentiary videos—evidentiary material typically has a retention period prescribed by law—some are proposing six-month or one-year periods, and the Oakland (CA) Police Department is currently storing all BWC videos indefinitely.[81] In another example, the pilot study conducted in Mesa, AZ produced 2327 video files in the first six months of its pilot in which it required officers to record all interactions with citizens, but the number of videos declined by 42% in the next six months when the policy changed to allow for officer discretion.[82] Notwithstanding the criticism that a 42% decline in videos may be counterproductive to the aims of increasing officer accountability and agency transparency, this demonstrates that policy choices can have tremendous impacts on the burdens of data management. While current research suggests that LEOs are far more receptive to BWC implementation than originally theorized, it is natural to hypothesize that the way law enforcement agencies select which officers to participate in programs (voluntary or required participation) will affect adoption rates and subsequently impact the amount of video produced.

Estimates of the number of videos, length of videos, and file sizes for BWC systems are difficult to compare and do not by themselves produce reliable estimates for law enforcement agencies wishing to calculate the overall impact that implementing a BWC program would have on IT resources. White argues, "Independent research on body-worn camera technology is urgently needed" because "most of the claims made by

[81] Police Executive Research Forum. "Implementing a Body Worn Camera Program." (33).
[82] White. "Police Officer Body-Worn Cameras." (31).

advocates and critics of the technology remain untested."[83] PERF warns, "Once an agency travels down the road of deploying body-worn cameras, it will be difficult to reverse course because the public will come to expect the availability of video records."[84] It is imperative that research establish the full scope of the demand on resources that BWC programs might incur before establishing the expectation that BWC programs be deployed ubiquitously.

[83] Ibid. (37).
[84] Police Executive Research Forum. "Implementing a Body Worn Camera Program." (51).

3.0 METHODOLOGY

This study used a quantitative, cross-sectional survey design targeting municipal and county law enforcement agencies in the United States that have piloted or implemented BWC and/or DashCam systems.

3.1 Research Questions

This research focused on the following questions:

- *Q1: What are the anticipated data production statistics (number of files, gigabytes, and length of video produced) for Body Worn Camera and DashCam systems per officer, per month for municipal and county law enforcement agencies?*
- *Q2: Can existing DashCam systems be used as a surrogate to estimate the data production statistics established in Q1 for municipal and county law enforcement agencies that have not yet deployed a Body Worn Camera program?*
- *Q3: Do policy decisions (e.g. voluntary vs. mandatory assignment of cameras, officer discretion to turn off cameras, public's notification of active camera, or retention periods) for Body Worn Camera / DashCam programs have an impact the data production statistics established in Q1?*

The primary aim (Q1) of this study was to obtain descriptive statistics for the number of files, gigabytes and hours produced per officer in a month-long period and to identify differences between BWC and DashCam systems. Assuming data production statistics for BWC and DashCam systems are similar, a municipal or county law enforcement agency could use an existing DashCam system to estimate the data production when deploying a new BWC program (Q2). These objectives make cross-

sectional design an optimal research method because the study's "emphasis in analysis is to examine the frequency distributions of single variables and the associations between two or more variables" at a specific point in time.[85] Since all variables were discrete numerical or nominal values, qualitative methods were unnecessary.

The secondary aim of the study (Q3) was to identify policy choices that may indirectly influence these video production statistics. While cross-sectional studies are effective for gathering the broad descriptive statistics necessary for this study, they are not effective instruments for demonstrating causal relationships.[86] The study design does allow, however, for detection of significant correlations, but the limitations of cross-sectional design mean that the results cannot make direct causal conclusions and generalizability may be suspect.[87] Instead, policies that demonstrate a significant correlation will help build the case for future experimental studies that can identify the causal connections between policies and production statistics (e.g. officer discretion, length of retention period, and voluntary vs. non-voluntary participation).

3.2 Study Population and Sample Frame

The study population was municipal and county law enforcement agencies in the United States who have piloted or implemented BWC and/or DashCam systems. The study did not include State, Federal and University agencies in the population since its goal is to describe the impacts that such programs have on local government agencies.

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[85] Bourque, Linda B. "Cross-Sectional Design." (2004). In *The SAGE Encyclopedia of Social Science Research Methods*, edited by Michael S. Lewis-Beck, Alan Bryman and Tim Futing Liao, 230-31. Thousand Oaks, CA: Sage Publications, Inc.

[86] Hall, John. (2008). "Cross-Sectional Survey Design." In *Encyclopedia of Survey Research Methods*, edited by Paul J. Lavrakas, 173-74. Thousand Oaks, CA: Sage Publications, Inc., 2008.

[87] Bynner, John. (2006). "CROSS-SECTIONAL SURVEY." In *The SAGE Dictionary of Social Research Methods*, edited by Victor Jupp, 53-55. London, England: SAGE Publications, Ltd.

State, Federal and University often have far more resources available than local governments and operate in distinctly different contexts. It is worth noting that while the survey recruitment population is municipal and county law enforcement agencies, the unit of analysis for the study is camera programs (either BWC or DashCam); a single law enforcement agency, therefore, could contribute from zero to two camera system observations to the study. While the number of law enforcement agencies electing to equip officers with BWC systems is on the rise, implementation is still rare in the entire population. In addition, while implementation of DashCam systems is far more widespread, they are more common in larger agencies.[88]

These facts present several challenges for data collection. First, since no comprehensive list of law enforcement agencies who have implemented BWC and/or DashCam programs is available, construction of a randomized sample is not possible. Furthermore, since BWC programs are an increasing but rare phenomena, a broad distribution of the survey instrument to all law enforcement agencies was unlikely to return enough valid BWC system observations to derive meaningful results. PERF's 2014 BWC study estimated that of 254 responding law enforcement agencies, only 25% (n=64) indicated they had piloted/implemented a BWC program.[89] Additionally, given the sensitive nature of topics surrounding BWC records, I expected survey participation to be low. For these reasons, the study adopted a non-probabilistic, non-proportional quota sample. This increased the chances of gathering a sufficient number of camera system observations for both camera systems and provided the ability to target agencies with known BWC programs.

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[88] International Association of Chiefs of Police. "Impact of Video Evidence." (10).
[89] Police Executive Research Forum. "Implementing a Body Worn Camera Program." (2).

Since one of the aims of the study was to compare the video production statistics between camera systems (Q2), it was important that both systems were represented adequately. A proportional quota sample was both unnecessary and impossible to determine since the proportion of BWC programs to DashCam programs is unknown. As Daniel (2012) explains, quota sampling offers several benefits, allowing for the "inclusion of stratification features in quota sampling thereby enhancing the representation of the sample and the ability to compare subgroups in the population."[90] Quota sampling ensures the inclusion of required subpopulations, introduces stratification into the sampling process, and reduces data collector error.[91]

3.3 Addressing Selection Bias

Adopting a non-probabilistic sample, however, limits the ability to calculate sampling error and increases the chance of selection bias.[92] Law enforcement agencies were recruited for participation in the study using two methods, each targeting a different segment of the population. First, the study distributed electronic surveys on three different professional electronic mailing lists in the state of North Carolina: NCACP (North Carolina Association of Chiefs of Police), NCGLISA (North Carolina Local Government Information Systems Association), and the UNC School of Government's electronic mailing list of City and County managers. Between these three electronic mailing lists, all 382 North Carolina local law enforcement agencies had an opportunity to participate in the study. Thus, law enforcement agencies included in this study have a

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[90] Daniel, Johnnie. (2012). "Chapter 4: Choosing the Type of Nonprobability Sampling." In *Sampling Essentials: Practical Guidelines for Making Sampling Choices*, 81-125. Thousand Oaks, CA: SAGE Publications, Inc.
[91] Ibid. (88).
[92] Lohr, S. L. (2010). Sampling: Design and Analysis. Second Edition. Boston: Brooks/Cole.

significant geographical bias toward North Carolina. The second method of survey distribution was through targeted direct emails to agencies throughout the United States that appeared in news articles reporting participation in BWC programs. The study also gathered candidate agencies from the Police Executive Research Forum's participant list for the 2013 BWC Conference.[93]

Using three different electronic mailing lists for survey recruitment was a method of handling the problem of whom to target in communication. The most appropriate person in the agency to complete the survey was an IT data custodian or program manager with access to the storage database system. The decision to participate in the study, however, was an executive prerogative, typically approved by the Chief of Police or County Sheriff. In some cases, these executives opted to complete the surveys rather than passing it along to those with more direct expertise. To avoid the potentially serious ramifications for the quality of data analysis, the study made efforts to contact IT professionals, law enforcement executives, and town and county government executives, making multiple stakeholders aware of the survey's purpose, and hopefully increasing the likelihood of the survey being passed along through the proper channels.

The purpose of recruiting participants heavily in NC is, in part, a factor of convenience. Since the UNC School of Government is well connected with the state's local governments, broad participation from NC local governments was expected. A major risk of surveying only North Carolina law enforcement agencies, however, was that an adequate number of BWC system observations would be unavailable. Additionally, it is unclear if results derived from North Carolina agencies would be

[93] Police Executive Research Forum. "Implementing a Body Worn Camera Program." (69).

generalizable to the rest of the US. To curb these risks, the study supplemented responses from law enforcement agencies from around the US known to be associated with BWC pilots/programs from newspaper articles or other sources. This intentional targeting, however, introduces other biases into the sample, specifically increasing the likelihood that agencies known to have BWC programs are overrepresented in the results. Additionally, the data may also suffer from self-selection bias since agencies interested in BWC programs may have been more likely to participate.

Despite these limitations and considering the lack of information available on this topic, the chosen sample significantly increased the feasibility of the study and reduces some of the selection bias that a pure convenience sample would create. Since all local governments within North Carolina had an opportunity to participate in the study, some statistics for the entire population of NC could be calculated. Comparisons between BWC programs and DashCam systems in NC might demonstrate additional evidence that the two systems are similar without the selection bias created by targeting specific known BWC systems in the second method. Finally, collecting camera system observations from both inside and outside NC allows the study to compare the populations with one another, and by extension assess if the results for the NC population might be generalizable to the whole. To assess the risks of selection bias and determine if results from North Carolina population are generalizable to the whole of the US, I conducted a two tailed T-test between the results gathered from both systems and both geographic regions. Even with these caveats, since BWC systems are so new, any statistically sound predictors will be beneficial to law enforcement agencies considering their implementation.

3.4 Survey Instrument

The study collected data on the BWC and/or DashCam programs using an electronic survey instrument (see Appendix 1). The survey instrument consisted of closed-ended questions that asked the IT data custodian or program manager to provide discrete numerical estimations for the number of files, gigabytes and hours produced by the program in a typical month. Since not all data storage systems are readily query-able, a "typical month" was left to the discretion of the respondent to decrease the difficulty of making estimations. Participants were also asked to provide programmatic information like the number of information requests per month, the number of officers equipped with cameras, the number of cameras, the number of duty officers employed and length of the program. Close-ended multiple choice questions also collected information on the agency's policies for officer discretion, voluntary or mandatory assignment, the retention period for captured videos, video redaction policies, and officer access to video files.

The survey instrument included 45 questions in three sections: BWC questions, DashCam questions, and Agency questions. The electronic survey form allowed participants to skip sections if, for instance, the agency did not have a BWC program, and allowed agencies to upload official policy documents if available. Agencies were also able to request the findings of the study as an incentive to participate.

3.5 Data Analysis

This study used a univariate linear regression model to predict each data production statistic (number of files, hours of video, and gigabytes produced in month-long period by the agency) as the dependent variable against the number of officers participating in the camera program as the independent variable. With this model, law

enforcement agencies could use the results to estimate data production for all three facets on a per-officer basis. In order to detect reasonable-size effects with reasonable power in a univariate/multivariate linear regression, a purposeful sample of at least 20 valid camera system observations were required for each camera system, thus ensuring a meaningful representation of both segments.[94] Since each law enforcement agency could have one, both, or neither system type, it was anticipated that the number of agencies surveyed would need to be significantly larger than 20; achieving more than 20 valid observations for each system would only improve the accuracy of the regression analysis. I also assumed that BWC system observations would be more difficult to obtain than DashCam system observations because of the prevalence of DashCam systems and the relative novelty of BWC systems.

Upon reaching the valid quotas for both BWC and DashCam systems, the survey results were broken apart into separate system observations and coded. The responses for each camera system reported by an agency were combined into a single data set of observed systems. Descriptive statistics of results were generated and analyzed for all questions. Then, answers to data production questions (i.e. questions collecting estimates of files, gigabytes, and hours of video produced in a typical month) were normalized against the number of officers participating in the camera program, allowing comparisons across agencies. T-tests were run against the distributions of each sub-segment (NC vs Non-NC, Small vs Large size of force, and BWC vs DashCam systems) to assess if differences between the segment means were statistically significant. Subsequently, the three video production estimations were examined through univariate linear regressions

[94] Harrell, F. E. (2001). *Regression modeling strategies: With applications to linear models, logistic regression, and survival analysis*. New York: Springer.

using the number of officers equipped with cameras as the independent variable; statistical significance was assessed for all results. Finally, T-tests were run to identify if the policies examined within the survey instrument (e.g. officer discretion, length of retention period, and voluntary vs. non-voluntary participation) may have significantly affected data production statistics.

3.6 Ethical Considerations

Participation in the study was voluntary, and despite the sensitive nature of the materials, no survey questions requested any information that would not otherwise be provided in a normal information request. Some candidates, however, still expressed reluctance to complete the survey due to the sensitive nature of the materials and/or due to a misunderstanding of how someone would use the data storage system to answer the questions without actually accessing the files themselves. This latent reluctance could have resulted in biased results since there is no way to assess how many agencies did not complete/respond to the survey out of this concern. All questions were posed as simple factual inquiries (i.e. “What is the total size (in gigabytes) of video data produced in a typical month,” or “Can officers view video prior to testifying in court or responding to a citizen complaint?”) and required no personal opinions or judgments. All emails to and from agencies were/are a matter of public record and not subject to confidentiality. All responses were sanitized and identifying information removed from data sets prior to analysis.

4.0 RESULTS

4.1 Survey Responses

Data collection began on January 8, 2015 and terminated five months later on June 8, 2015. All 384 municipal and county law enforcement agencies in North Carolina had an opportunity to participate in the study through the three North Carolina electronic mailing lists used to distribute the survey. I invited 120 law enforcement agencies outside of North Carolina to participate through direct email. Responding agencies were located throughout the United States (see Figure 1). Due to the survey design, the two groups (NC and Non-NC) differ in one significant factor. It was unknown whether agencies

Figure 1

Map of Agencies Responding to Survey

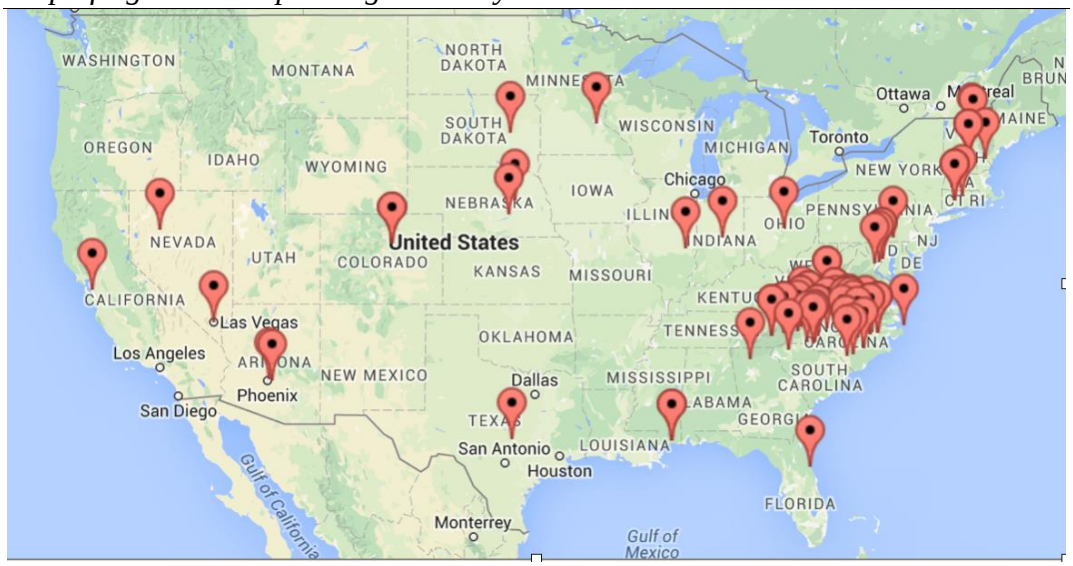


Table 1

Agency Survey Responses by Location

	NC Agencies	Non-NC Agencies	All Agencies
Surveys Distributed	384	120	504
Surveys Completed	34	42	76
Dropouts	13	43	56
Declined to Participate	17	14	31
Response Rate*	8.9%	35.0%	15.1%
Dropout Rate**	20.3%	43.4%	34.4%

Note. * The percentage of surveys completed out of total number of surveys distributed
** The percentage of total survey dropouts and declines out of total number of agencies submitting any response

within North Carolina had existing camera systems, but law enforcement agencies outside of North Carolina were invited to participate based on indications of an existing BWC program (i.e. media articles or participation in PERF's 2014 study).[95]

Given my existing relationship through the UNC's School of Government, it was expected that North Carolina agencies would have a higher participation rate than those outside of the state. This is because the School of Government collaborates with the North Carolina municipal and county governments frequently. Conversely, response rates for those agencies outside of North Carolina were expected to be increased by the fact that all agencies surveyed in that group either had existing or were considering implementation of BWC a program. The overall response rate to the survey was 15.1% with 76 agencies participating (see Table 1). The dropout rate for the survey was higher than anticipated at 34.4%. Several factors contributed to these results.

[95] Police Executive Research Forum. "Implementing a Body Worn Camera Program."

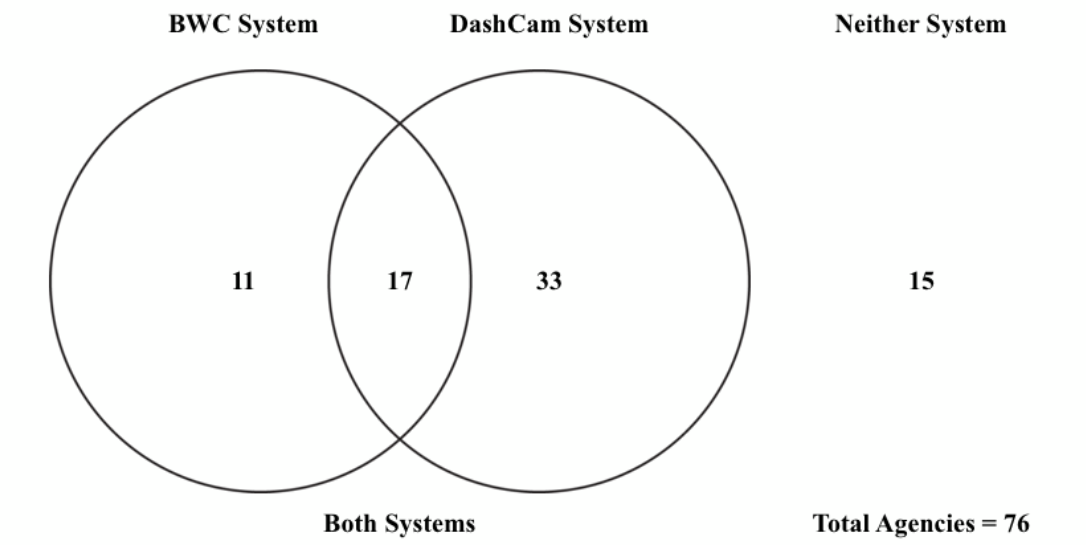
First, the survey instrument required the respondent to be familiar with the average amount of data produced for a typical month, and the initial recipient of the email invitation was not always capable of answering all questions. In several cases, Police Chiefs or Sheriffs emailed me personally to tell me they had started the survey, making assurances that they had passed it along to someone capable of completing it accurately. Additionally, many respondents stopped filling out the survey upon reaching questions that required querying their storage systems (e.g. "How many hours of BWC video does your agency produce in a typical month?"). Follow-up interviews revealed that many respondents started the survey away from work and forgot to resume the survey at a later time. Through follow-up interviews conducted from March through June 2015, I was able to reduce the dropout rate by about fifty percent.

Second, this survey revealed that many law enforcement agencies (particularly smaller county agencies) have neither BWC nor DashCam programs. Follow-ups revealed that several agencies that started the survey stopped upon realizing that the survey instrument was asking detailed questions about systems the agency had not deployed. Surprisingly, 20% (n=15) of agencies responding reported they had neither deployed nor piloted either system (see Figure 2), but it is possible that a large proportion of the drop rate is a result of this factor. While 17 agencies reported having both BWC and DashCam systems, the fact that 11 agencies reported piloting or implementing a BWC system without a pre-existing DashCam system was surprising.

Finally, 31 law enforcement agencies opted out of the survey, emailing me personally outside of the collected survey responses. 25% (n=8) of those declining to participate in the study cited that it was because the agency had neither camera system.

Figure 2

Distribution of BWC and DashCam Systems Among Responding Agencies



Note: The total number of agencies participating in the study was 76. Responding agencies could have between 0 and 2 camera systems. The figure above illustrates this breakdown. This figure does not include agencies that dropped out or declined to participate in the study.

The remaining 75% (n=23) cited the sensitive nature of BWC records as a reason not to fulfill the request. With the increased scrutiny on BWC and the often-undefined status of BWC records, agencies are reluctant to share information even if the information requested is for aggregated counts. This is particularly the case when public records law provides clear exemptions for police records, as it does in North Carolina. For these reasons, the results of this study should not be used to as an indication of how widespread BWC or DashCam usage is among municipal and county law enforcement agencies in the US. The intentional targeting of agencies that have deployed BWC systems coupled with the nonresponse bias discussed above preclude any such analysis.

Since each response from the 76 responding law enforcement agencies could potentially capture data from zero to two camera systems, the data consists of 152

Table 2

BWC and DashCam Program Distribution by Location

		NC Agencies	Non-NC Agencies	All Agencies
Agencies Responding		34	42	76
Valid Camera System Observations	BWC	31% (13)	42% (15)	36% (28)
	DashCam	69% (29)	58% (21)	64% (50)
	Total	42	36	78

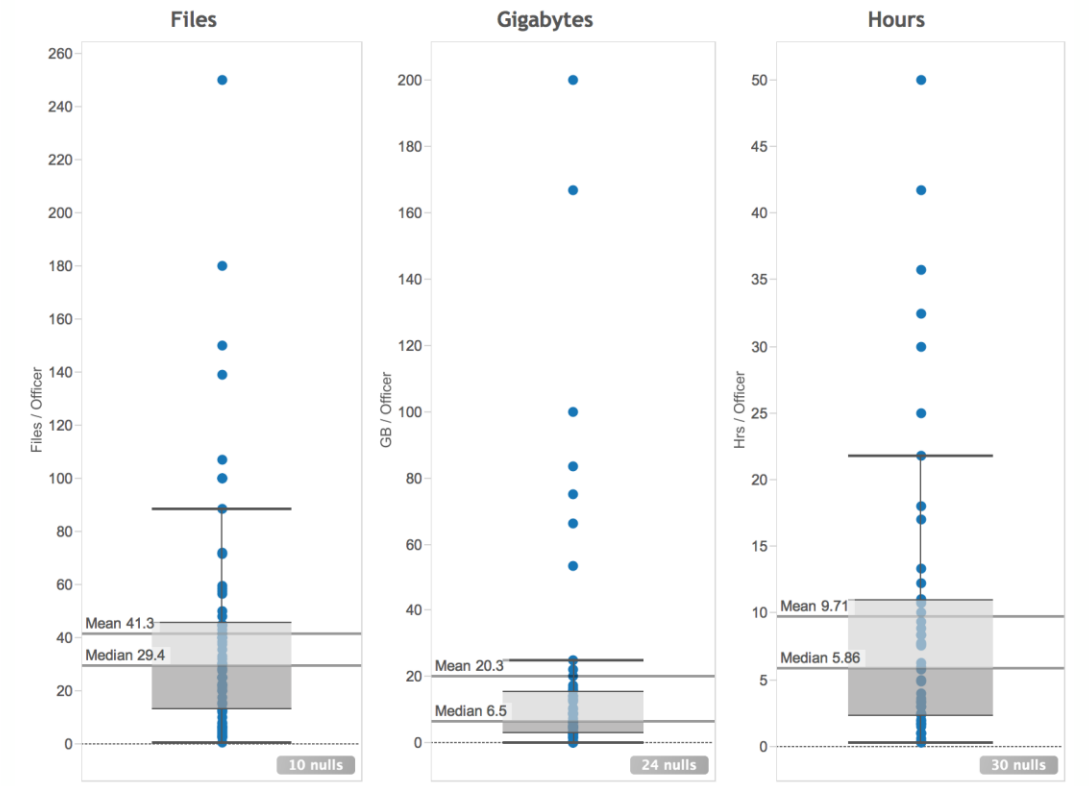
possible camera system observations. Many agencies, however, indicated they had not implemented or piloted one or both systems. Of the possible responses, 78 valid camera system observations exist in the final data set: 28 BWC and 50 DashCam (see Table 2). As expected, due to the quota sampling method adopted, the percentage of agencies reporting BWC programs from Non-NC agencies (42%, n=15) was higher than the percentage of BWC programs reported in NC (31%, n=13). Given their use in the public sector for more than 20 years and their immense utility for law enforcement agencies, it was assumed that DashCam systems would be deployed nearly universally. Surprisingly, however, DashCam system deployments were not as widespread as assumed, with only 64% (n=50) of all agencies reporting these systems were in use. The actual percentage of DashCam system deployments is probably much lower since there is likely a high self-selection bias for participating agencies (i.e. agencies without either system would be much less likely to respond to the survey).

4.2 Descriptive Statistics for Files, Gigabytes, and Hours produced per officer

The survey instrument asked agencies to provide estimations of the amount of files, gigabytes, and hours produced for each system by the agency in a typical month.

Figure 3

Distribution of Data Production Statistics (Files, Gigabytes, Hours) produced per Officer by Agencies in a Typical Month



Note. For all charts, the number of possible camera system observations is 78.

Agencies also indicated how many officers participated in the program. In order to compare agencies of different sizes to one another, I normalized the estimations reported by the agencies by the number of officers equipped with cameras for each camera system observation. An agency with ten officers will produce a very different amount of data per month than an agency with one hundred officers, so normalizing agency estimations on a per officer basis was required to calculate distributions (see Figure 3). The mean number of files produced per officer by agencies in a typical month was 41.3 (median=29.4). The mean number of gigabytes produced per officer by agencies in a typical month was 20.3

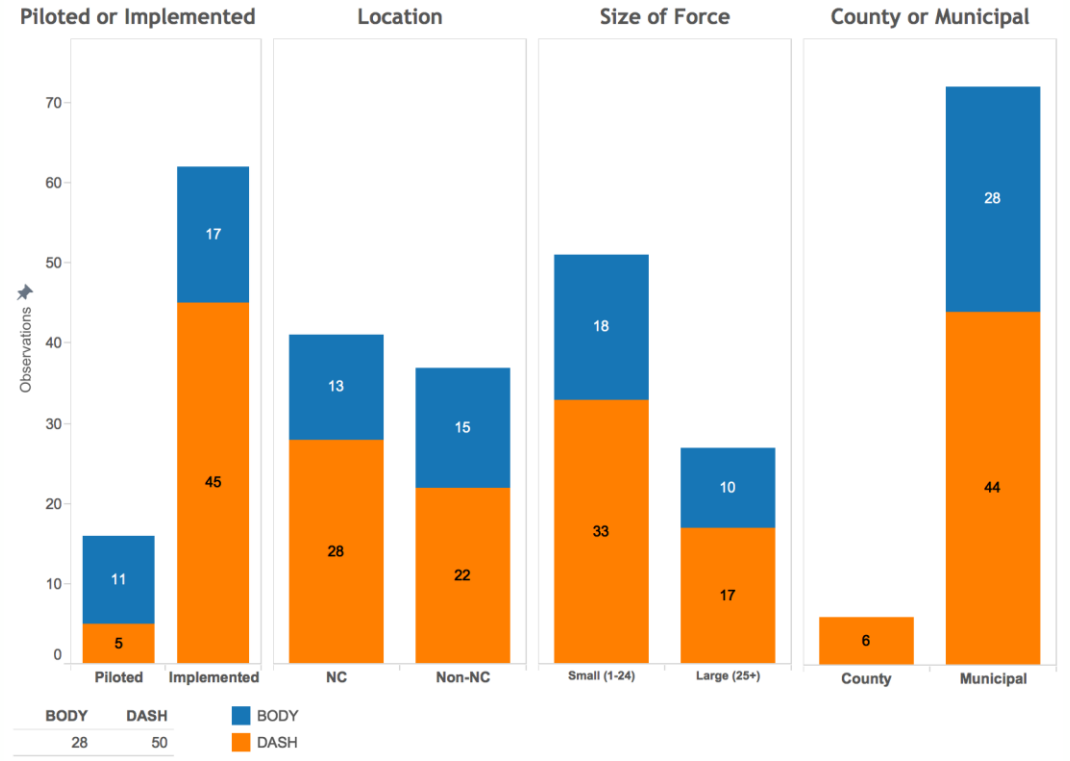
(median=6.5). The mean number of files produced per officer by agencies in a typical month was 9.71 (median=5.86).

The descriptive statistics for agency responses show a number of outliers that may have skewed results. To asses if a particular sub-segment was responsible for outliers, I ran T-tests against all of the following segment pairs: NC agencies vs non-NC agencies, piloted vs fully implemented programs, BWC vs DashCam systems, county vs municipal agencies, and agencies with a small (1-24 officers) vs large (24+ officers) size of force. T-test analysis demonstrates that in all cases, the observed difference between the sample means for each segment pair is not convincing enough to say that the averages differ significantly at $p < .05$ (see Appendix 2). For the purposes of this study, evidence that the segments do not differ significantly is evidence that all camera system observations can be used in the following regression analysis with one important caveat. While segment analysis clearly demonstrates that the differences between the means in the current sample cannot be said to be different with statistical certainty, several of the segment bins contain few camera system observations (e.g. county vs municipal agencies) and therefore the segments cannot be assumed to be the same with an absolute degree of certainty (see Figure 4).

The segmentation analysis does reveal some interesting trends, however. The survey responses were heavily biased toward municipal agencies with only 6 county agencies responding with valid system responses. Additionally, no county agency reported piloting or implementing a BWC system. It was also more likely for a pilot program to be a BWC system than a DashCam system, unsurprising given the recency of BWC technology compared to DashCams. Distribution of systems across agency

Figure 4

Distribution of BWC and DashCam Systems Across Segments



Note. For all charts, the number of possible camera system observations is 78.

locations was similar with 31% of NC agencies reporting a BWC system compared to 40.5% of Non-NC agencies. Similarly, there was little difference in the distribution of systems between agencies with a small (1-24) vs large (25+) size of force. According to the US Department of Justice, most law enforcement agencies in the US are small, with 75% of law enforcement agencies employing fewer than 25 officers.[96] With 65% of camera system observations in this study provided by agencies with fewer than 25 officers, the sample is close to representative of the US population in terms of size of force.

[96] Reaves, B.A. (2008). "Census of State and Local Law Enforcement Agencies, 2008." US Department of Justice. Retrieved from http://www.bjs.gov/content/pub/pdf/csllea08.pdf

4.3 Regression Analysis

While descriptive statistics are informative (see Appendix 4 for histograms), they do not have predictive validity. The core objective of this study (Research Q1) is to provide county and municipal agencies considering the implementation of a BWC system a confident method of estimating how much video it will produce per month based on the number of officers it equips with cameras. Univariate regression analysis of each data production variable provided by agencies found that the number of officers deployed with a given camera system is a strong predictor of the quantity of video produced; the more officers equipped with cameras, the more files, gigabytes, and hours of video are produced (see Appendix 5 for regression plots).

Univariate linear regressions found that all data production statistics reported by responding agencies (files, gigabytes, and hours produces per typical month) could be reliably predicted as a function of the number of officers equipped with cameras by an agency. All regressions were statistically significant at $p<.05$ or lower (see Table 3).

The univariate linear regression for the files produced per month for all systems considered in aggregate examined 68 camera system observations and found that 34.998 files were produced for each officer equipped at a significance of $p<0.001$, explaining 88% of the variance in the data. Similarly constructed regressions run on DashCam systems only (n=42, b=35.559, $p<0.001$, $R^2=.981$) and BWC systems only (n=26, b=32.601,$p<0.001$, $R^2=.521$) generated similar coefficients and significance levels, but the regression for BWC systems explains substantially less of the variance in the number of files produced per month. This can be partially explained by the fact that there are

Table 3

Summary of Univariate Regressions for Number of Officers Equipped with Cameras Predicting Files, Hours, and Gigabytes Produced in a Typical Month by System Segment (All, DashCam only, or BWC only)

		Number of Officers Equipped predicting Files Produced in a Typical Month					
		Coefficient			Model		
Dimension	n	B	SE B	t	f	df	R^2
All Systems	68	34.998	1.546	22.642***	512.7***	66	0.886
DashCam Systems	42	35.559	0.793	44.856***	2012***	40	0.981
BWC Systems	26	32.601	6.381	5.109***	26.1***	24	0.521

		Number of Officers Equipped predicting Hours Produced in a Typical Month					
		Coefficient			Model		
Dimension	n	B	SE B	t	f	df	R^2
All Systems	48	11.1271	0.756	14.712***	216.4***	46	0.825
DashCam Systems	29	11.8772	0.433	27.44***	752.8***	27	0.965
BWC Systems	19	7.149	2.668	2.68*	7.18*	17	0.297

		Number of Officers Equipped predicting Gigabytes Produced in a Typical Month					
		Coefficient			Model		
Dimension	n	B	SE B	t	f	df	R^2
All Systems	54	11.709	1.184	9.887***	97.75***	52	0.653
DashCam Systems	32	12.875	1.508	8.538***	72.9***	30	0.709
BWC Systems	22	4.13	1.363	3.061**	9.37**	20	0.319

Note. * Statistically significant at 0.05, ** Statistically significant at 0.01, *** Statistically significant at 0.001 or lower

fewer BWC system observations than DashCam system observations, and there was greater variance in the number of files produced in a typical month for BWC programs.

The univariate linear regression for the hours produced per month for all systems considered in aggregate examined 48 camera system observations and found that 11.1271 hours were produced for each officer equipped at a significance of $p<0.001$, explaining 82% of the variance in the data. Similarly constructed regressions run on DashCam systems only (n=29, b=11.1271, $p<0.001$, $R^2=.965$) explained marginally more of the

variance in the number of hours produced per month with similar coefficients and significance levels. Similar to the differences found in the regressions conducted on files produced per month, the regression on BWC systems only for hours per month (n=19, b=7.149, $p<0.05$, $R^2=.297$) explains substantially less of the variance in the data. As with number of files produced per month, there are fewer BWC system observations than DashCam system observations, and there is greater variance for hours produced in a typical month than that reported for DashCam systems.

The univariate linear regression for the gigabytes produced per month for all systems considered in aggregate examined 54 camera system observations and found that 11.709 gigabytes were produced for each officer equipped at a significance of $p<0.001$ and explaining 65.3% of the variance in the data. A similarly constructed regression run on DashCam systems only (n=32, b=12.875, $p<0.001$, $R^2=.653$) produced comparable results, however, the regression for BWC systems only (n=22, b=4.13, $p<0.01$, $R^2=.319$) produced a substantially different coefficient and explains only half the variance in the number of gigabytes produced. The reduced R^2 values for all regressions run on gigabytes produced per month as compared to files and hours produced per month indicate that other factors contribute to the variance than the number of officers equipped with cameras.

The lower R^2 values for BWC systems overall indicate that there are more factors involved in BWC deployments than DashCams. This could be, in part, due to the novelty of BWC programs, since DashCam programs have been in effect for much longer; 95% of DashCam systems were reported as being implemented for a year or more, compared to 66% for BWC in a sample biased toward established BWC programs. In addition,

BWC programs are more likely to be pilot programs consisting of limited tests by multiple officers. This environment would significantly skew analysis results. Conversely, established DashCam programs appear to generate less variable outputs, possibly due to more uniform deployment and consistent use requirements across officers.

Despite these limitations, the significance levels for all regressions were lower than 0.05 and regressions for files and hours produced per month explain at least 80% of the variance. These results partially fulfill the objective of Research Q1, providing agencies with a method of estimating files and hours produced by a DashCam or BWC system based on the number of officers intends to equip with cameras.

4.4 Estimating Gigabytes produced per Month per Officer

Of the three video production statistics, gigabytes produced per month had the lowest R^2 values across all three regressions, indicating that other factors beyond number of officers equipped explain the variation in data. One possible explanation for this variation is video capture quality; video sampling rate, resolution and file compression all significantly impact the storage space required for video files, and video resolution in particularly varies widely among BWC and DashCam systems. Controlling for these variables would require a far larger study due to the wide variation in systems deployed by different agencies. As part of the survey, agencies were asked to provide which systems were deployed (see Appendix 3). 17 systems (11 BWC and 6 DashCam) were reported, however, exact descriptions (i.e. which generation of technology) were frequently omitted making a comprehensive study of how the systems chosen affected data production statistics impossible. Agencies were also asked to provide what

resolution and compression rates were used for video captures, however, answers to this question were often omitted or provided incomplete information. An additional complication is that many camera systems currently on the marketplace capture video at variable rates depending on the ambient light conditions. This unanticipated issue made controlling for video resolution infeasible for the scope of this study.

Since regression analysis for hours produced per month produced far higher R^2 values, however, these can be used to reliably calculate storage space required given the assumed video resolution of various systems. Using the regression results for hours produced per month and number of officers equipped for all camera systems (11.1271 hours), Table 4 provides estimates for the number of gigabytes produced per month per officer based on a camera system's video resolution. Using this table, agencies considering implementation of a new system can estimate the amount of gigabytes produced by multiple systems on a per month per officer basis and obtain a more reliable indication of storage requirements.

4.5 Policy Choices of Responding Agencies

Responses to the survey revealed a wide variety of policy choices by agencies deploying BWC and DashCam systems. As discussed in the literature review, retention and storage of the video files produced by the camera systems was a major concern for agencies. With the increase in interest in BWC, a number of third-party vendors have begun providing solutions for storing BWC and DashCam video through cloud-hosted services (like Evidence.com). Despite this trend, 84% of agencies (n=61) reported that all storage of video files were stored by internally maintained servers. One contributing factor for this result could be that agencies with preexisting DashCam are more likely to

Table 4

*Gigabytes per Officer per Month by Video Resolution Assuming Officers Produce 11.1271 Hours Per Month**

Resolution	BWC Systems***	DashCam Systems***	Average GB/HR**	GB/Mo per Officer
640x480	TASER AXON Body/Flex Scorpion Micro DV StalkerVUE MuviView Pro Series	-	0.92	10.24
720x480	-	L3 Flashback II Digital Ally DVM-500 Custom Signals G3 Vision	1.03	11.46
1080x720	-	-	1.67	18.58
1280x720	VIEVU LE3 FirstVu HD iKam Extreme HD MuviView HD Series BodyCam by Provision	WatchGuard 4RE Digital Ally DVM-800	1.83	20.36
1920x1080	Wolfcom 3rd Eye Prima Facie by Safety Vision	Panasonic Arbitrator 360	3.4	37.83

Note. *Actual space taken up may differ due to embedded audio, frame size and aspect ratios.
**Average gigabytes per hour based on tests using MPEG-4 and 30 frames per second benchmarks.
***Many camera systems support multiple resolution capture rates. Systems have been sorted based on maximum capacity.

have established storage infrastructure available that predate advances in cloud technologies. This is supported by the fact that of the 13 camera system observations that reported using third-party storage solutions, 11 were agencies with only BWC programs, and 2 were agencies with both BWC and DashCam programs. All agencies that reported having only DashCam programs managed storage internally instead of using third-party cloud storage.

Although the secondary aim of this study (Research Q3) was to identify what policy points have an impact on the video production statistics discussed above, findings were limited. Since quotas were not set for each policy subgroup, the number of camera

system observations for some of the variable's classes is small. Additionally, due to the non-experimental design of this study, demonstration of causal relationships was not possible. Regardless, T-test analysis can be used to demonstrate significant differences in means for the policy choices and help build the case for future experimental studies that can identify the causal connections between policies and production statistics. The study examined the following policy choices by agencies:

- Officer had either no discretion or some discretion in turning off camera
- Officer required to inform citizen of camera in operation
- Officer allowed to view footage prior to making a shift report
- Officer allowed to view footage prior to responding to complaint and/or testify
- Officer participation in the program was mandatory or voluntary

Analysis revealed only two policies have statistically significant differences in means: 1) the requirement to inform citizens of cameras in operation and 2) allowing officers to view footage prior to making a shift report (see Table 5).

Agencies that did not require officers to inform the public that they were being taped by a BWC or DashCam system (n=60) generated a mean of 43.79 files per month per officer compared to 24.79 files for those agencies (n=12) that did require informing the public ($t=2.1044$, $df=31.775$, $p<0.05$). Differences in means for gigabytes and hours produced per month per officer were not statistically significant, however, for this policy. The large gap in camera system observations, however, indicates that more data should be collected to confirm that this substantial difference holds true generally.

Agencies that allowed officers to view camera footage prior to making a shift report had a substantially higher amount of video data captured. Agencies allowing officers to view footage (n=67) generated a mean of 43.77 files per month per officer compared to 8.42 files for those agencies (n=6) that did not allow officers to view video

(t=-5.4587, df=57.574, p<.0001). Results for this policy also demonstrated a statistically significant difference in means for hours generated per month per officer. Agencies allowing officers to view footage (n=67) generated a mean of 10.10 hours per month per officer compared to 3.17 hours for those agencies (n=6) that did not allow officers to view video (t=-2.5531, df=14.654, p<.05). A difference in the means for gigabytes

Table 5

Results of Two-tailed T-tests by Policy Choices for Files Produced per Month per Officer

	Officer discretion to turn off camera				
	Some Discretion	No Discretion	*t*	*df*	P(T<=t) two-tail
Files produced per officer	33.40 n=46	55.17 n=25	1.59	29	0.121
	Officer must inform citizen of camera				
	Yes	No	*t*	*df*	P(T<=t) two-tail
Files produced per officer	24.79 n=12	43.79 n=60	2.10**	31	0.043
	Officer can view footage prior to report				
	Yes	No	*t*	*df*	P(T<=t) two-tail
Files produced per officer	43.77 n=67	8.42 n=6	-5.45***	57	1.061e-06
	Officer can view footage prior testify				
	Yes	No	*t*	*df*	P(T<=t) two-tail
Files produced per officer	41.33 n=73	0 n=0	NA*	NA	NA
	Officer participation in program				
	Mandatory	Voluntary	*t*	*df*	P(T<=t) two-tail
Files produced per officer	38.24 n=55	49.17 n=18	-0.70	17	0.489

Note. *No agencies prevented officers from viewing footage prior to testifying or responding to citizen complaint. Analysis not available.
** Statistically significant at p<.05.
*** Statistically significant at p<.0001

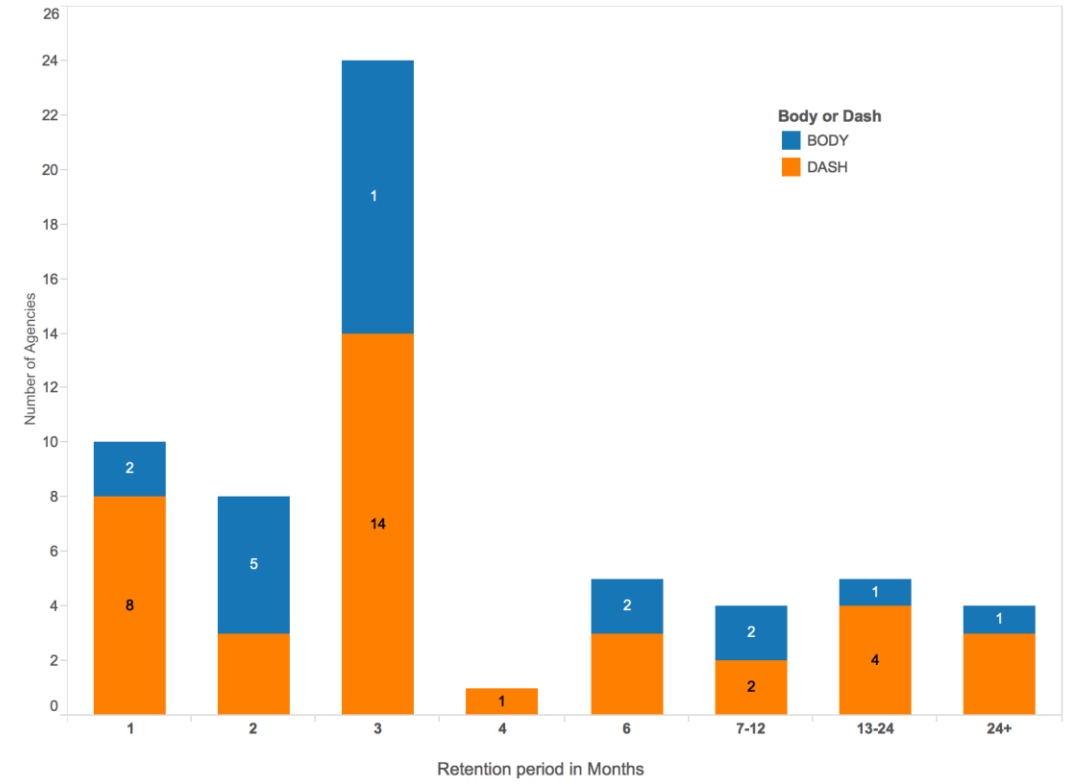
produced per month was not significant for the same reasons previous univariate regressions were not significant (i.e. the study's inability to control for video resolution). The large gap in camera system observations between classes, however, indicates that more data should be collected to confirm that this substantial difference holds true generally for files and hours produced per month.

4.6 Retention Periods for Video Files

A major policy decision that intimately affects the how much data must be maintained in a storage system is an agency's retention period for records. While retention policies for evidentiary videos are typically strictly defined by statute, disposition of non-evidentiary video files is discretionary in many cases. Additionally, evidentiary video files are typically migrated into more formal evidence storage environments or formatted as a physical copy in order to preserve the evidence's chain of custody. Alternatively, non-evidentiary video files are maintained as part of the camera program's objective to document excessive use of force and not as evidence for criminal/judicial proceedings. The median retention period for non-evidentiary video files reported in the study was three months, with the majority of agencies reporting a retention period of less than 6 months and a third of agencies (n=18) reporting periods extending beyond 6 months (see Figure 5). Retention policies significantly affect overall storage overhead since the coefficients provided by the regression analysis will be multiplied by the number of months in an agency's non-evidentiary video retention policy.

Figure 5

Retention Periods (in Months) for Non-Evidentiary Video Files Produced by BWC and DashCam Systems



Note. Total number of non-null observations is 61.

With established retention policies for both evidentiary and non-evidentiary video files, it is possible to estimate the total storage required for the lifecycle of these records. For example, an agency migrating all evidentiary video files to physical copies and maintaining non-evidentiary video for 3 months will only require a server capable of storing three months of data on a revolving basis. However, agencies were also asked to estimate how many video files were retained beyond the defined retention period for non-evidentiary video files. Agencies can retain files beyond established retention periods for administrative purposes as part of an internal force-wide assessment or as part of an officer's personnel file. Agencies reported that 0.6% of files produced by the agency each

month were retained beyond the established retention period for non-evidentiary video files without a defined period for disposition. Since these files are managed outside of an established policy, this statistic can be used as an estimate of the incremental growth in storage overhead required by the system each month (e.g. .06% of files generated any given month may be retained for an indefinite period).

4.6 Redaction of Video Files in Response to Records Requests

As discussed in the literature review, the potential increase of required redaction services for BWC footage has become a growing concern among Police Chiefs and public administrators. Without explicit statutes excluding BWC and DashCam video from public record requests, agencies may be required to allocate a large amount of resources into time-intensive redaction in order to preserve individual privacy rights. Agencies were asked how frequently BWC and DashCam videos required redaction in response to a records request, and also, when redaction was required, how long it typically took to redact files. Response rates to these questions were extremely low, however, the handful of responses provided by agencies indicate that redaction is indeed a subject for concern. Of the six agencies responding, the mean number of requests for redaction per month was 4.28, with a minimum of one redaction request and a maximum of ten. When asked how many man-hours were typically required to process a single redaction request, the mean response was three hours. One agency in the study estimated that video redaction takes approximately 10x the length of the video on average. While these numbers are not large, they represent a significant demand in labor for a relatively small number of requests.

5.0 DISCUSSION

The core objectives of this study were to provide municipal and county law enforcement agencies with a clearer picture of how much data BWC systems produce. Current estimates in popular media fail to provide a full picture of all three aspects of the data (number of files, gigabytes and hours produced), and no research to date has attempted to systematically estimate the data produced on a per officer basis. Law enforcement agencies are left to make policy choices without a clear picture of the resulting outcomes and the storage requirements these systems require. Of the three research questions proposed, analysis of responses from the agencies surveyed successfully answers the first two and partially answers the third. Discussion of results and several limitations of the analysis are provided below.

5.1 Discussion of Research Question 1

Q1: What are the anticipated data production statistics (number of files, gigabytes, and length of video produced) for Body Worn Camera and DashCam systems per officer, per month for municipal and county law enforcement agencies?

The results of this study provide law enforcement agencies and policy makers with discrete numerical predications that can be used to calculate the the number of files and hours produced per month per officer (see Table 3). Similarity of regression analysis results for BWC and Dashcam systems for files and hours produced per month suggest

that systems can be used interchangably and in aggregate, particularly when predicting the number of files produced per month. According to this analysis, county and municipal law enforcement agencies can expect to produce roughly 35 files and 11 hours of video per month per officer. While regression analysis of the number of gigabytes per month generated statistically significant results, the lower R^2 values for these regressions suggest that other factors (i.e. various video resolutions used) are important contributing factors to the amount of data produced. Since this study failed to control for the numerous capture rates used by contributing agencies, a surrogate statistic was generated using the more reliable regressionf for number of hours produced per month and estimating gigabyte outputs for each resolution/bit rate (see Table 4). This table will also help law enforcement administrators compare the various systems availible to them, and weigh whether higher-quality video capture is worth the investment required for storage.

There were a total of 78 valid system observations used to calculate regressions, surpassing the benchmark quotas established by the study's methodology. However, this analysis could certianly benefit from more participation from agencies that have implemented or piloted BWC programs. The study suggests that BWC systems are still not widely adopted by all county and municipal law enforcement agencies, but as more agencies opt to conduct pilot programs, these finding could be enriched. Another significant limitation of this study is its low response rate and high drop out rate. Given the origin of the survey (a graduate student conducting academic research with no preestablished relationship with candidate agencies), it is not surprising that these rates were limited; it is assumed that research conducted under the heading of a more well known entity to law enforcement agencies (e.g. PERF) would genereate a higher rate of

response and minimize the security concerns that some drop outs had under the current study. Despite these limitations, the current analysis is very strong and is vast improvement over the dearth of information currently availible to law enforcement agencies.

5.2 Discussion of Research Question 2

Q2: Can existing DashCam systems be used as a surrogate to estimate the data production statistics established in Q1 for municipal and county law enforcement agencies that have not yet deployed a Body Worn Camera program?

The similarity in number of files and hours produced between BWC and DashCam systems suggest that agencies considering implementation of BWC systems can use existing DashCam systems as a benchmark for predicting the impact of a BWC program. T-tests analysis between the BWC and DashCam segments could not determine a statistical significance between means, and regression analysis for files and hours produced per month were generally comparable between the two systems. This indicates that an agency with a preexisting DashCam system might use the data production statistics from its established system as a benchmark for the new system and the amount of data it produces. As with the previous research question, this analysis could benefit from more camera system observations, but the evidence in the current analysis very strong.

5.3 Discussion of Research Question 3

Q3: Do policy decisions (e.g. voluntary vs. mandatory assignment of cameras, officer discretion to turn off cameras, public's notification of active camera, or retention periods) for Body Worn Camera / DashCam programs have an impact the data production statistics established in Q1?

The lack of responses to the survey instrument hampered analysis of the impacts of policy on the amount of data produced by agencies. Due to the number of possible classes in each variable, confident results were not possible. Additionally, since the methodology of this study was non-experimental, it could not test any causal assumptions. Despite these challenges, analysis revealed statistically significant differences in the means of two policies: 1) officers not required to inform citizen of camera in operation produced more files than those required to inform citizens, 2) officers allowed to view footage prior to making a shift report produced more files and hours of video than not allowed to view footage. One possible explanation for this finding is that citizens' awareness of being videotaped may increase the chances of them requesting cameras be turned off. Additionally, it is possible that officers able to use camera footage to help them do their duties (complete shift reports) may see the utility of camera systems and be more willing adopters. Given the distribution of responses, however, these assumptions should be tested further in experimentally designed studies.

5.4 Implications of Analysis

The results above reveal that camera systems will have a sizable impact on IT resources. Applying the findings of the research done here, a municipal law enforcement agency of 325 line/duty sworn officers using a 12 month retention period for non-evidentiary video would generate a revolving storage of 179 thousand files, 57 thousand hours, and 102 terabytes of raw data for medium-high quality video. To play this scenario out, in order to properly store 102 terabytes of data with redundant backups at minimum enterprise standards (Raid 6 array) a system such as this would require a 225 terabyte server. While the cost of such a server is certainly not impractical, it is not a trivial detail

either, and it pales in comparison to the costs for maintenance and power supply of the system or administrative costs for indexing and maintaining the storage database. In contrast, with a retention period of 3 months (the average retention period for non-evidentiary files among agencies surveyed) the same agency's revolving data footprint would only be 76 thousand files, 24 thousand hours, and 41 terabytes respectively. This represents a tremendous reduction the cost of implementation both in terms of construction and maintenance. In the absence of realistic information on which to base the proposed city's policies, it is likely to build a far more burdensome and complex information system than is necessary to fulfill those objectives. The findings in this research may help eliminate that risk.

The surprising finding that DashCam systems are not as widely used as assumed (particularly for small agencies) indicates that some agencies may face practical barriers that prevent implementation. Fiscal constraints may prevent smaller agencies from deploying BWC systems due to the initial investments required to create the system. Since many agencies indicate that BWC technology is unlikely to replace existing DashCam systems, but rather, augment current practices, it is probable that agencies will need to maintain storage for both systems. Third-party cloud storage options have appeared more recently to reduce the cost of maintenance to a fixed rate on a per officer basis. It is still an open question whether cloud storage is the appropriate environment for storing these potentially sensitive records. If the goal is for all law enforcement agencies in the US to deploy BWC systems, policy makers will need to determine methods of overcoming these barriers.

Considering the significant multiplying effect that retention periods have for the requirements for storage and management of these systems, it is highly recommended that agencies and policy makers establish minimal record retention periods to minimize the increased storage costs. Minimal retention periods for non-evidentiary videos will also help reduce ongoing costs from public information requests. While there are compelling arguments on the other side of this issue (e.g. maintaining records longer for longitudinal study), separate, more narrowly defined retention policies should be created to manage these types of secondary purposes. The baseline retention period established for non-evidentiary records should be narrowly defined to support the primary purposes for collecting the records: capturing instances of excessive use of force and providing agencies a more robust method of keeping individual officers accountable. If agencies or policy-makers wish to leverage these records for other purposes, narrowly defined segments of the records should be reclassified under other retention polices to support these purposes.

Using the findings in this paper as a foundation, future studies can further elaborate on the secondary maintenance costs on agencies that adopt BWC systems (e.g. information retrieval, redaction labor, etc.). The need for this research is clear. Were BWC systems adopted ubiquitously in the United States and all officers were equipped with cameras, it is estimated that 900,000 sworn officers would produce 29 billion files, 1140 years of video, and 17.4 petabytes of data every month. In aggregate, these are extremely large numbers, practicalities that should be factored into policy decisions. This continued research will help law enforcement agencies and policy makers to make better-informed decisions on BWC legislation and agency retention policies

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APPENDIX 1

Survey Instrument

Assessing the Data Management Requirements of Body Worn Camera and DashCam Systems

Rationale:
In the past year, interest in implementing Body Worn Camera (BWC) programs for law enforcement has increased significantly. Despite the broad interest in BWC technology, there are relatively few objective studies on BWC programs and virtually nothing on implementation or impact on IT resources. The difficulties of assessing the costs of BWC programs remain a major concern for law enforcement agencies.
Too often policy makers have adopted policy language without considering the practical limitations. Management of the data contributes to significant labor costs beyond the significant financial costs of storage.

Request:
This survey is part of a study aggregating file production statistics on piloted BWC programs and current DashCam systems, and is part of my Master of Public Administration and Master of Information Science combined thesis at the UNC.

The purpose of this study is to provide policy makers, law enforcement administrators and IT professionals with the information to make more informed policy decisions regarding this new technology.

Survey information:
This 20-25 min survey requests data production estimates, but does not require any sensitive information or opinion regarding specific case files. It will, however, require access to the agency's BWC or DashCam file storage system to make accurate estimations.

All responses will be aggregated and anonymized.

Also, all interested participants providing contact information will be provided with the results of the study.

Thank you for your participation.
Justin Kreft
MSIS & MPA Candidate
University of North Carolina at Chapel Hill

Survey Instructions
This survey **will require access to the agency's BWC or DashCam file storage system** to make accurate estimations of file production statistics

You may exit at anytime and your answers will be saved. Click on the link in your email to return to the survey at anytime

The survey will take between 15-25 minutes depending on the number of systems your agency has piloted/implemented

You may skip any question if not applicable except for "Agency Name"

HOWEVER, all textboxes are open-ended, so you may explain your answer fully or provide a partial answer with explanation.
Please enter the full name of your agency:
_____

System Information[97]
Has your agency piloted or implemented a Body Worn Camera program?
- □ Piloted
- □ Implemented
- □ No

Production Metrics for Body Worn Camera Program
IMPORTANT NOTE:
The following questions are the most important of this survey.
All questions request an estimate of a typical month of the program's operation.
This information could be obtained by querying your storage system for a random month, or derived by other statistical means.
Note: all textboxes are open-ended, so you may explain your answer fully or provide a partial answer with explanation.

What is the total number of video files captured (or cameras activations occurring) in a typical month?
_____

What is the total size (in gigabytes) of video data produced in a typical month?
_____

What is the total number hours of video produced in a typical month?
_____

If available, at what bit rate is video captured?
_____

Retention and Requests of Body Worn Camera videos
Note: These questions use the following definitions:

[97] N.B. Section repeats for DashCam Systems in actual survey instrument

Evidentiary video involves footage of an incident or encounter that could prove useful for investigative purposes, such as a crime, an arrest or citation, a search, etc. The retention period is governed by state evidentiary rules for that incident.
Non-evidentiary video involves footage that does necessarily have value to aid in an investigation or prosecution, such as footage of an incident or encounter that does not lead to an arrest or citation. Non-evidentiary videos are generally not subject to state evidentiary laws.
Note: all textboxes are open-ended, so you may explain your answer fully or provide a partial answer with explanation.

How many video files produced in a typical month are classified as **evidentiary**?

_____

What is the retention period the agency has designated for **non-evidentiary** video files in months?

_____

In a typical month, how many **non-evidentiary** video files are retained beyond the agency's non-evidentiary retention period for an administrative purpose? (Administrative purposes includes disciplinary, training, internal studies, citizen complaint, etc).

_____

How many requests for video files (evidentiary or non-evidentiary) occur in a typical month?

_____

Body Worn Camera Program Implementation Information
Note: all textboxes are open-ended, so you may explain your answer fully or provide a partial answer with explanation.

How long did the Body Worn Camera program run or is it ongoing?

_____

How many total Body Worn Cameras were active/deployed during a typical month of the program?

_____

How many duty/patrol/line officers participated in the Body Worn Camera program?

_____

Was officer participation in the Body Worn Camera program voluntary, mandatory, assigned, or mixed?

_____

What is the primary Body Worn Camera system (make and model) your agency deployed?
**Note: for all future questions, please use this system as the basis for your estimations (i.e. if you piloted two systems, please select one and answer for that system only).*

_____

Policy Questions on Body Worn Camera Program

Does the program's working policy allow for officer discretion when making a recording?

- □ No discretion (i.e. policy stipulates officers must make recordings of all citizen interactions)
- □ Narrow discretion (i.e. officers may turn off cameras at citizen request)
- □ Moderate discretion (i.e. officers may turn off cameras for qualified exception in policy, for example, interviewing domestic abuse victims)
- □ Broad discretion (i.e. officers may elect to not make recordings at their professional discretion)

Can officers view video prior to making a shift report?

- □ Yes
- □ No

Can officers view video prior to testifying in court or responding to a citizen complaint?

- □ Yes
- □ No

Does the policy require officer to inform citizen of the video camera?

- □ Yes
- □ No
- □ Requests officer inform but not required

Redaction services for sensitive video files

Note: all textboxes are open-ended, so you may explain your answer fully or provide a partial answer with explanation.

If applicable, does IT Services (or other organizational structure) provide redaction services for requested files when necessary?

- □ Yes
- □ No

If applicable, how many hours does it take (on average) to redact a video file?

_____

If applicable, how many requests for redaction occur in a typical month?

_____

Agency questions and Conclusion

Note: all textboxes are open-ended, so you may explain your answer fully or provide a partial answer with explanation.

How many sworn officers are employed by the agency?

How many duty/line/patrol officers are deployed by the agency?

**Note: for the purposes of this question, a duty/line/patrol officer is one likely to be equipped with a camera if implementation of a camera program were agency wide.*

How are the department's IT services provided?

- □ by Internal Agency IT services
- □ by Parent Local Government IT services
- □ by Contracted third-party

Are program's video files stored internally or by third party vendor, like Evidence.com?

- internally
- third-party vendor

Thank you for your time.
If you would be willing to discuss any questions I might have regarding your answers to this survey, please include your name and preferred contact information.

Name
_____

Email Address
_____

Business Phone Number
_____

Thankyou.

APPENDIX 2

Results of Two-tailed T-tests for Location, Size of Force, Camera System, and Government Type Segmentations Measuring Difference of Means by Files, Gigabytes, and Hours Produced Per Officer Equipped

	Location				
	NC	Non-NC	*t*	*df*	P(T<=t) two-tail
Files produced per officer	50.04 (54.82) n=34	32.63 (29.41) n=34	1.63	51	0.109
Gigabytes produced per officer	16.9 (25.57) n=27	23.77 (48.86) n=27	0.65	39	0.521
Hrs produced per officer	11.66 (12.79) n=23	7.91 (10.02) n=25	1.13	46	0.263
	Size of Police Force				
	Small (1-24)	Large (25+)	*t*	*df*	P(T<=t) two-tail
Files produced per officer	36.51 (38.15) n=45	50.78 (54.66) n=23	1.12	33	0.270
Gigabytes produced per officer	19.81 (36.3) n=31	21.04 (42.74) n=23	0.11	52	0.909
Hrs produced per officer	10.06 (11.1) n=28	9.22 (12.23) n=20	-0.25	46	0.806
	Camera System				
	BWC	DashCam	*t*	*df*	P(T<=t) two-tail
Files produced per officer	53.22 (53.28) n=26	33.98 (36.94) n=42	1.62	40	0.114
GB produced per officer	17.56 (24.21) n=22	22.25 (46.53) n=17	0.48	49	0.631
Hrs produced per officer	11.52 (13.14) n=19	8.52 (10.29) n=29	0.88	46	0.382

	Government Type				
	Municipal	County	*t*	*df*	P(T<=t) two-tail
Files produced per officer	43.86 (45.65) n=62	21.07 (16.96) n=4	0.99	64	0.327
GB produced per officer	17.64 (30.77) n=50	54.01 (97.37) n=4	0.74	3	0.511
Hrs produced per officer	9.64 (8.64) n=43	10.3 (17.61) n=5	0.08	4	0.938

	Pilot or Fully Implemented Program				
	Pilot	Full	*t*	*df*	P(T<=t) two-tail
Files produced per officer	43.03 (41.51) n=14	40.9 (45.65) n=54	-0.16	66	0.875
GB produced per officer	32.54 (50.6) n=10	17.56 (35.72) n=44	1.1	52	0.274
Hrs produced per officer	15.44 (10.4) n=9	8.38 (11.41) n=39	-1.7	46	0.096

Note. Standard Deviations appear in parentheses below means. No sub-segments P values were less than .05 and the differences in means for each pairing cannot be said to be statistically significant for all data production statistics gathered.

APPENDIX 3

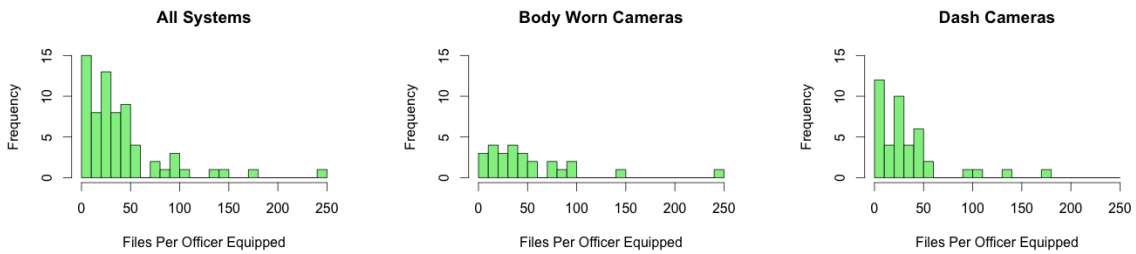
BWC and DashCam Systems Reported by Agencies Surveyed

Camera System	Agencies deploying system
Taser Axon Flex	14
Digital Ally FirstVu HD	11
Null	11
L3 Mobile Vision	6
Pannasonic Arbitrator 360	5
Watchguard (generic)	5
WatchGuard 4RE	4
L3 Flashback	3
Watchguard DV1	2
BodyCam by ProVision	1
Coban Edge	1
Custom Signals G3 Vision	1
Data 911	1
Digital Patroller (generic)	1
i-Kam Extreme	1
Kuston Ion	1
Prima Facie by Safety Vision	1
Scorpion (generic)	1
Stalker (generic)	1
Veho Muvi Pro	1
Vievu LE3	1
VuVault FirstVu HD	1
Wolfcom 3rd Eye	1

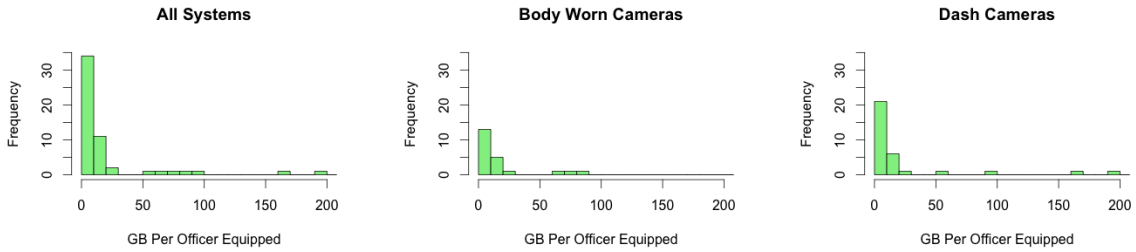
APPENDIX 4

Distributions of Reported Video Production Statistics (Files, Gigabytes, and Hours Produced) per Month Per Officer Equipped

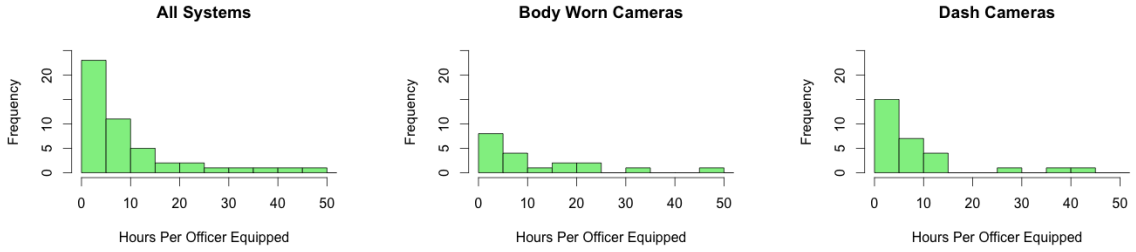
Distribution of Files Produced Per Officer Equipped



Distribution of Gigabytes Produced Per Officer Equipped



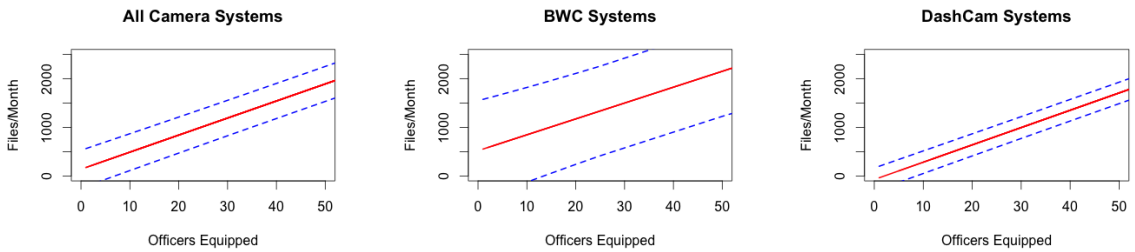
Distribution of Hours Produced Per Officer Equipped



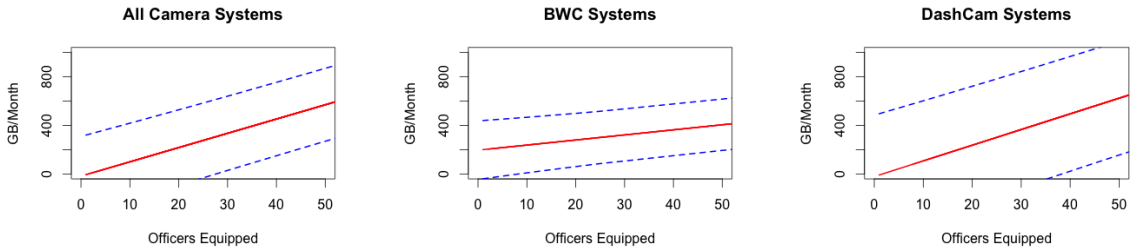
APPENDIX 5

Plots of Univariate Linear Regressions for Video Production Statistics (Files, Gigabytes, and Hours Produced) per Month as Reported by Agencies Against Number of Officers Equipped

Plots of Files Produced by Officer Equipped



Plots of Gigabytes Produced by Officer Equipped



Plots of Hours Produced by Officer Equipped