



Article

Predictive Policing and Crime Control in The United States of America and Europe: Trends in a Decade of Research and the Future of Predictive Policing

Ishmael Mugari * and Emeka E. Obioha

Department of Social Sciences, Walter Sisulu University, Mthatha 5099, South Africa; eobioha@wsu.ac.za

* Correspondence: ishiemugari@gmail.com; Tel.: +27-790-815-604

Abstract: There has been a significant focus on predictive policing systems, as law enforcement agents embrace modern technology to forecast criminal activity. Most developed nations have implemented predictive policing, albeit with mixed reactions over its effectiveness. Whilst at its inception, predictive policing involved simple heuristics and algorithms, it has increased in sophistication in the ever-changing technological environment. This paper, which is based on a literature survey, examines predictive policing over the last decade (2010 to 2020). The paper examines how various nations have implemented predictive policing and also documents the impediments to predictive policing. The paper reveals that despite the adoption of predictive software applications such as PredPol, Risk Terrain Modelling, HunchLab, PreMap, PRECOBS, Crime Anticipation System, and Azevea, there are several impediments that have militated against the effectiveness of predictive policing, and these include low predictive accuracy, limited scope of crimes that can be predicted, high cost of predictive policing software, flawed data input, and the biased nature of some predictive software applications. Despite these challenges, the paper reveals that there is consensus by the majority of the researchers on the importance of predictive algorithms on the policing landscape.

Keywords: algorithms; crime analysis; crime prevention; policing technology; predictive policing



Citation: Mugari, Ishmael, and Emeka E. Obioha. 2021. Predictive Policing and Crime Control in The United States of America and Europe: Trends in a Decade of Research and the Future of Predictive Policing. *Social Sciences* 10: 234. <https://doi.org/10.3390/socsci10060234>

Academic Editors: Lauren Dundes and Nigel Parton

Received: 11 March 2021

Accepted: 8 May 2021

Published: 20 June 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Crime prevention strategies have evolved over the years. Historically, crime management strategies mainly focussed on reactionary tactics, whereby the focus of policing was on reacting to incidents of crime. Thus, police evaluation was mainly based on how the police react to crime incidents and how they manage to solve the reported crime incidents. However, as the policing landscape evolves, there has been a paradigm change from a reactive policing style to proactive policing. Thus, the new thrust is on preventing crime rather than reacting to it. There has been a longstanding argument that prevention of crime has greater value for the public than reacting to crime (Martens 2017; Portland State University (PSU) 2012; Pearsall 2010). Importantly, prevention of crime is more closely related to proactive policing than reactive policing. Crime prevention strategies such as community-oriented policing (COP), problem-oriented policing (POP), intelligence-led policing (ILP), and hotspot policing were introduced with proactive policing in mind (Ferguson 2020; Lum and Isaac 2016; Sherman 2013). In recent years, one proactive data-driven policing strategy that has emerged is predictive policing. Broadly speaking, predictive policing makes use of information technology, data, and analytical techniques in order to identify likely places and times of future crimes or individuals at high risk of offending or becoming victims of crime (Halterlein 2021). As shall be seen in this paper, statistical predictions of predictive policing fall into two broad categories—predictions of places and predictions of persons. The use of predictive analytics and machine learning has attracted enormous attention, linking predictive policing with digital innovations in automation rapidly advancing across numerous employment sectors (Wilson 2020). Whilst it can be

argued that the collection and use of data has always been an aspect of police work, technological advancement and increased availability of policing data have led to a shift from predominantly reactionary police work towards a more proactive policing (Jansen 2018; Brayne 2017; Hardyns and Rummens 2017). However, it needs to be emphasised that predictive policing is not meant to replace tried-and-tested proactive policing techniques such as POP, COP, evidence-based policing, and ILP but rather builds from these proactive policing models (Martens 2017; Pearsall 2010). Improving on traditional proactive policing techniques, machine learning and refined algorithms allow police to track both individuals and areas with greater accuracy in order to predict when, where, and by whom a crime may be committed (Panelli 2018).

The predictive narrative moves the police from focussing on what happened to focussing on what might happen, as well as the effective and efficient deployment of resources to fight crime (Beck and McCue, in Pearsall 2010). Though an ideal scenario for any rationale police agency is to prevent the occurrence of criminal activities, predictive policing also plays an instrumental role in reacting to incidents of crime. For instance, it can assist the police in catching the criminal in the act (Martens 2017). Whilst it has been argued that predictive policing has been there for several decades (Ferguson 2020; Ferguson 2017; Bachner 2013; Perry et al. 2013), perhaps the centrality of advanced technology to enhance predictive policing has been a recent phenomenon. Before the move towards reliance on technology to predict crime, it was human experience and knowledge that allowed the police to make these predictions about crime. In the 1990s, however, Geographic Information Systems (GIS) and Computerised Statistics (CompStat) were used to predict and respond to crime in developed countries such as the United States of America (CCI 2020; Ferguson 2017). Whereas the traditional use of GIS and CompStat were predominantly reactive, the focus of predictive policing is proactive, that is, crime should be prevented from occurring in the first place (Bachner 2013). Notwithstanding the immense contribution of these 1990s data-driven technologies to deal with crime, this paper, however, focuses on recent advanced technological applications to predict crime.

The paper offers a convergence of a decade of sparse literature on predictive policing. Whilst studies have been conducted to evaluate the effectiveness of predictive policing applications in different countries, this article provides amalgamated insights into how predictive policing has been carried out in different countries. This article seeks to address the following three research objectives: (1) to document the nature of predictive policing initiatives in different countries; (2) to assess the effectiveness of predictive policing initiatives; and (3) to document the hurdles to the effective adoption of predictive policing. Despite the three specific objectives, we need to stress that the objectives are intertwined. For example, in the process of documentation of the predictive policing initiatives in different countries, reference is also made to studies that evaluated the effectiveness of these initiatives. Given the divergent objectives and findings on predictive policing in the previous empirical literature, this paper provides unique insights that interrogate the efficacy of this recent policing initiative. The identification of possible hurdles to predictive policing provides an opportunity for policy makers, predictive software developers, and law enforcement agencies to self-introspect and provide ways to circumvent these hurdles. Moreover, given the rapid technological advancement, technology-enhanced policing approaches will continue to take centre stage. Thus, continuous interrogation of predictive policing, as a technology-enhanced policing technique, is paramount. The paper also presents compelling arguments for the adoption of technology and machine-learning-enhanced predictive policing in countries and regions which are yet to embrace this modern policing initiative. The paper also gives an up-to-date objective assessment of predictive policing, an objective assessment critical for nations intending to adopt predictive policing.

2. Methodology

This paper was based on a survey of articles and documents on predictive policing from the year 2010 to the year 2020. Whilst the idea of predictive policing using advanced

technologies was mooted in 2008 (Perry et al. 2013), real implementation of predictive policing started in 2010, and this justifies the focus from the year 2010. An internet search was conducted on Google Firefox using the following search words: predictive policing; predictive policing approaches; predictive policing challenges; and predictive policing benefits. After the internet search, the researcher selected 52 documents, comprising journal articles, research papers, newspaper articles, and a report from an international non-governmental organisation. For journal articles, the criterion of inclusion was that the article was either peer-reviewed or the journal is indexed in Scopus. To this end, of the 33 selected journal articles, 20 were from Scopus-indexed journals, whilst the remaining 12 were from other peer-reviewed journals. As regards research papers, the researcher considered the methodology, the rigour of the research, as well as the relevance of the research paper to the current paper. A total of 11 research papers from renowned universities and organisations were identified. Four articles from prominent media houses, namely, the Independent (United Kingdom), Fox News, and the Guardian, were selected. Their insights into operational aspects of predictive policing were viewed to be important for this paper. Lastly, a document from an international NGO—Amnesty International—and a thesis on predictive policing were also reviewed. Whilst efforts were made to review the most relevant articles and documents, the researcher needs to highlight that the materials that were reviewed on predictive policing are not exhaustive. This notwithstanding, the article gives some positive insights into this contemporary policing initiative.

The paper begins by identifying a definitional convergence on the concept of predictive policing. The paper then looks at predictive policing approaches in various countries, with the paper specifically focussing on four countries, namely, the United States of America, Germany, the Netherlands, and the United Kingdom. The selection of these countries was based on the availability of literature on predictive policing. Whilst there is vast literature on predictive policing in the United States, a European organisation, Cutting Crime Impact (CCI 2020), identifies Germany, the Netherlands, and the United Kingdom as the countries that have largely embraced predictive policing in Europe. Moreover, for a country to be included, we needed to have at least five documents that would have been written on predictive policing in that country. This allowed a comprehensive analysis of predictive policing within the identified countries. All the four countries use different software applications for predictive policing, and this necessitated a comparison of predictive policing approaches between countries. The paper then looks at the challenges of predictive policing and, lastly, the future of predictive policing.

3. Definition and Scope of Predictive Policing

Despite vast research on predicting policing, especially over the last decade, there has been definitional divergence amongst most authors. This definitional challenge is acknowledged by Meijer and Wessels (2019), who point out the absence of a unanimous definition of predictive policing. An earlier attempt to define predictive policing was made by Pearsall (2010), who defined it as “the taking of data from disparate sources, analysing them and then using the result to anticipate, prevent and respond more effectively to future crime”. Despite its simplicity, Pearsall’s definition failed to capture the important role that technology plays in the crime prediction process. Given that the thrust of this paper, and perhaps the future of predictive policing, is predicated on advanced technology, a definition that captures the essence of technology in crime prediction is necessary. Perhaps a clearer definition, which has also been adopted by several authors, is from Perry et al. (2013). They define predictive policing as “the application of analytical techniques- particularly quantifiable techniques- to identify likely targets for police intervention and prevent crime or solve past crimes by making statistical predictions” (Perry et al. 2013). Similarly, Uchida, cited by Meijer and Wessels (2019), rather captures the essence of predictive policing as follows: “Predictive policing is a concept that is built on the premise that it is possible to predict when and where crimes will occur again in the future by using sophisticated computer analysis of information about previously committed crimes” (2019, p. 1033). A

more recent definition is given by Meijer and Wessels as follows: “Predictive policing is the collection and analysis of data about previous crimes for identification and statistical prediction of individuals or geospatial areas in with an increased probability of criminal activity to help developing policing intervention and prevention strategies and tactics” (2019, p. 1033). Whilst the definition seems to capture the fundamental aspects of predictive policing, the definition is perhaps a bit complex.

Modern definitions seem to capture the central role that technology plays in crime prediction. Three key aspects can be derived from the above definitions, and these are the importance of historic crime data, the essence of computer-based applications, and the anticipation of future crime. Another important observation relates to the use of vast data from disparate sources, and we want to emphasise, as shall be seen in this paper, that some of the data may not necessarily be relating to crime but other sociodemographic aspects. Having reviewed definitions from eminent scholars on predictive policing, and in an attempt to find a definitional convergence, we offer the following simplified definition of predictive policing: “Predictive policing is a policing model that uses historic crime and socio-demographic data from disparate sources to predict future crimes using sophisticated computer applications”. The primary goal of crime prediction is to assist the police in curbing crime—both at strategic and tactical level. Thus, crime prediction per se is not enough until the results from crime prediction are used for decision making, especially decisions pertaining to the deployment of personnel and resources.

Having attempted a definitional convergence, it is also imperative to discuss the scope of predictive policing. First, it is important to reiterate that the police can analyse historic crime data in order to predict the geographical areas which are likely to have increased chances of criminal activity. Thus, data pertaining to prior crimes and offenders are fed into a computer system with the aim of predicting where and when future crimes will occur. Whilst data on criminal offenders are critical, data on victims of crime are equally important (Portland State University (PSU 2012), as they are needed for the prediction of likely future victims of crime. Similarly, other important environmental factors such as population and demographics need to be factored in during the analysis phase, as they have a significant bearing on the nature of criminal activities in a community (Browning et al. 2010). In some cases, family history has been proven to play a significant role in predicting criminality (Lopes et al. 2012; PSU 2012). Whilst vast information may be available for analysis, the challenge lies in selecting the right information for effective prediction.

Several authors have suggested different approaches to predictive policing, though there is a bit of convergence on the fundamental aspects. It is thus prudent to have an overview of the predictive policing taxonomies, without going into detail on specific predictive policing applications. Perhaps an earlier and more detailed study on predictive policing approaches was done by Perry et al. (2013), whose thrust was on the importance of crime forecasting in policing. The study identified four taxonomies of predictive policing, which have formed the bedrock for predictive policing approaches and studies across the globe. These taxonomies pertain to the prediction of crimes, perpetrators, and victims of crime (Perry et al. 2013). Also of particular importance is their classification of the predictive analytic techniques. Amongst others, they identify the following broad classes of techniques: classical statistical techniques which involve statistical processes such as regression, time-series analysis, and data mining; simple methods not requiring much sophisticated computing, for example, most heuristic methods; and complex methods, which require large amounts of data and sophisticated computing tools (Perry et al. 2013). Ferguson (2017) also came up with an almost similar taxonomy of predictive policing approaches, and he identified the following: targeting places where property crime is likely to occur, which he termed predictive policing 1.0; targeting places where violent crime is likely to occur, which he termed predictive policing 2.0; and targeting perpetrators, which he termed predictive policing 3.0. However, Ferguson was specific in the nature of crimes on which predictive policing can be applied, that is, property crime and violent crime.

Bachner (2013) seems to offer a different taxonomy of predictive policing methodologies. She identifies three methodologies, namely, space analysis, time and space analysis, and social networks analysis. Analysis of space is more focussed identification of hotspots, while the analysis of time is centred on detecting locations where criminal activities are likely to occur based on past occurrence of crime. The chief purpose of these two categories is the targeting of geographic locations (Bachner 2013). The targeting of geographical locations is also premised on the longstanding finding that crime is concentrated in few places (Eck et al. 2017; Lee et al. 2017; Weisburd 2015). Social network analysis is largely used in the detection of persons of interest as distinct from locations of interest. A closer analysis of Bachner's taxonomies shows that they mirror Perry et al. (2013)'s and Ferguson (2017)'s taxonomies, albeit with different terminologies. For example, methods of predicting crime (Perry et al. 2013) and targeting places where property and violent crimes are likely to occur—predictive policing 1.0 and 2.0 (Ferguson 2017)—can be equated to Bachner (2013)'s analysis of space, and analysis of space and time. Similarly, Bachner (2013)'s analysis of social networks can also be equated to Perry et al. (2013)'s methods of predicting perpetrators and victims of crime, and Ferguson (2017)'s predictive policing 3.0—targeting of persons involved in criminal activity. Having looked at the different taxonomies of predictive policing, it can be argued that predictive policing has three primary facets—predicting the crime, predicting the offender, and predicting the victim.

4. Predictive Policing Approaches in Different Countries

4.1. Predictive Policing in The United States of America

The United States of America is perhaps the first nation to utilise software applications for predictive policing. In 2011, researchers from three universities, in collaboration with analysts from Santa Cruz Police Department, developed a predictive policing software known as PredPol (Perry et al. 2013; Bachner 2013). The software programme was aimed at identification of places that were expected to witness heightened levels of criminal activities in a given time frame (Perry et al. 2013; Bachner 2013), and it relied on three key variables, namely, type of crime, date and time, and place (Shapiro 2017). Thus, PredPol uses minimal data, as well as very limited variables in the analysis (Ferguson 2020). After analysis of data, highlighted maps showing areas prone to criminal activities are given to police officers on patrol, with the police officers expected to regularly visit the targeted areas (Ferguson 2017; Sherman 2013), the rationale being that police presence at an identified area will likely disrupt criminal activities in that area. According to Bachner (2013), preliminary observations indicated that PredPol had been successful, especially with respect to curbing burglaries. For example, she notes a 27 percent drop in burglary incidents in 2011, when the program was introduced, compared to 2010 (Bachner 2013). PredPol, which was subsequently embraced in several other cities in the USA, has also expanded its focus to include gun-related violence. For instance, PredPol examined gun-related crimes in Chicago between 2009 and 2011 and analysed them in comparison with homicides, wherein a positive correlation was established between gun-related crimes and homicide (Ferguson 2017). An evaluation of the data showed that PredPol could predict the location in 50 percent of gun homicides (Ferguson 2017). Similarly, Atlanta Police Department (APD) showed the benefit of PredPol through a notable reduction in crime compared to marginal rises in crime in areas where PredPol was not utilised (Turner et al. 2014). A peer-reviewed evaluation of PredPol in Los Angeles over 117 days revealed that the algorithm predicted 4.7% of the crimes, whilst crime analysts predicted 2.1% of the crimes (Ferguson 2020).

Risk Terrain Modelling (RTM) is another tool that has been embraced by law enforcement departments in the United States. Risk Terrain Modelling is a geospatial crime analysis tool that is designed to examine environmental risk factors associated with crime and to identify the areas where their spatial influence is linked with vulnerability to criminal behaviour (Caplan et al. 2017). The RTM model views the physical reality of a city as a terrain of interlocking risks, and if the risks are in close proximity to one another, this results

in increased risk of forecast crime (Ferguson 2020). Thus, RTM locates areas of spatial vulnerability that are associated with particular crime types. RTM is premised on the long-standing finding that geographically-focussed law enforcement strategies have consistently proven to be effective (Ferguson 2020; Kennedy et al. 2015; Braga et al. 2014). The basic RTM process involves incorporating environmental features such as educational institutions, bars, and public transportation stops into the assessment places' crime vulnerability (Caplan et al. 2015). An area's vulnerability to crime is heightened by the allocation of criminogenic features which create requisite conditions conducive to crime (Caplan et al. 2017; Kennedy et al. 2015). As a way of increasing the accessibility of RTM, the Risk Terrain Modelling Diagnostics (RTMDx) Utility—a free desktop software application which automates RTM—was developed by Rutgers University (Caplan et al. 2015). The RTMDx Utility software was used in different studies, with satisfactory results. For instance, the RTMDx Utility software was used in the study of assault in Chicago (Kennedy et al. 2015), and the study on robbery (Caplan et al. 2017). Though the impact of RTM on crime reduction is still subject to debate, studies have demonstrated the significant influence of the environmental factors on crime. A careful analysis of these environmental factors will lead to informed policy decisions on crime control.

Perhaps the recent and probably more complicated predictive policing application in the United States is the HunchLab, which, according to Ferguson (2020), features the elements of technologies underlying RTM and PredPol, as well as adding other factors. HunchLab considers a number of aspects which, among others, include underlying crime rates, near repeat patterns, socioeconomic factors, temporal factors, and social events (Ferguson 2017; Shapiro 2017). The information is fed into a machine learning algorithm, and there will be updates for every police shift (Ferguson 2017). Using machine learning techniques, HunchLab analyses the crime data through training and testing of the data before modelling the data for use in forecasts, which are then used for patrol allocation suggestions (Ferguson 2020). Given its thrust on patrol-related police responses, HunchLab calls itself a “patrol management system”. To support officers on patrol, HunchLab is built into mobile devices to allow police patrol officers to view in real time the areas where criminal activities are likely to occur (Ferguson 2020). Through the use of HunchLab tools, commanders can customise patrol priorities by adding constraints such as the size of manpower and time available for deployment (Shapiro 2017). In terms of effectiveness, early testing of HunchLab showed a positive impact on crime reduction in Chicago and Philadelphia (Fingas, in Ferguson 2020).

Advanced predictive policing analytics has also enabled police departments to collect useful intelligence on suspected criminals and crime syndicates, as well as victims (Ferguson 2017). For example, Los Angeles developed a project called Operation Laser (Los Angeles Strategic Extraction and Restoration), which identifies individuals who are likely to commit crime. The project develops “Chronic Offender Bulletins” of targeted individuals (Braga et al. 2014), and law enforcement officers are provided with these bulletins for the purpose of surveillance and criminal investigations (Ferguson 2017). In Chicago, intelligence officers came up with the Strategic Subjects List (SSL), which lists, in a ranking order, potential victims of crime, as well as subjects/individuals who have a greater predisposition for violence. The list is prepared from software that is generated from empirical data that list the following attributes, among others: the subject's criminal record, reported incidents of violence among the subject's accomplices, the extent to which the subject's criminal activities are increasing, and the intensity of the subject's criminal history (Ferguson 2017). Similarly, in Kansas City, a sophisticated social network analysis pertaining to the likely offenders in the city was also conducted. A Smart Policing Initiative (SPI) team was set up and employed advanced social network analysis through the use of offence data, gang-related data, and field interview forms (Ferguson 2017; Braga et al. 2014). The analysis locates networks that are socially deviant, as well as connections between the deviants (Braga et al. 2014).

4.2. Predictive Policing in Germany

Predictive policing has also been embraced in some European jurisdictions. In Germany, applied predictive policing mainly focusses on residential burglary (Gerstner 2018; Sommerer 2017). Due to rising cases of domestic burglary in Germany, predictive policing was introduced in 2014, with different systems being developed across the 16 federal states (CCI 2020). In 2014, the police in Lower Saxony, in collaboration with IBM and the Karlsruhe Institute for Technology, developed a predictive policing software called PreMap (Predictive Mobile Analytics for Police), which built on near-repeat approach to crime (CCI 2020). Results from the analysis enable increased patrols in areas at risk of crime. Moreover, potential offenders would be deterred or arrested whilst attempting to commit burglary. PreMap also provides a so-called “Crime Radar” that maps offences relevant to public spaces over the last four weeks (CCI 2020). Subtly acknowledging the shortcomings of the PreMap in Lower Saxony, CCI (2020) notes: “...the pilot phase has shown that there is still room for PreMap’s further development in order to increase its effectiveness as a tool in the strategic alignment of the police”.

A pilot project known as Predictive Policing (P4) was launched in the federal state of Baden-Württemberg in October 2015 using predictive policing software PRECOBS (Gerstner 2018). PRECOBS was developed to forecast the likelihood of future burglaries and is based on the premise that crime incidents are usually followed by further incidents in close proximity (near-repeat phenomenon). The software application uses historic data, usually for the past five years, for analysis (Gerstner 2018). As with other predictive policing applications, it is important to note that not all burglary incidents will be predicted by PRECOBS, but the application only predicts potential burglary incidents that follow an initial incident in spatial and temporal proximity. Whilst the project was significant in the spheres of predictive policing, Gerstner (2018) recommends a cautionary approach to the results, largely due to the following factors: limited evaluation period, a small size of the trial areas, and absence of an experimental design. Moreover, notwithstanding some positive results, “the impact on crime remains unclear and the size of crime reducing effects appears to be moderate” (Gerstner 2018). Despite its German origin, PRECOBS has also been used for predictive policing in Switzerland (Jansen 2018; Hardyns and Rummens 2017).

4.3. Predictive Policing in The Netherlands

Although predictive policing tools are used by several police forces, mainly in the US and in Europe, the Netherlands were the first country in the world to deploy predictive policing on a national scale (Strikwerda 2020). Several police forces in the Netherlands are turning to the Crime Anticipation System (CAS) for predictive policing (Jansen 2018; Martens 2017). This data-driven system predicts crime through analysis of statistics from three sources: Central Crime Database, Municipal Administration, and Demographics Statistics Netherlands. Thus, CAS combines crime data with demographic and socioeconomic data in its prediction. CAS is a spatiotemporal prediction system that identifies crime “hotspots” and “hot times” (CCI 2020), as well as individuals at risk of victimisation (Querbach 2019). Data are presented in the form of heat maps that highlight crime risk areas, and these heat maps are used in the deployment of policing resources. CAS is suitable for certain types of crime, such as burglary, robbery, and theft (specifically pickpocketing), although it is also used to provide some information about offenders (CCI 2020). Strikwerda (2020) also notes System Risk Identification (SyRI) as another predictive policing tool in the Netherlands, though the tool is also used by other government departments. Unlike the majority of predictive software applications in countries such as the USA, Germany, and the United Kingdom, which are predominantly used to predict violence-related crimes, burglary, and robbery, Strikwerda (2020) SyRI is used by the police for predicting fraudsters.

4.4. Predictive Policing in The United Kingdom

At the inception of predictive policing in the UK, police forces mainly relied on commercially developed software programs such as Azevea, Palantir, and PredPol, whose usage was, however, discontinued due to high costs (Couchman 2019). At the present moment, the majority of police departments in the UK are implementing predictive mapping systems that are developed “in-house” (Jansen 2018). For instance, the London Metropolitan Police developed the Gang Matrix, which identifies potential members of crime gangs and allocates scores on gang members based on the perceived risk that they pose to communities (Jansen 2018). However, concerns were raised over the discriminatory nature of the Gang Matrix, as most of the gang members were young black men (Amnesty International 2018; Scott 2018; Jansen 2018). The West Midlands police introduced the National Data Analytics Solution (NDAS), which combines statistics and Artificial Intelligence (AI) to ascertain the likelihood of someone committing or becoming a victim of gun-related or knife-related offence (Baraniuk 2018; Jansen 2018). As regards data analysis, the strongest indicators for future crime prediction for NDAS are the individual’s criminal history and the number of offences committed within social networks (Baraniuk (2018) in Jansen (2018)). In Avon and Somerset, a predictive software programme known as Qlik is used by the police, and its aim is to predict the likelihood that an individual will commit a certain crime, as well as to predict the likelihood of a person becoming violent when stopped by police (Dencik et al. 2018).

5. The Enduring Challenges of Predictive Policing

Despite the upswing in the uptake of predictive technologies by police departments, there have been concerns over the potential downsides of the technology. In fact, there is vast literature on the downside of predictive technologies. One main challenge relates to mixed feelings over its effectiveness. In terms of crime prevention, results of predictive policing are a matter of debate (CCI 2020). Studies that have evaluated the efficacy of predictive policing technologies have produced mixed results and have not established that predictive policing has a significant impact on crime reduction (CCI 2020; Scanlan 2019; Saunders et al. 2016). In Germany, for instance, Gerstner (2018) notes that despite the evaluation of PRECOBS, it is hard to ascertain the extent to which the predictive application can lead to a reduction in burglary incidents. Similarly, in Chicago, the Strategic Subjects Lists suffered from low predictive accuracy and challenges on how to effectively link predictions with police operations (Gerstner 2018; Saunders et al. 2016). In studies which have shown that predictive policing has reduced crime, the fact that the studies were conducted by the software companies in collaboration with academics raises conflict of interest issues, thus negatively impacting the results’ credibility (Scanlan 2019). This point is reiterated by Shapiro (2017, p. 460), who avers that “companies that conduct field experiments with police departments in exchange for discounted rates raise concerns about conflicts of interest”. Whilst most predictive policing systems help to identify hotspots, with the subsequent police action focussing on the hotspots, Summers and Rossimo (2018) suggest that potential offenders may seek opportunities in locations that are not being patrolled. Thus, deploying police officers into crime prone areas which would have been identified by the predictive policing systems will only lead to displacement of crime to less patrolled areas.

One major criticism lies in the limited scope of crimes that prediction software can predict. For instance, PredPol is mainly effective in predicting burglary (Bachner 2013), automobile theft, and theft from automobiles (Ferguson 2020). Similarly, the Risk Terrain Modelling Diagnostics (RTMDx) Utility software works well on robbery (Caplan et al. 2017), whilst PRECOBS mainly focusses on burglary (Gerstner 2018). Whilst it can be argued that different predictive policing software programs in different jurisdictions were introduced with crimes of concern in mind, the fact that they may not apply on a host other criminal activities is a cause for concern. In order to deal with various other criminal activities, individual police departments may have to purchase or develop several software

programs—each for a particular crime of concern. However, this may not be financially prudent, given the high cost of predictive policing software. Another key aspect is to review the impact of predictive policing technologies in the broad context of technological breakthroughs. Whilst predictive policing is a product of technological advancement, there is also a concomitant rise in technology-enhanced crimes, which the current predictive algorithms may not address. Moreover, data analytics is also being utilised by criminals to improve their operations through reverse engineering of predictive policing or counter predictive policing (Gstrein et al. 2020; Zwitter 2015). Thus, in as much as predictive policing helps to curb criminal activities, it can also perpetuate criminal activities.

Another obstacle lies in the high cost of predictive policing software (Couchman 2019) as some of the companies develop the software for commercial purposes. In the UK, for instance, some police departments discontinued the use of commercial predictive policing software programs such as PredPol and Azevea due to their exorbitant costs (Couchman 2019; Jansen 2018). The solution to the high cost of predictive policing software lies in the in-house development of software, a route which has been taken by some police departments in the UK (Jansen 2018) and most police departments in Germany (CCI 2020; Gerstner 2018). Whilst there has been a growing trend towards in-house development of predictive policing software (CCI 2020; Jansen 2018), there may be concerns over the availability of the necessary expertise to develop the software (Robinson 2017). Though developed nations may have the capacity in terms of the requisite software development skills, developing nations may not be equipped with the necessary human and technological resources, leaving them with no option but to purchase expensive predictive software from commercial developers.

Concerns have also been raised over the accuracy of crime data that are used for predictive policing. In some instances, predictive policing systems have been developed on flawed data, which at times will either be racially biased or will have been unlawfully gathered, thus raising the risk of inaccurate or systematically biased predictions (Richardson et al. 2019). Consequently, if the predictions are informed by inaccurate and biased data, this will eventually result in biased and unlawful policing practices (Richardson et al. 2019). For example, in 2018, the Baltimore police (United States of America) faced several lawsuits which were related to tainted records (Lepola 2018). Similarly, a survey in 2011 revealed that precinct commanders visited crime scenes to persuade victims not to file complaints, with the ultimate goal of keeping the reported numbers of serious crimes low (Richardson et al. 2019). Moreover, an analysis by Richardson et al. (2019) revealed nine jurisdictions where predictive policing systems were informed by police data where departments had allegedly engaged in unlawful and biased policing practices. However, a high-quality and accurate police database is the bedrock which sustains predictive policing.

Whilst the preceding paragraph discussed the negative implications of inaccuracy of data for input into the predictive policing systems, there have been concerns over the biased nature of some predictive policing systems. Predictive policing systems have been empirically shown to be susceptible to runaway feedback loops, where police are repeatedly sent back to the same neighbourhoods regardless of the true crime rate (Ensign et al. 2018; Lum and Isaac 2016). As a result of biased police data in the USA, concerns have been raised by researchers regarding the overpolicing of African American neighbourhoods (Jansen 2018; Isaac 2018; Lum and Isaac 2016). A study conducted by the Human Rights Data Analysis Group found that the algorithm used to target drug offenses in Oakland, California, targeted areas with higher concentrations of Latinos and Blacks despite evidence that shows that drug usage is more evenly dispersed across all Oakland's neighbourhoods (Shapiro 2017). The death of George Floyd in the hands of the police in 2020 heightened the public's resentment of predictive policing applications over racial bias and police brutality issues (Castelvecchi 2020). In addition to worldwide protests over the death of George Floyd, more than 1400 mathematicians in the United States signed a petition calling on the mathematics discipline to stop working on predictive policing algorithms and other

models (Castelvecchi 2020). In the United Kingdom, the London Metropolitan police was ordered to radically reform the Gang Matrix after the revelation that the predictive policing system was discriminatory in nature (Crisp 2019; Dodd 2018; Jansen 2018). Similarly, the “Black, Asian and Minority ethnic” (BAME) communities have a disproportionate likelihood of being arrested in the UK, and this results in a wrongful assumption that there are more criminal activities in their residential areas (Couchman 2019). By contrast, affluent populations also commit crimes, which, however, are different, and hence, the predictive software may not be in a position to capture the distinction in criminality among different groups (Kutnowski 2017). These arguments are summed up by Gstrein et al. (2020) when they point out that predictive policing interventions can lead to stigmatisation of individuals, environments, and community areas. Ultimately, if corrective measures are not taken, predictive policing may heighten the challenge of bias during police operations (Scanlan 2019). Similarly, there may be a challenge of algorithmic bias (Scanlan 2019). Consequently, despite the system being automated, there is still a need for human intuition in the development and scoring of the variables and parameters. This latitude in the scoring of variables and setting of parameters gives room to bias. The algorithmic bias is compounded by the tendency of some vendors to voluntarily omit certain crimes and data sources for training algorithms (Shapiro 2017).

Lastly, concerns have been raised over public transparency and social and legal ramifications of predictive policing technologies (Gstrein et al. 2020; Scanlan 2019; Bakke 2018; Ferguson 2017). Transparency denotes openness and susceptibility of systems to review by an independent person or body. Due to the highly technical nature of predictive policing, public transparency should be a priority (Bakke 2018). However, the development of predictive software by private actors shelters algorithms from public scrutiny (Bakke 2018; Perry et al. 2013). There are concerns that police departments have refused to disclose the specifics of the programs and algorithms that they use, in favour of protecting officers in the field who may be using the technology (Panelli 2018). Consequently, “there is a danger that the predictions become the results of a process hidden in a black box” (Gstrein et al. 2020), making it difficult for citizens and policy makers to comprehend. Few predictive policing software developers and vendors provide detailed information about how their predictive systems operate, the nature of data for each jurisdiction, or the oversight mechanisms for addressing data inaccuracy or bias (Richardson et al. 2019). On the social front, notwithstanding the broad focus on community safety, targeting specific neighbourhoods and individuals leads to deterioration of police–community relations. Predictive technology-induced targeting results in the use of intervention methods such as surveillance or negative enforcement actions, which, however, have been found to be detrimental to police–public relations (Isaac 2018). Unfair targeting of certain groups also diminishes trust in the police in particular and the state in general (Gstrein et al. 2020). The tendency to stop suspects who have not yet committed any crime has also been challenged by civil liberties advocates (Isaac 2018; Lum and Isaac 2016). There are also concerns about increased government-led monitoring and surveillance, an issue which has attracted much debate regarding privacy in the digital age (Gstrein et al. 2020). In the Netherlands, the government stopped using SyRI in 2020 after the District Court of The Hague ruled that it violates the right to privacy (Strikwerda 2020).

6. The Future of Predictive Policing

Despite the longstanding debate on the effectiveness of predictive policing in crime control, law enforcement agencies need to capitalise on the positive aspects of predictive policing. Whilst there are several studies that cast doubt on its effectiveness, none of the studies recommended discontinuance of this modern policing initiative. They rather point out some of the areas that need improvement—the major areas being data reliability, bias, transparency, and human rights implications. There is therefore a need to address the concerns that were raised by the authors. Whilst there is a rise in the body of literature that is critical to predictive policing, failure to acknowledge the positive aspects will be akin to

throwing the baby out with the bathwater. Given that predictive policing may continue for the foreseeable future, albeit with necessary adjustments, we therefore highlight some of the areas that need to be addressed.

There is a need for a paradigm shift in the way predictive policing is viewed. Importantly, the predictive policing approach needs to not be viewed as a standalone strategy but as part of a comprehensive crime prevention strategy (Perry et al. 2013). Prediction is just part of the broader process of crime control; hence, predictive policing should not be viewed as an end in itself but rather a means to an end. Moreover, no one is arguing that predictive policing is the solution to all law enforcement challenges, but supporters contend that predictive algorithms, along with other tools, can make policing more effective, efficient, legitimate, and fair (Bakke 2018). Ferguson (2020) succinctly shows the link between predictive policing and three other policing strategies, namely, hotspot policing, POP, and COP. Hence, the effectiveness of predictive policing should be understood in the context of its importance in other policing strategies and tactics. Rather than being a standalone policing strategy, “predictive policing merely provides additional information about the places and persons involved in criminal activity that supplements rather than replace, existing police techniques and strategy” (Ferguson 2017).

There is a need for policy makers and police departments to address the concerns that were raised in the previous empirical studies. First, there is need for measures to enhance transparency in developing and implementing predictive policing. The public needs to be informed by police departments regarding the predictive systems they choose and how they evaluate the systems (Shapiro 2017). In the interest of transparency and accountability, community members need to be engaged when setting policing priorities in which algorithmic decision support systems will be necessary (Isaac 2018). Convergence on policy priorities will lead to input data that align with true public policy goals (Robinson 2017). Internal and external mechanisms should be put in place to evaluate predictive policing systems. Whilst internal mechanisms are to be found within the police departments, external mechanisms are to be found outside the departments, and they vary. Shneiderman (2016) suggests a scenario whereby the developers or the police submit their tool or algorithm to a review board before any real-world implementation. However, Isaac (2018) argues that an independent review board is resource-intensive, and he supports oversight by civil society groups. However, we support a two-pronged approach involving both an internal mechanism and external mechanisms. In consonance with Shneiderman (2016), we recommend an independent review board, whose role should however not be limited to oversight of predictive policing algorithms but to the broad policing activities. Given that such independent boards are present in most jurisdictions, there will be no cost implications, as it will be a matter of expanding the board’s mandate to incorporate predictive policing.

Closely tied to transparency is the need to address the ethical and legal issues surrounding predictive policing. As highlighted earlier, one of the ethical hurdles of predictive policing is inaccurate or “dirty” data. Given that accurate data are the fulcrum of predictive policing algorithms, a sound data management culture becomes imperative. Data for input into the predictive algorithms need to be evaluated for authenticity and accuracy. In case of commercial vendors, data should be verified with official crime statistics and physical verification with the law enforcement records. For internally developed algorithms, departments should put in place policies for validation of data before input into the predictive policing systems. The government should also play a critical role in addressing some of the ethical and legal hurdles. The legislature should promulgate laws which require external audits of all the predictive policing algorithms that are used by the police (Scanlan 2019). In the case of “dirty” data, we propose that governments, through their legislative arms, should pass laws which penalise manipulation of crime data. Isaac (2018) also notes that the long-term success of predictive policing systems will depend on a regulatory framework which ensures that law officials are held to account for any unethical issues.

Lastly, predictive policing software developers and law enforcement agents should take cognisance of civil and privacy rights. Though it may be inevitable, the very act of labelling some places and certain individuals as worthy of further policing attention will inherently raise concerns about civil and privacy rights (Perry et al. 2013). One way of pacifying the community and pressure groups is to engage them in the process of developing predictive policing algorithms. Moreover, transparency in the development and implementation of the predictive algorithms will prompt support from citizens, and there will be less agitation over civil and privacy rights.

7. Conclusions

Predictive policing has been embraced by the police in the developed world. Whilst different types of predictive policing algorithms have been developed, the central aspect of these algorithms is to predict places and individuals who are at risk of criminal activities. With some studies revealing a modest to significant impact on crime reduction, there is, however, a growing body of literature on the challenges of predictive policing. Despite the challenges, there seems to be consensus by the majority of researchers on the importance of predictive algorithms on the policing landscape. Moreover, the challenges are not insurmountable, and in the latter part of this paper, we highlighted some of the measures to address the challenges. Lastly, we would like to reiterate that predictive policing is not an end in itself but a means to an end. Thus, policy makers and law enforcement departments should not fall into the trappings of judging the predictive policing algorithms by their accuracy in crime prediction. To this end, we aver that the future of predictive policing looks bright, albeit with a constant need to address ethical, social, and legal hurdles that impede its success. Given the benefits of predictive policing and its future prospects, more countries and regions should embrace this modern policing initiative.

Author Contributions: Conceptualisation and motivation of this research originated from I.M. and E.E.O. Methodological issues were done by I.M. and approved by E.E.O. Subsequent investigation was done by I.M., and E.E.O. Writing and Original Draft Preparation was done by I.M., while E.E.O. played a supervisory role. Both authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

- Amnesty International. 2018. Trapped in the Matrix: Secrecy, Stigma, and Bias in the Met's. *Gangs Database*, May. Available online: https://www.amnesty.org.uk/files/201805/Trapped%20in%20the%20Matrix%20Amnesty%20report.pdf?HSxuOdpdZW_8neOqHt_Kxu1DKk_gHtSL (accessed on 13 January 2019).
- Bachner, Jennifer. 2013. *Predictive Policing: Preventing Crime with Data and Analytics*. Washington, DC: IBM, Centre for the Business of Government, pp. 86–90.
- Bakke, Erik. 2018. Predictive Policing: The Argument for police Transparency. *NYU Annual. Survey of American Law* 74: 131–72.
- Baraniuk, Chris. 2018. Exclusive: UK police wants AI to stop violent crime before it happens. *New Scientist*, November 26. Available online: <https://www.newscientist.com/article/2186512-exclusiveuk-police-wants-ai-to-stop-violent-crime-before-it-happens/> (accessed on 21 December 2019).
- Braga, Antony, Webster Daniel, Michael White, and Hildy Saizow. 2014. *Smart Approaches to Reducing Gun Violence*; Washington, DC: US Department of Justice, vol. 4.
- Brayne, Sarah. 2017. Big Data Surveillance: The Case of Policing. *American Sociological Review* 82: 977–1008. [CrossRef]
- Browning, Christopher R., Reginald A. Byron, Catherine A. Calder, Lauren J. Krivo, Mei-Po Kwan, Jae-Yong Lee, and Ruth D. Peterson. 2010. Commercial density, residential concentration, and crime: Land use patterns and violence in neighbourhood context. *Journal of Research in Crime and Delinquency* 47: 329–57. [CrossRef]

- Caplan, Joel, Leslie Kennedy, and Jeremy Barnun. 2015. Risk Terrain Modelling for Spatial Risk Assessment. *Cityscape: A Journal of Policy Development and Research* 17: 7–16.
- Caplan, Joel, Leslie Kennedy, Jeremy Barnun, and Eric Piza. 2017. Crime in Context: Utilising Risk Terrain Modelling and Conjunctive Analysis of Case Configurations to Explore the Dynamics of Criminogenic Behaviour Settings. *Journal of Contemporary Criminal Justice* 33: 133–51. [CrossRef]
- Castelvecchi, Davide. 2020. Mathematicians urge colleagues to boycott police work in wake of killings. *Nature News*, June 19. [CrossRef]
- Couchman, Hannah. 2019. Policing by Machine: Predictive Policing and the Threats to Our Rights Liberty. Available online: <https://www.libertyhumanrights.org.uk/sites/default/files/LIB%2011%20Predictive%20Policing%20Report%20WEB.pdf> (accessed on 21 December 2019).
- Crisp, W. 2019. Concern Hub: New Metropolitan Police Gang Database Sparks Privacy and Profiling Fears. *Independent*, March 13. Available online: <https://www.independent.co.uk/news/uk/crime/concern-hub-metropolitan-police-gang-matrix-database-a8812371.html> (accessed on 1 August 2019).
- Cutting Crime Impact (CCI). 2020. *Fact Sheet: Predictive Policing*. Salford: CCI.
- Dencik, Lina, Arne Hintz, Joanna Redden, and Harry Warne. 2018. *Data Scores as Governance: Investigating Uses of Citizen Scoring in Public Services*. Research Report. Cardiff: Cardiff University.
- Dodd, Vikram. 2018. Police gang strategy 'targets people unlikely to commit violence'. *The Guardian*, May 7. Available online: <https://www.theguardian.com/uk-news/2018/may/07/police-gang-violence-matrix-strategy-haringey-london-assessments> (accessed on 21 December 2018).
- Eck, John E., YongJei Lee, O. SooHyun, and Natalie Martinez. 2017. Compared to what? Estimating the relative concentration of crime at places using systematic and other reviews. *Crime Science* 6: 1–17. [CrossRef]
- Ensign, Danielle, Sorelle Friedler, Scott Neville, and Carlos Scheidegger. 2018. Runaway feedback loops in predictive policing. *Proceedings of Machine Learning Research* 81: 1–12.
- Ferguson, Andrew. 2017. Policing predictive policing. *Washington University Law Review* 94: 1109–88.
- Ferguson, Andrew. 2020. Predictive Policing Theory. *Washington College of Law Research* 24: 2020–10.
- Gerstner, Dominik. 2018. Predictive Policing in the context of Residential Burglary: An Empirical Illustration on the Basis of a Pilot Project in Baden-Württemberg, Germany. *European Journal for Security Research*. [CrossRef]
- Gstrein, Oskar J., Anno Bunnik, and Andrej Zwitter. 2020. Ethical, legal and social challenges of Predictive Policing. *Catolica Law Review* 3: 77–98.
- Halterlein, Jens. 2021. Epistemologies of predictive policing: Mathematical social science, social physics and machine learning. *Big Data & Society*, 1–13. [CrossRef]
- Hardyns, Wim, and Anneleen Rummens. 2017. Predictive Policing as a New Tool for Law Enforcement? Recent Developments and Challenges. *European Journal on Criminal Policy and Research*. [CrossRef]
- Isaac, William. S. 2018. Hope, Hype, and Fear: The Promise and Potential Pitfalls of Artificial Intelligence in Criminal Justice. *Ohio State Journal of Criminal Law* 15: 543–58.
- Jansen, Fieke. 2018. *Data Driven Policy in the Context of Europe*. Working Paper. Cardiff: Data Justice Lab, May 7.
- Kennedy, Leslie, Joel Caplan, Eric Piza, and Henri Buccine-Shrader. 2015. Vulnerability and Exposure to Crime: Applying Risk Terrain Modelling to the Study of Assault in Chicago. *Applied Spatial Analysis and Policing* 9: 529–48. [CrossRef]
- Kutnowski, Moish. 2017. The ethical dangers and merits of predictive policing. *Journal of Community Safety & Wellbeing* 2: 13–17.
- Lee, YonJei, John Eck, O SooHyn, and Natalie Martinez. 2017. How concentrated is crime at places? A systematic review from 1970 to 2015. *Crime Science* 6: 1–16. [CrossRef]
- Lepola, Joy. 2018. Baltimore faces up to 55 possible lawsuits over police corruption. *Fox News*, June 19.
- Lopes, Giza, Marvin D. Krohn, Alan J. Lizotte, Nicole M. Schmidt, Bob E. Vasquez, and Jon G. Bernburg. 2012. Labelling and cumulative disadvantage: The impact of formal police Intervention on life chances and crime during emerging adulthood. *Crime & Delinquency* 58: 456–88.
- Lum, Kristian, and William Isaac. 2016. To predict and serve? *Significance* 13: 14–19. [CrossRef]
- Martens, Pascal. 2017. Predictive Policing: Tension between Analytics and Intuition. Master's dissertation, Canterbury Christ Church University, Canterbury, UK.
- Meijer, Albert, and Martijn Wessels. 2019. Predictive Policing; Review of Benefits and drawbacks. *International Journal of Public Administration* 42: 1031–39. [CrossRef]
- Panelli, Jeremy. 2018. Ethics of Predictive Policing. *Viterbi Conversations in Ethics* 2. Available online: <https://vce.usc.edu/volume-2-issue-2/ethics-of-predictive-policing/> (accessed on 23 June 2020).
- Pearsall, Beth. 2010. Predictive policing: The Future of Law Enforcement. *National Institute of Justice Journal* 266: 16–19.
- Perry, Walter L., Brian McInnis, Carter C. Price, Susan C. Smith, and John S. Hollywood. 2013. *Predictive Policing: The Role of Crime Forecasting in Law Enforcement Operations*. Washington, DC: RAND Corporation.
- Portland State University (PSU). 2012. Predictive Policing: A Review of Literature. Criminology and Criminal Justice Senior Capstone Project, Paper 5. Available online: http://pdxscholar.library.pdx.edu/ccj_capstone/5 (accessed on 15 May 2020).
- Querbach, Maximilian. 2019. Review of State of art: Predictive Policing. *Cutting Crime Impact*, April 30.
- Richardson, Rashida, Jason M. Schultz, and Kate Crawford. 2019. Dirty Predictions: How civil Rights violations impact police data, predictive policing and justice. *New York University Law Review* 94: 193–64.

- Robinson, David G. 2017. The challenges of Prediction: Lessons from Criminal Justice. *I/S: A Journal of Law and Policy* 14: 152–86.
- Saunders, Jessica, Priscilla Hunt, and John S. Hollywood. 2016. Predictions put into practice: A quasi-experimental evaluation of Chicago's predictive policing pilot. *Journal of Experimental Criminology* 12: 347–71. [CrossRef]
- Scanlan, Jeremiah. 2019. Auditing Predictive Policing. *Brigham Young University Prelaw Review* 33: 4.
- Scott, Stafford. 2018. The War on Gangs or a Racialised War on Working Class Black Youths Monitoring Group. Available online: <http://www.tmg-uk.org/wp-content/uploads/2018/05/The-war-on-Gangs-FINAL.pdf> (accessed on 23 June 2020).
- Shapiro, Aaron. 2017. Reform Predictive policing. *Nature* 541: 458–60. [CrossRef]
- Sherman, Lawrence W. 2013. The rise of evidence based policing: Targeting, Testing and Tracking. *Crime and Justice* 42: 377–426. [CrossRef]
- Shneiderman, Ben. 2016. The Dangers of Faulty, Biased, or Malicious Algorithms Requires independent oversight. *Proceedings of the National Academy of Sciences* 113: 13538–39. [CrossRef]
- Sommerer, Lucia M. 2017. Geospatial Predictive policing: Research outlook & a call for legal debate. *N K Neue Kriminalpolitik* 29: 147–64.
- Strikwerda, Litska. 2020. Predictive policing: The risks associated with risks assessment. *Police Journal: Theory, Practice and Principles* 20: 1–15. [CrossRef]
- Summers, Lucia D., and Kim Rossimo. 2018. Offender interviews: Implications for intelligence-led policing. *Policing: An International Journal* 42: 31–42. [CrossRef]
- Turner, George, Jeff Brantingham, and George Mohler. 2014. Technology Talk: Predictive policing in action in Atlanta, Georgia. *The Police Chief* 81: 72–74.
- Weisburd, David. 2015. The law of crime concentration and the criminology of place. *Criminology* 53: 133–57. [CrossRef]
- Wilson, Dean. 2020. Predictive policing management: A brief history of patrol automation. *New Formations: A Journal of Culture, Theory, Politics* 98: 139–55. [CrossRef]
- Zwitter, Andrej. 2015. Big data and international relations. *Ethics & International Affairs* 29: 377–89.