Considerations on the UK Re-Arrest Hazard Data Analysis: How Model Selection can alter Conclusions for Policy Development

Brett Houlding and Simon P. Wilson

Discipline of Statistics, Trinity College Dublin, Ireland.
Introduction

- Profiling a person’s deoxyribonucleic acid (DNA) following an arrest, but where No Further Action (NFA) is subsequently taken, divides the opinions of society.
Introduction

- Profiling a person’s deoxyribonucleic acid (DNA) following an arrest, but where No Further Action (NFA) is subsequently taken, divides the opinions of society.

- Those against the practise argue it discriminates members of society from others who are also entitled to a presumption of innocence, leading to stigmatization.
Introduction

- Profiling a person’s deoxyribonucleic acid (DNA) following an arrest, but where No Further Action (NFA) is subsequently taken, divides the opinions of society.
- Those against the practise argue it discriminates members of society from others who are also entitled to a presumption of innocence, leading to stigmatization.
- They also claim all non-convicted or cautioned individuals should have the same right to a private life.
Introduction

- Profiling a person’s deoxyribonucleic acid (DNA) following an arrest, but where No Further Action (NFA) is subsequently taken, divides the opinions of society.

- Those against the practise argue it discriminates members of society from others who are also entitled to a presumption of innocence, leading to stigmatization.

- They also claim all non-convicted or cautioned individuals should have the same right to a private life.

- Alternatively, those in favour claim that, other than if a person were to commit a future offence, such profiling should have no direct consequence.
Introduction

- Profiling a person’s deoxyribonucleic acid (DNA) following an arrest, but where No Further Action (NFA) is subsequently taken, divides the opinions of society.

- Those against the practise argue it discriminates members of society from others who are also entitled to a presumption of innocence, leading to stigmatization.

- They also claim all non-convicted or cautioned individuals should have the same right to a private life.

- Alternatively, those in favour claim that, other than if a person were to commit a future offence, such profiling should have no direct consequence.

- They also cite studies claiming that persons subject to NFA are statistically more likely to be arrested again in the future.
ACPO Retention

- At present, the policy for processing of DNA and Identification profiles for Constabularies within England and Wales is determined by the Association of Chief Police Officer’s (ACPO) 2006 Retention Guidelines for Nominal Records on the Police National Computer.
ACPO Retention

- At present, the policy for processing of DNA and Identification profiles for Constabularies within England and Wales is determined by the Association of Chief Police Officer’s (ACPO) 2006 Retention Guidelines for Nominal Records on the Police National Computer.
- This requires indefinite retention unless the arestee can prove their case is exceptional, e.g., prove no offence existed, or arrest was unlawful.
ACPO Retention

- At present, the policy for processing of DNA and Identification profiles for Constabularies within England and Wales is determined by the Association of Chief Police Officer’s (ACPO) 2006 Retention Guidelines for Nominal Records on the Police National Computer.

- This requires indefinite retention unless the arestee can prove their case is exceptional, e.g., prove no offence existed, or arrest was unlawful.

- This changes the burden of proof from the State to that of the suspect.
ACPO Retention

- At present, the policy for processing of DNA and Identification profiles for Constabularies within England and Wales is determined by the Association of Chief Police Officer’s (ACPO) 2006 Retention Guidelines for Nominal Records on the Police National Computer.
- This requires indefinite retention unless the arestee can prove their case is exceptional, e.g., prove no offence existed, or arrest was unlawful.
- This changes the burden of proof from the State to that of the suspect.
- As such, by 2010 there were over 5 million people on the UK database with approximately 1 million of these subject to NFA.
This policy was challenged, first unsuccessfully through the UK judicial system, before successfully being appealed in the European Court of Human Rights (ECtHR): *S & Marper vs. UK, 2008.*
Court Rulings

- This policy was challenged, first unsuccessfully through the UK judicial system, before successfully being appealed in the European Court of Human Rights (ECtHR): *S & Marper vs. UK, 2008*.

- In particular, the ECtHR ruled the policy was an unlawful violation of a person’s rights under Article 8 European Convention on Human Rights:
Court Rulings

• This policy was challenged, first unsuccessfully through the UK judicial system, before successfully being appealed in the European Court of Human Rights (ECtHR): *S & Marper vs. UK*, 2008.

• In particular, the ECtHR ruled the policy was an unlawful violation of a person’s rights under Article 8 European Convention on Human Rights:

  1. *Everyone has the right to respect for his private and family life, his home and his correspondence.*
This policy was challenged, first unsuccessfully through the UK judicial system, before successfully being appealed in the European Court of Human Rights (ECtHR): *S & Marper vs. UK, 2008.*

In particular, the ECtHR ruled the policy was an unlawful violation of a person’s rights under Article 8 European Convention on Human Rights:

1. *Everyone has the right to respect for his private and family life, his home and his correspondence.*
2. *There shall be no interference ... except such as is ... necessary ... for the prevention of disorder or crime ...*
Court Rulings

• As part of the proceedings in the ECtHR, representatives of the UK referred to what was described as impressive statistical reports:
Court Rulings

• As part of the proceedings in the ECtHR, representatives of the UK referred to what was described as impressive statistical reports:

• By 30th September 2005, the National DNA database held profiles of approximately 181,000 persons subject to either NFA or acquittal, out of which 8,251 were subsequently linked with crime scene stains of 13,079 claimed offences, including 109 murders, 55 attempted murders, 116 rapes, 67 sexual offences, 105 aggravated burglaries, and 126 offences of the supply of controlled drugs.
Court Rulings

- The Applicants’ Representative argued that such statistics were misleading and lacked empirical evidence for justifying indefinite retention.
Court Rulings

- The Applicants’ Representative argued that such statistics were misleading and lacked empirical evidence for justifying indefinite retention.

- In particular, it did not reveal the extent of any link between being associated with a crime scene sample and obtaining any conviction that might otherwise not have been obtained.
The Applicants’ Representative argued that such statistics were misleading and lacked empirical evidence for justifying indefinite retention.

In particular, it did not reveal the extent of any link between being associated with a crime scene sample and obtaining any conviction that might otherwise not have been obtained.

Also, for the majority of cases mentioned, the matches were only with earlier crime scene stains already retained on the database, meaning they would have been made in any case despite any further retention.
Government Response

- Until the UK Government changes its legislation, ACPO intend to continue previous guidelines.
Government Response

- Until the UK Government changes its legislation, ACPO intend to continue previous guidelines.

- In 2010 the then Labour Government passed the Crime and Securities Act 2010, limiting retention to 6 years (though, due to a subsequent change in Government this never received a commencement order).
Government Response

- Until the UK Government changes its legislation, ACPO intend to continue previous guidelines.
- In 2010 the then Labour Government passed the Crime and Securities Act 2010, limiting retention to 6 years (though, due to a subsequent change in Government this never received a commencement order).
- The 6 year retention policy is in line with conclusions from a UK Home Office arrest-arrest analysis.
Government Response

- Until the UK Government changes its legislation, ACPO intend to continue previous previous guidelines.

- In 2010 the then Labour Government passed the Crime and Securities Act 2010, limiting retention to 6 years (though, due to a subsequent change in Government this never received a commencement order).

- The 6 year retention policy is in line with conclusions from a UK Home Office arrest-arrest analysis.

- The new Coalition Government, however, intends to adopt the Scottish model (only retain profiles of suspects of violent or sexual crimes for up to 3 years).
"I want finally to turn to DNA, which is another area where we believe that the Government are going too far. My right hon. Friend the Member for Kingston upon Hull West and Hessle had already legislated for safeguards on DNA use, including a six-year limit on retention for those who were not convicted. He based those safeguards on analysis of reoffending rates and the benefits in terms of preventing and solving crimes. The Government have decided to reject those safeguards and to go much further in restricting the use of DNA, but not on the basis of evidence."

Rt. Hon Yvette Cooper, Shadow Home Secretary, in the 2nd Parliamentary Reading of the Protection of Freedom Bill, 1 March 2011.
Further Judicial Challenge

- In May 2011 the UK Supreme Court (in a decision of 5 out of 7) found ACPO’s Guidelines as unlawful under the Human Rights Act, but stopped short of proposing a ‘lawful’ alternative.
Further Judicial Challenge

• In May 2011 the UK Supreme Court (in a decision of 5 out of 7) found ACPO’s Guidelines as unlawful under the Human Rights Act, but stopped short of proposing a ‘lawful’ alternative.

• In particular Lady Hale noted that:
Further Judicial Challenge

- In May 2011 the UK Supreme Court (in a decision of 5 out of 7) found ACPO’s Guidelines as unlawful under the Human Rights Act, but stopped short of proposing a ‘lawful’ alternative.

- In particular Lady Hale noted that:

- “The Equality and Human Rights Commission argue, in their intervention in this case, that the premise on which such data are kept, that people who are arrested are more likely than the general population to be involved in future offending, is unsustainable”.
In May 2011 the UK Supreme Court (in a decision of 5 out of 7) found ACPO’s Guidelines as unlawful under the Human Rights Act, but stopped short of proposing a ‘lawful’ alternative.

In particular Lady Hale noted that:

“The Equality and Human Rights Commission argue, in their intervention in this case, that the premise on which such data are kept, that people who are arrested are more likely than the general population to be involved in future offending, is unsustainable”.

“...It is not clear that the underlying premise is indeed that people who have been arrested but not charged or convicted are more likely than the general population to commit crimes...”
Re-Arrest Data Analysis

• To determine a statistical basis for DNA retention beyond an initial check against historical crime scene samples, the Home Office performed an analysis on arrest-to-arrest rates.
Re-Arrest Data Analysis

• To determine a statistical basis for DNA retention beyond an initial check against historical crime scene samples, the Home Office performed an analysis on arrest-to-arrest rates.

• The aim was to establish a probability of future arrest as a function of time elapsed since initial arrest.
Re-Arrest Data Analysis

- To determine a statistical basis for DNA retention beyond an initial check against historical crime scene samples, the Home Office performed an analysis on arrest-to-arrest rates.

- The aim was to establish a probability of future arrest as a function of time elapsed since initial arrest.

- As such, the NFA population arrested in April 2006 (NFA Group) were monitored until 1st August 2009 to observe if they were re-arrested.
Re-Arrest Data Analysis

- To determine a statistical basis for DNA retention beyond an initial check against historical crime scene samples, the Home Office performed an analysis on arrest-to-arrest rates.

- The aim was to establish a probability of future arrest as a function of time elapsed since initial arrest.

- As such, the NFA population arrested in April 2006 (NFA Group) were monitored until 1st August 2009 to observe if they were re-arrested.

- Arrest-Conviction and Conviction-Conviction rates, whilst being more appropriate, were not considered as in the former there would be a time lapse from court procedures, whilst the latter would not have supported any response to the ECtHR ruling.
Re-Arrest Data Analysis

- The NFA Group consisted of 17,239 individuals, 6,748 of whom were found to be re-arrested over the monitoring period.
Re-Arrest Data Analysis

- The NFA Group consisted of 17,239 individuals, 6,748 of whom were found to be re-arrested over the monitoring period.

- Denoting $T$ as the unknown number of years until future arrest, interest was in estimating the hazard rate $h(t)$:

$$h(t) = \lim_{\Delta t \to 0} P(t < T < t + \Delta t \mid T > t) \approx P(t < T < t + 1 \mid T > t)$$
## Data

<table>
<thead>
<tr>
<th>Years</th>
<th>Arrested</th>
<th>Sample</th>
<th>Q. Hzd.</th>
<th>A. Hzd.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>1,500</td>
<td>17,239</td>
<td>8.7%</td>
<td>30.5%</td>
</tr>
<tr>
<td>0.50</td>
<td>990</td>
<td>15,739</td>
<td>6.3%</td>
<td>22.9%</td>
</tr>
<tr>
<td>0.75</td>
<td>772</td>
<td>14,749</td>
<td>5.2%</td>
<td>19.3%</td>
</tr>
<tr>
<td>1.00</td>
<td>618</td>
<td>13,977</td>
<td>4.4%</td>
<td>16.5%</td>
</tr>
<tr>
<td>1.25</td>
<td>523</td>
<td>13,359</td>
<td>3.9%</td>
<td>14.8%</td>
</tr>
<tr>
<td>1.50</td>
<td>441</td>
<td>12,836</td>
<td>3.4%</td>
<td>13.1%</td>
</tr>
<tr>
<td>1.75</td>
<td>364</td>
<td>12,395</td>
<td>2.9%</td>
<td>11.2%</td>
</tr>
<tr>
<td>2.00</td>
<td>334</td>
<td>12,031</td>
<td>2.8%</td>
<td>10.7%</td>
</tr>
<tr>
<td>2.25</td>
<td>313</td>
<td>11,697</td>
<td>2.7%</td>
<td>10.3%</td>
</tr>
<tr>
<td>2.50</td>
<td>237</td>
<td>11,384</td>
<td>2.1%</td>
<td>8.1%</td>
</tr>
<tr>
<td>2.75</td>
<td>234</td>
<td>11,147</td>
<td>2.1%</td>
<td>8.1%</td>
</tr>
<tr>
<td>3.00</td>
<td>218</td>
<td>10,913</td>
<td>2.0%</td>
<td>7.8%</td>
</tr>
<tr>
<td>3.25</td>
<td>204</td>
<td>10,695</td>
<td>1.9%</td>
<td>7.4%</td>
</tr>
</tbody>
</table>
The Quarterly Hazard Rate is the percentage of the sample arrested in the Quarter.
Data

- The Quarterly Hazard Rate is the percentage of the sample arrested in the Quarter.

- This is annualized by assuming it remains constant over the next successive three quarters.
Data

- The Quarterly Hazard Rate is the percentage of the sample arrested in the Quarter.

- This is annualized by assuming it remains constant over the next successive three quarters.

- Hence $\text{Ann. Hzd.} = 100(1 - (1 - \text{Q. Hzd.}/100)^4)$. 
Weibull & Exponential Models

- For the first year after arrest, the estimated hazard was taken to be the observed annualized hazard.
Weibull & Exponential Models

- For the first year after arrest, the estimated hazard was taken to be the observed annualized hazard.
- Beyond the first year a power-curve regression was fitted by assuming \( h(t) = at^b \), which arises from a Wiebull survival model.
Weibull & Exponential Models

- For the first year after arrest, the estimated hazard was taken to be the observed annualized hazard.

- Beyond the first year a power-curve regression was fitted by assuming \( h(t) = at^b \), which arises from a Wiebull survival model.

- The parameters were found to be \( a = 0.166 \) and \( b = -0.686 \).
Weibull & Exponential Models

- For the first year after arrest, the estimated hazard was taken to be the observed annualized hazard.

- Beyond the first year a power-curve regression was fitted by assuming $h(t) = at^b$, which arises from a Wiebull survival model.

- The parameters were found to be $a = 0.166$ and $b = -0.686$.

- Using data on national arrest rates an all-person comparator value of general arrest risk was also estimated as $h(t) = 0.049$, which arises from an Exponential survival model.
Results

![Graph showing estimated probability of arrest within the next year conditional on arrest not already occurred over years from initialization of study. The graph compares two groups: NFA Group (solid line) and All Person Comparator (dashed line). The y-axis represents the estimated probability ranging from 0.00 to 0.30. The x-axis represents the years from the initialization of the study, ranging from 0 to 8. Key milestones are marked: Start of use of model at year 1 and End of monitoring at year 8.]
Confidence Intervals

- No straightforward method of determining actual confidence intervals without making further assumptions, but here we considered the following ‘bootstrap’ type approach:
Confidence Intervals

- No straightforward method of determining actual confidence intervals without making further assumptions, but here we considered the following ‘bootstrap’ type approach:

- 95% CIs for the estimated parameters of the model were considered as providing bounds on regions where 95% of the probability mass would be located under the assumption that these parameters were Normally distributed.
Confidence Intervals

- So if $a$ has 95% CI $(a_L, a_U)$, then the mean $\mu_a$ and variance $\sigma_a^2$ of the Normal distribution are calculated as $\mu_a = (a_L + a_U)/2$ and $\sigma_a^2 = (a_U - a_L)^2/2$. 
Confidence Intervals

• So if \( a \) has 95\% CI \((a_L, a_U)\), then the mean \( \mu_a \) and variance \( \sigma_a^2 \) of the Normal distribution are calculated as \( \mu_a = (a_L + a_U)/2 \) and \( \sigma_a^2 = (a_U - a_L)^2/2 \).

• 1,000 simulations were then drawn from this Normal distribution, and for each simulation, the resulting hazard curve was calculated.
Confidence Intervals

- So if $a$ has 95% CI $(a_L, a_U)$, then the mean $\mu_a$ and variance $\sigma^2_a$ of the Normal distribution are calculated as $\mu_a = (a_L + a_U)/2$ and $\sigma^2_a = (a_U - a_L)^2/2$.

- 1,000 simulations were then drawn from this Normal distribution, and for each simulation, the resulting hazard curve was calculated.

- An approximate 95% CI for the hazard curve was then estimated by calculating the 2.5 percentile and the 97.5 percentile of the value of the simulated hazard curves for each time point.
Weibull & Exponential Models

- For the NFA group the parametric hazard rate was a power curve function of time $t$, whilst for the all-person comparator this was independent of $t$. Both are common modeling assumptions within reliability modeling.
Weibull & Exponential Models

• For the NFA group the parametric hazard rate was a power curve function of time $t$, whilst for the all-person comparator this was independent of $t$. Both are common modeling assumptions within reliability modeling.

• A constant hazard arises from the assumption that the time to event (arrest) follows an exponential distribution, which is appropriate when systems do not degrade over time and when the times between events occur continuously and independently at a constant average rate.
Weibull & Exponential Models

- For the NFA group the parametric hazard rate was a power curve function of time $t$, whilst for the all-person comparator this was independent of $t$. Both are common modeling assumptions within reliability modeling.

- A constant hazard arises from the assumption that the time to event (arrest) follows an exponential distribution, which is appropriate when systems do not degrade over time and when the times between events occur continuously and independently at a constant average rate.

- The Weibull assumption, however, is appropriate when event (arrest) occurs as a result of the first of a number of competing and comparable independent processes fails. Could these independent and comparable processes be suspicion of the commission of any number of crimes?
Paradoxical Results

- Note that under the exponential model, \( E[T] = 20.4 \) and that \( P(T \leq 15) > 0.5 \).
Paradoxical Results

- Note that under the exponential model, $E[T] = 20.4$ and that $P(T \leq 15) > 0.5$.
- For the Weibull model $E[T] = 57.9$ (?!?), whist $P(T \leq 2) > 0.5$. 
Paradoxical Results

- Note that under the exponential model, \( E[T] = 20.4 \) and that \( P(T \leq 15) > 0.5 \).
- For the Weibull model \( E[T] = 57.9 \) (?!?), whist \( P(T \leq 2) > 0.5 \).
- This is because of tail behavior as \( t \to \infty \).
Paradoxical Results

- Note that under the exponential model, $E[T] = 20.4$ and that $P(T \leq 15) > 0.5$.
- For the Weibull model $E[T] = 57.9$ (?!?), whist $P(T \leq 2) > 0.5$.
- This is because of tail behavior as $t \to \infty$.
- Beyond $t = 6$ NFA people are less risk to society then not previously arrested people?
Probabilistic Causality

- The use of two different modeling assumptions would imply that the underlying process leading to arrest differs between the NFA group and the general population, suggesting the act of being arrested fundamentally alters the assumed behavior of that person.
Probabilistic Causality

- The use of two different modeling assumptions would imply that the underlying process leading to arrest differs between the NFA group and the general population, suggesting the act of being arrested fundamentally alters the assumed behavior of that person.

- The status of a probability being greater depending on whether or not a conditional event has occurred is the subject of the theory of probabilistic causality.
Probabilistic Causality

- The use of two different modeling assumptions would imply that the underlying process leading to arrest differs between the NFA group and the general population, suggesting the act of being arrested fundamentally alters the assumed behavior of that person.

- The status of a probability being greater depending on whether or not a conditional event has occurred is the subject of the theory of probabilistic causality.

- Traditional causality is generally thought of as being one of ‘materialist’ (laws of physics), ‘spiritualist’ (supernatural beings), ‘rationalist’ (reason and consequence), and ‘phenomenalist’ (empirical observation or association).
Probabilistic Causality

- The use of two different modeling assumptions would imply that the underlying process leading to arrest differs between the NFA group and the general population, suggesting the act of being arrested fundamentally alters the assumed behavior of that person.

- The status of a probability being greater depending on whether or not a conditional event has occurred is the subject of the theory of probabilistic causality.

- Traditional causality is generally thought of as being one of ‘materialist’ (laws of physics), ‘spiritualist’ (supernatural beings), ‘rationalist’ (reason and consequence), and ‘phenomenalist’ (empirical observation or association).

- The Phenomenalist approach is relevant here.
Probabilistic Causality

- A non-zero probability event $Y$ is said to be a *prima facie* (at first sight) probabilistic cause of event $Z$ if it occurs prior to event $Z$ and if there is a positive association (correlation) between $Y$ and $Z$. 

- Think alcohol consumption and contracting lung cancer.

- Yet a *prima facie* probabilistic cause may be due to a confounding factor, and may not be a genuine probabilistic cause.

- A non-zero probability event $Y$ is said to be a spurious *prima facie* probabilistic cause if it is as above, but also such that an additional non-zero probability event $X$ occurs prior to $Y$, is such that both $X$ and $Y$ can both occur, and that the probability of $Z$'s occurrence is independent of $Y$ if $X$ does occur.

- Think alcohol consumption, smoking, and contracting lung cancer.
Probabilistic Causality

- A non-zero probability event $Y$ is said to be a *prima facie* (at first sight) probabilistic cause of event $Z$ if it occurs prior to event $Z$ and if there is a positive association (correlation) between $Y$ and $Z$.

- Think alcohol consumption and contracting lung cancer.
Probabilistic Causality

- A non-zero probability event $Y$ is said to be a *prima facie* (at first sight) probabilistic cause of event $Z$ if it occurs prior to event $Z$ and if there is a positive association (correlation) between $Y$ and $Z$.

- Think alcohol consumption and contracting lung cancer.

- Yet a *prima facie* probabilistic cause may be due to a confounding factor, and may not be a genuine probabilistic cause.
Probabilistic Causality

- A non-zero probability event $Y$ is said to be a *prima facie* (at first sight) probabilistic cause of event $Z$ if it occurs prior to event $Z$ and if there is a positive association (correlation) between $Y$ and $Z$.

- Think alcohol consumption and contracting lung cancer.

- Yet a *prima facie* probabilistic cause may be due to a confounding factor, and may not be a genuine probabilistic cause.

- A non-zero probability event $Y$ is said to be a spurious *prima facie* probabilistic cause if it is as above, but also such that an additional non-zero probability event $X$ occurs prior to $Y$, is such that both $X$ and $Y$ can both occur, and that the probability of $Z$'s occurrence is independent of $Y$ if $X$ does occur.
Probabilistic Causality

- A non-zero probability event $Y$ is said to be a *prima facie* (at first sight) probabilistic cause of event $Z$ if it occurs prior to event $Z$ and if there is a positive association (correlation) between $Y$ and $Z$.

- Think alcohol consumption and contracting lung cancer.

- Yet a *prima facie* probabilistic cause may be due to a confounding factor, and may not be a genuine probabilistic cause.

- A non-zero probability event $Y$ is said to be a spurious *prima facie* probabilistic cause if it is as above, but also such that an additional non-zero probability event $X$ occurs prior to $Y$, is such that both $X$ and $Y$ can both occur, and that the probability of $Z$'s occurrence is independent of $Y$ if $X$ does occur.

- Think alcohol consumption, smoking, and contracting lung cancer.
Probabilistic Causality

- As an example, various studies have considered whether or not time spent under a custodial sentence increases offence risk upon release?
Probabilistic Causality

- As an example, various studies have considered whether or not time spent under a custodial sentence increases offence risk upon release?
- A 2002 Home Office Prison Statistics Report commissioned to consider this question noted that:

The proportion of prisoners reconvicted following discharge from custody is mainly associated with the characteristics of those offenders, rather than the impact of custody. The main predictors of reconviction are: the number and rate of previous convictions, age at sentence, whether they are male or female, and the type of offence for which they were imprisoned...

When comparing the impact of custody on reconviction rates over time it is therefore necessary to control for changes in the characteristics of offenders being given custodial sentences.
Probabilistic Causality

- As an example, various studies have considered whether or not time spent under a custodial sentence increases offence risk upon release?

- A 2002 Home Office Prison Statistics Report commissioned to consider this question noted that:

- The proportion of prisoners reconvicted following discharge from custody is mainly associated with the characteristics of those offenders, rather than the impact of custody. The main predictors of reconviction are: the number and rate of previous convictions, age at sentence, whether they are male or female, and the type of offence for which they were imprisoned...
Probabilistic Causality

- As an example, various studies have considered whether or not time spent under a custodial sentence increases offence risk upon release?
- A 2002 Home Office Prison Statistics Report commissioned to consider this question noted that:
  - The proportion of prisoners reconvicted following discharge from custody is mainly associated with the characteristics of those offenders, rather than the impact of custody. The main predictors of reconviction are: the number and rate of previous convictions, age at sentence, whether they are male or female, and the type of offence for which they were imprisoned...
- When comparing the impact of custody on reconviction rates over time it is therefore necessary to control for changes in the characteristics of offenders being given custodial sentences.
Mixture Exponential

- To avoid this problem of using different probabilistic rationales we can consider the use of a Mixture Exponential.
**Mixture Exponential**

- To avoid this problem of using different probabilistic rationales we can consider the use of a Mixture Exponential.

- The time to future arrest $T$ either follows the Exponential model of the all-person comparator with probability $p$, or follows another Exponential with rate parameter $\alpha > 0.049$. 

---

**UK DNA Retention Policy**

**Re-Arrest Data Analysis**

**Discussion**
Mixture Exponential

• To avoid this problem of using different probabilistic rationales we can consider the use of a Mixture Exponential.

• The time to future arrest $T$ either follows the Exponential model of the all-person comparator with probability $p$, or follows another Exponential with rate parameter $\alpha > 0.049$.

• Allows modelling of a situation whereby some of the NFA group are no different to the general un-arrested population, whilst others are more inclined to criminality.
Mixture Exponential

- To avoid this problem of using different probabilistic rationales we can consider the use of a Mixture Exponential.

- The time to future arrest $T$ either follows the Exponential model of the all-person comparator with probability $p$, or follows another Exponential with rate parameter $\alpha > 0.049$.

- Allows modelling of a situation whereby some of the NFA group are no different to the general un-arrested population, whilst others are more inclined to criminality.

- Denote these as NFA-G1 and NFA-G2, respectively.
Mixture Exponential

- To avoid this problem of using different probabilistic rationales we can consider the use of a Mixture Exponential.

- The time to future arrest $T$ either follows the Exponential model of the all-person comparator with probability $p$, or follows another Exponential with rate parameter $\alpha > 0.049$.

- Allows modelling of a situation whereby some of the NFA group are no different to the general un-arrested population, whilst others are more inclined to criminality.

- Denote these as NFA-G1 and NFA-G2, respectively.

- Optimal fit under $p = 0.72$ and $\alpha = 0.87$, meaning 72% of the NFA group are no different to the un-arrested population, with the other 28% being nearly 18 times more likely to be arrested.
Results

The graph shows the estimated probability of arrest within the next year, conditional on arrest not already occurring. The x-axis represents years from the initialization of the study, while the y-axis represents the probability. Three lines are depicted:

- Solid line: NFA Group (Weibull)
- Dotted line: NFA Group (Mixture Exponential)
- Dashed line: All Person Comparator

Key events are indicated:
- Start of use of Model
- End of Monitoring

The graph illustrates how the probability of arrest decreases over time for each group.
Conditional Probability of Group Assignment

- This allows determination of the conditional probability of assignment given re-arrest has not occurred by time $t$:

\[
P(NFA - G1 | T > t) = \frac{P(T > t | NFA - G1)P(NFA - G1)}{\sum_{i=1}^{2} P(T > t | NFA - Gi)P(NFA - Gi)}
\]
Conditional Probability of Group Assignment

- This allows determination of the conditional probability of assignment given re-arrest has not occurred by time $t$:

$$P(NFA - G_1 | T > t) = \frac{P(T > t | NFA - G_1)P(NFA - G_1)}{\sum_{i=1}^2 P(T > t | NFA - G_i)P(NFA - G_i)}$$

- $P(T > t | NFA - G_1)$ is the all-person comparator model.
Conditional Probability of Group Assignment

- This allows determination of the conditional probability of assignment given re-arrest has not occurred by time $t$:

\[ P(NFA - G1 | T > t) = \frac{P(T > t | NFA - G1)P(NFA - G1)}{\sum_{i=1}^{2} P(T > t | NFA - Gi)P(NFA - Gi)} \]

- $P(T > t | NFA - G1)$ is the all-person comparator model.
- $P(T > t | NFA - G2)$ is the increased exponential model with $\alpha = 0.87$. 
Conditional Probability of Group Assignment

• This allows determination of the conditional probability of assignment given re-arrest has not occurred by time $t$:

$$P(NFA - G1|T > t) = \frac{P(T > t|NFA - G1)P(NFA - G1)}{\sum_{i=1}^{2} P(T > t|NFA - Gi)P(NFA - Gi)}$$

• $P(T > t|NFA - G1)$ is the all-person comparator model.

• $P(T > t|NFA - G2)$ is the increased exponential model with $\alpha = 0.87$.

• $P(NFA - G1) = 1 - P(NFA - G2)$ is the estimated value of $p = 0.72$. 
Results

![Graph showing the probability of being in NFA-G1 conditional on re-arrest having not occurred over years from initialization.](image-url)
Goodness of Fit

The AIC score for the Weibull model is $-80.5$, which is larger (hence worse) than that for the mixture Exponential model which is $-84.9$. 
**Goodness of Fit**

- The AIC score for the Weibull model is $-80.5$, which is larger (hence worse) than that for the mixture Exponential model which is $-84.9$.
- Note both models fit two-parameters.
Results
Discussion

- No causal explanation why arrest with NFA should make re-arrest more likely (other than violation of bail conditions).
Discussion

- No causal explanation why arrest with NFA should make re-arrest more likely (other than violation of bail conditions).
- Mixture-Exponential model has a (slightly) enhanced fit and more appropriate behavior when extrapolated.
Discussion

- No causal explanation why arrest with NFA should make re-arrest more likely (other than violation of bail conditions).

- Mixture-Exponential model has a (slightly) enhanced fit and more appropriate behavior when extrapolated.

- Whilst group membership assignment might be made with additional covariates (offence leading to arrest etc.), it supports a policy of much reduced retention duration, e.g., 95% of being no different to un-arrested population if not re-arrested after 2.42 years.