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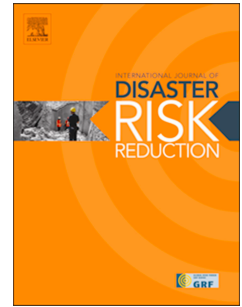
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**PERSISTENCE OF RISK AWARENESS:
MANCHESTER ARENA BOMBING ON 22 MAY 2017**

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1. Introduction

Whenever a major societal disaster strikes, the ensuing trauma heightens the sense of risk awareness, which generally fades in the public consciousness over time. For those immediately impacted by the disaster, the physical and psychological harm may last for many months, if not years, or even a lifetime. For others who have some recollection of what happened, the memory of the disaster may be reawakened from time to time, perhaps on the anniversary, or in connection with the judicial process or another similar disaster. In addition, there are those who were too young, or too distant, to have any recollection of the event.

With effective counter-terrorism operations, most terrorist plots are foiled, before the terrorists move towards their targets. Due to human outcome cognitive bias, the memory of failed plots fades much more rapidly than the memory of successful plots. Thus, the ambitious 2006 Al Qaeda liquid explosives plot, which aimed to bring down seven transatlantic aircraft and might have been the worst terrorist attack since 9/11, is unknown to most air travellers passing through airport security, with large bottles of liquids disallowed.

Terrorism risk in the countries of the western alliance is largely counterfactual (Woo, 2011). Most significant terrorist plots, including the above liquid explosives plot, are interdicted by the security services, or fail for technical reasons. Those plots which evade the security services and succeed technically are of special importance in civic terrorism risk awareness and preparedness. So even though public interest in failed terrorist plots is comparatively low, important insights into disaster risk perception, and risk communication, can be gained from tracking over time the level of public interest in an actual notable terrorist attack.

The Manchester Arena attack of 22 May 2017 was specifically chosen because of its special significance, being the worst historical terrorist attack in Northwest England as measured by casualties. The Ariane Grande concert was an optimal target for inflicting maximal societal loss; indeed, many of the victims were children. In regions where major terrorist attacks are more frequent, the attention given to any specific event will be reduced accordingly, and would have less of a shock impact.

On the evening of 22 May 2017, the American celebrity singer, Ariana Grande, with hundreds of millions of social media followers, had just finished her concert when, at 10.30pm, a backpack bomb was detonated in the foyer by Salman Abedi. From this same Arndale Centre, Salman Abedi had bought a rucksack on Friday, 19 May 2017 to be filled with improvised explosives and shrapnel such as nuts and bolts to maximise injury. Shreds of this rucksack were found in the foyer of the Manchester Arena concert venue on the following Monday night, 22 May 2017.

The national significance of this terrorist attack, which killed 22 mainly young people and injured more than a hundred others, is reflected in the statement made on the morning after by the UK Prime Minister, Theresa May: *'The people of Manchester and of this country have fallen victim to a callous terrorist attack, an attack that targeted some of the youngest people in our society with cold calculation. It is the worst attack the city has experienced and the worst-ever to hit the north of England.'*

Salman Abedi had a choice of dates to bomb the Manchester Arena. Amongst the other stars performing in May 2017 was Céline Dion. But no other performer had the universal popular draw of Ariana Grande. In the aftermath of the suicide bombing, identification of the event with a global superstar amplified the attention in social media, and coverage in the media in general.

However, with the passage of time, even the most publicised and newsworthy events disappear from public memory or even become a subject of misinformation (Elroy, Erokhin, Komendantova, & Yosipof, 2023; Elroy & Yosipof, 2022; Erokhin, Yosipof, & Komendantova, 2022). Features of human cognition lead to reliance on shortcuts, to cognitive biases which may lead to the creation of a subjective reality about the event, its causes and consequences. Without being addressed these biases can lead to inaccurate judgements and other kinds of irrationality.

Nowadays when digital technologies are providing new opportunities for the exchange of information, they can be used to disseminate information about such events. Therefore, social media which are largely based on digital technologies, are becoming an important source of information exchange. This leads to questions as to how information webs are being used to address these cognitive biases. What are the patterns of usage of such sources as Wikipedia when people are searching for information about major disasters such as the Manchester bombing? Is there any correlation between publications in mass media about the event and the

intention of people to search for further information about the event while using Wikipedia? What are the temporal dynamics of the Wikipedia Manchester bombing page traffic? The research aim of this study is to address these questions about the persistence of risk awareness. In the statistical analysis presented below, persistence is demonstrated through statistical tests. The association between persistence of Wikipedia access and risk awareness is based on the general premise that the sample of people accessing Wikipedia is sufficiently representative of the regional population as to allow such an inference. Counter-terrorism authorities need a measure of public risk awareness, because their operational effectiveness depends on it; not just so that the public are alert to potential terrorist danger, but also because the public can provide tipoffs about suspicious behaviour. The Manchester Arena bomber might potentially have been brought to police attention whilst obtaining materials and constructing his improvised explosive device, packed with nuts and bolts.

2. Background

2.1. Communication about the Manchester Arena Suicide Bombing

Manchester, the largest city of northern England, features significantly in the annals of UK terrorism. On 15 June 1996, the Irish Republican Army (IRA) detonated a 1,500 kg lorry bomb in the principal shopping district. This remains to this day the biggest bomb detonated in UK since World War II. In deference to their Catholic support base, the IRA gave a bomb warning to minimise casualties. Even so, there were several hundred injured, mostly from flying glass. With no warning of any kind provided, the terrorist attack by suicide bomber Salman Abedi was far worse in human loss outcome.

On the fourth anniversary of the Manchester Arena Suicide Bombing tragedy, in May 2021, Ariana Grande took to Instagram to share her ever-present grief with her 300 million followers, recognising that their relationship with the event is constantly evolving. By stating that her heart was with Manchester, today and always, and remembering individually each of the 22 lives lost, she endeared herself to her fans, ensuring that all over the world the memory of the victims lives on, and that a public sense of risk awareness and vigilance persists.

As a concert performer, Ariana Grande, has a personal concern over security and interest in ensuring minimum standards of security at public venues. But this requires action by law makers, and individual initiatives to promote security at public venues.

The day after the Arena bombing, an insensitive automated Facebook message invited a friend of Martyn Hett to rate his experience at the Manchester Arena. Martyn Hett, aged 29, was one of the sons who never returned from the concert. His mother, Figen Murray, has led the national UK campaign which would require all large public venues to have appropriate security measures in place. Such legislation, known as Martyn's Law, is supported by the UK government.

When Martyn's Law is eventually passed, the increased security at all large public venues will be a constant reminder of Martyn and the others who were killed or injured on 22 May 2017. This Protect Duty legislation would then be a lasting legal monument to the 22 victims of Salman Abedi, as well as being a permanent public reminder of the need for terrorism risk awareness and vigilance.

Pending such legislation, public memory of the Manchester Arena bombing five years after the terrorist attack was jogged by the publication of the second volume of the public inquiry (Saunders, 2022), which focused on the emergency response. With the report's finding that the performance of the emergency services was far below what it should have been, the tragedy of 22 May 2017 must remain at the forefront of future risk management practice. All those entrusted with public safety should be familiar with this report, which itself stands as a permanent memorial to the victims.

In the years following the Manchester Arena bombing, further news stories have revived public interest in the event. In August 2020, Hashem Abedi, was jailed for assisting his brother in his suicide bombing plot; in July 2022, his older brother, Ismail, was convicted of failing to attend a public inquiry. Sadly, a further death attributable to the trauma of the bombing was recorded in August 2021, when 20 year-old Eve Aston took her own life, after suffering depression and PTSD since attending the Ariana Grande concert.

2.2. Social media and their impact on risk perceptions

Most significant terrorist attacks are not driven by emotion or whim, but have been planned with cold calculation, ruthless and heartless in execution to leverage the maximum harmful

impact, and generate 24/7 global media publicity to promote their own terrorist agenda, and encourage recruitment. Given the global superstar status of Ariana Grande, her concert at the Manchester Arena was the optimal local target for Salman Abedi. A suicide bomber can only die once, with only one opportunity for attracting the mass publicity that terrorists desperately crave: terrorism is the language of being noticed. In this respect, the suicide bomber succeeded.

In a general assessment of the influence of media and social media during and after terrorism events, Innes et al. (2018) identified six key groups of communicative actors:

1. Perpetrators of a terror event, and their supporters;
2. Participants who were physically present at the attack scene;
3. Public reached by media and responding to the media;
4. Practitioners who orchestrate the operational response in real time;
5. Press and publicisers who report on the event;
6. Political leaders who shape reactions to the event.

Over days, weeks and months, these messenger groups are influential in the dynamics of broader social reaction. In respect of the 22 May 2017 terrorist attack, the role of each of these six messenger groups can be highlighted as follows.

[1] The perpetrator of the attack died in his own bomb blast. Islamic State (ISIS) claimed responsibility on social media for the bombing. As the civilized world mourned, ISIS supporters celebrated the Manchester suicide bombing on social media. Terrorism is the ultimate act of *Schadenfreude*: rejoicing in the misfortune and suffering of others.

[2] Around 14,000 were at the Arena, including staff and stewards. The concert attendees, their families and friends were very active on social media trying to locate loved ones, searching for information. Many Twitter messages about the missing and the found used the hashtag #MissinginManchester.

[3] The general public contributed their own commentary on the unfolding events. This commentary included some misinformation as well as occasional disinformation. In UK, millions of messages were posted on Twitter in the first 24 hours of the terrorist attack (Bérubé et al., 2018). After the initial shock of the attack, a reaction phase began with posts on Twitter focusing on the issues raised by the attack and its root causes.

[4] The practitioners involved with the operational response were hampered by the inability of Greater Manchester Police to issue an incident response number. The emergency telephone

hotline, provided by a leading commercial telecoms provider, suffered a catastrophic failure. In addition, there were other regional incidents, potentially terrorism related, which distracted police attention (Kerslake, 2018). The first responders had trained for a marauding style of terrorist attack, with multiple operatives and locations, such as struck Paris only two years earlier.

[5] The press was at the forefront of information gathering about the attack. Such press attention is an inevitable consequence of the press adage for editors keen on selling newspapers: if it bleeds, it leads. Regrettably, the press search for information led to some intrusive reporting, and harassment of families of victims. Some members of the press posed as the police in the quest for information.

[6] Political leaders, including the UK Prime Minister quoted above, were quick to condemn the brutality of the terrorist attack. The mayor of Greater Manchester, Andy Burnham, took a leading role in the Manchester response. The UK threat level was raised from severe to critical for a number of days, for the first time since 2007.

3. Use of Wikipedia page views to track public interest in the Manchester attack

The maintenance of public interest in the Manchester terrorist attack of 22 May 2017 contributes to terrorism risk awareness, and the general public alert level concerning terrorist behaviour and safety in public places. As a means of tracking public interest, Wikipedia traffic data was collected for the Manchester Arena bombing English page between 22/05/2017 and 22/11/2022 using the Wikipedia API's endpoints. The dataset includes a time series of 2,010 days, with the Manchester arena bombing page views frequency for each day. The Manchester Arena bombing page views range was found to be between 1 to 48,879 views, with a daily average of 2,001 views and standard deviation of 2,204 views. The data set is charted in Figure 1, which displays the daily views frequency for the Manchester Arena bombing English page on Wikipedia. This time series data was analysed by the following four statistical tests:

[1] Autocorrelation

This is a mathematical representation of the degree of similarity between a time series such as the Wikipedia traffic Manchester arena bombing time series and a lagged version of that time series. The autocorrelation measures the relationship between the current Manchester arena bombing page traffic and its past value.

[2] STL decomposition

A time series is comprised of mainly three main patterns: a trend, seasonality, and residuals. Decomposition is a statistical method for decomposing the time series data into these three components. The seasonal component captures the repeating patterns in the data, such as weekly or monthly fluctuations. The trend component captures the underlying trend regardless of the seasonality. The residual component represents the remaining fluctuations in the data that are not accounted for by the other two components. In this research, the daily views frequency time series was decomposed using Seasonal and Trend decomposition using the robust Loess (STL) method of time series decomposition (Cleveland et al., 1990).

[3] ARIMA

ARIMA is an Auto-Regressive Integrated Moving Average model that aims to forecast future lags in a time series. ARIMA model looks at the history of the time series and uses this history, with an error term, to predict future values of the time series.

[4] Cross-Correlation

To compare the Manchester arena bombing page traffic in English to other languages, we used the Cross-Correlation Function (CCF). CCF measure the similarity between two-time series in different lags. In this study, we used CCF to measure the relationship between the Manchester arena bombing page traffic in English and the page traffic in Arabic. The choice of Arabic is significant, because this is the official language of Libya, with which the suicide bomber, Salman Abedi, had a close association.

4. Results

Analysis of the daily frequency views time series provided in Figure 1 has identified several phenomena of interest. A recurring, seasonal peak can be observed on the Memorial Day, 22 May (marked as A's, Figure 1). The annual Memorial Day exhibits a large number of page viewers every year, between 48,879 to 25,265 views, with an average and standard deviation of $34,661 \pm 9,216$ views, respectively. The substantially larger peak at the first annual Memorial Day (22/5/2018, Figure 1), reflects the increased media coverage of the event prior to the first Memorial Day, with a series of media reports including updates about the victims and claims of misconduct of journalists when approaching victims' families (BBC, 2018).

On 22 August 2020, a pick can be seen in Figure 1 (marked as B) with a total of 22,060 page views for the conviction of Hashem Abedi, the brother of the suicide bomber. Another notable pick on the time series can be seen on 3 November 2022 (Figure 1, marked as C) with a frequency of 14,595 page views for the publication of the important public inquiry second report investigating the emergency response on the day of the bombing (Saunders, 2022).

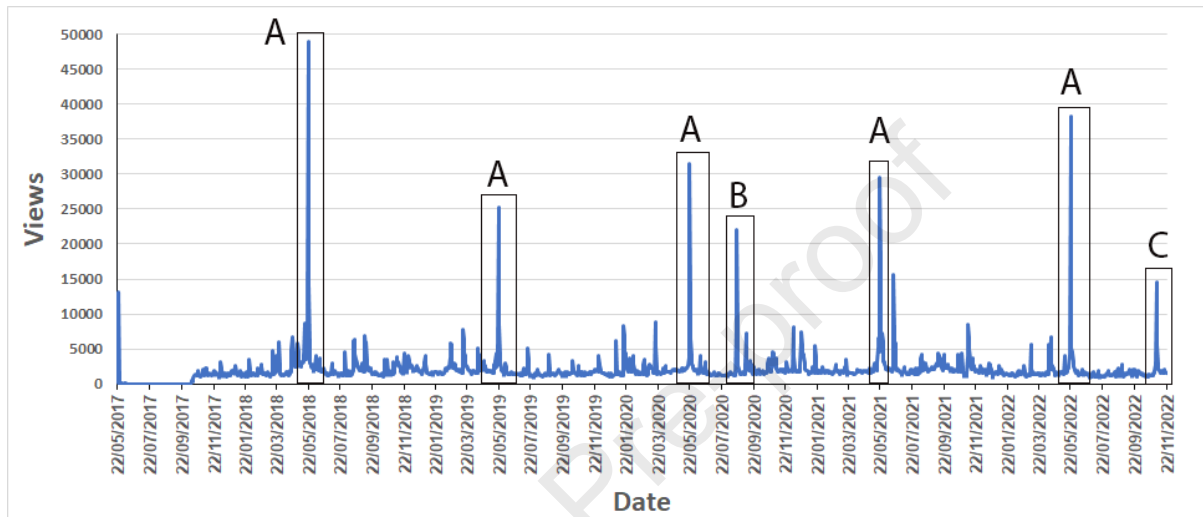


Figure 1: Wikipedia daily views frequency for the Manchester Arena bombing page in English.

Analysis of the temporal dynamics characteristics of the views frequency time series found high autocorrelation at the first lag ($r=0.55$, $p\text{-value}<0.001$). High autocorrelation implies stronger persistence of the viewer's behaviour from one day to the next for the Manchester Arena bombing. The autocorrelation test results suggest that the temporal characteristics of the viewer's behaviour depend on the previous day. This is indicative of temporal persistence of public interest in the event. Any media publicity about the event would impact Wikipedia views for a few days.

The STL decomposition decomposes the time series into the trend, seasonal and residual components. Most fluctuations were explained using the trend and seasonality indicating a yearly seasonal systematic pattern (May of each year). To determine the main effect on time series, the strength of the trend and seasonality of the time series were calculated. The strength of the trend and seasonality is computed using the variation of the three components, and the scale is between 0 to 1, representing no trend/seasonal and high trend/seasonal, respectively. The seasonal effect was high (0.66), while the trend strength was low (0.15), determining that the time series is mainly affected by the seasonal pattern. The 22 May anniversary of the

Manchester Arena bombing is the most significant recurring date for public remembrance of that ill-fated day in 2017. The broadcast media focus on such anniversaries of national importance.

The ARIMA model consist of three parameters p , d , and q . The p corresponds to the order of the autoregressive component which represents the relationship between the current value and its past value. The d corresponds to the order of the difference component and the q corresponds to the moving average component that represents the relationship between the current value and the past residual. The order of the optimal ARIMA model was found to be (1,0,1) meaning the model uses one autoregressive term (AR), no differencing, and one moving average term (MA) see equation 1. Where y_t represents the Manchester arena bombing English page traffic in time t .

$$(1) y_t = 2001.28 + 0.58y_{t-1} - 0.08MA_{t-1}$$

The autoregressive (AR) term (y_{t-1} , equation 1) was found to be with a coefficient of 0.58 which defines a positive relationship between the current value of the time series and the value at lag $t-1$. The moving average term (MA_{t-1} , equation 1) was found to be with a coefficient of -0.08, indicating a negative relationship between the current value of the time series and the past error at lag $t-1$. The ARIMA model indicates that the weight given to the AR coefficient, which represents the weight given to the past value at lag $t-1$ accounts for most of the variation in the time series. This means that most of the variation in the Manchester Arena bombing Wikipedia page views frequency at day t can be explained by its past value at lag $t-1$. This is further indication of temporal persistence in general interest in the Manchester suicide bombing.

In comparison to the Manchester arena bombing page traffic in English, the Manchester arena bombing page traffic in Arabic exhibits a lower traffic. The Manchester Arena bombing Arabic page views range was found to be between 0 to 3,695 views, with a daily average of 20 views and a standard deviation of 124 views. Similar to the English page a recurring, seasonal peak was observed on the Memorial Day, 22 May. While the publication of the public inquiry second report investigating the emergency response on the 3 November 2022 cannot be seen in the traffic of the Arabic page, and only 25 people visited the Arabic page on that day. The cross-correlation results between the English and the Arabic page show a positive correlation of $r=0.12$ between the daily traffic of the English and the Arabic page at time t . This finding means

that a change in the traffic of either language is reflected in the traffic of the other language on the same day.

Whilst the temporal persistence has been investigated, there is a lack of geographical resolution of Wikipedia page views. However, the comparative analysis of Arabic page views is interesting for terrorism risk analysts, because of the ISIS support for the Manchester Arena attack. For Arabic-speaking Islamist extremists, the anniversary of the successful Jihadist attack is noteworthy, whilst the English public inquiry would not be.

A proportion of the Wikipedia English page views may originate from outside UK, especially amongst international fans of Ariana Grande, but the great majority are likely to be from UK, where there was the most media publicity about the Manchester Arena bombing. Research by Roach et al. (2020) has indicated that a footprint of fear is essentially localised in close proximity to the site of the terrorist attack, and that those closest will be the most frightened.

4.1 Conclusions

An analysis of Wikipedia page views for a period of five and a half years following the terrorist attack shows the persistence of interest in the Manchester Arena bombing from day to day. Some of those who view the Wikipedia page on a given day may return the next, perhaps after seeing media reports; or may share information with others, who may view the page on the following day. Prior to a salient event concerning the Manchester Arena bombing, there may be broadcast and print media publicity which would drive attention towards the Wikipedia page for several days. This persistence of interest could help close a gap in public risk communication; supplementary campaigns in terrorism risk awareness may be timed to take advantage of this persistence. The Manchester Arena bombing is the focus here, but further research can explore the value of such risk awareness campaigns elsewhere. UK Counter-terrorism policing involves the PREVENT strategy, aimed at preventing vulnerable people from being drawn into extremism. Public risk awareness, as gauged by Wikipedia access, enables the security services to have a fuller sense of the degree of public assistance in identifying prospective extremists, and deterring radicalisation.

It is a reflection of cognitive outcome bias, that far more attention is given to actual historical losses than for near-misses, such as failed terrorist attacks, of which there are many in UK. In the four years after 2017, there were as many as 31 late-stage terrorist attacks foiled, according

to MI5, the UK security service. Most thoughts that people have about the past are upward counterfactuals, how things might have been better; few are downward counterfactuals, how things might have been worse (Woo, 2019). Further research into information sought about failed attacks might be helpful in enhancing public awareness of latent terrorism risk.

The justification for focusing on the 22 May 2017 Manchester Arena bombing is that it is a rare example of a successful terrorist attack, that was not interdicted by MI5, nor stopped by the police or security staff operating at the concert venue. Crucially, there was also a lack of intelligence coming from members of the public about Salman Abedi's suspicious behaviour. Such public intelligence sources in future depend on the level of public risk awareness, which may be gauged indirectly from Wikipedia access statistics. The research methodology adopted is based on leveraging the available Wikipedia access statistics for insights into public risk awareness.

The importance of the 22 May 2017 terrorist attack is reflected in the extensive public inquiry held (Saunders, 2022). Prior to this attack, the previous most lethal UK terrorist attack was the London transport multiple bombing on 7 July 2005, but this was in the early years of Wikipedia, which started in 2001. The generalisability of the findings of this study is limited to its focus on the single most traumatising UK terrorist attack in the modern era of widespread online information access. There is an opportunity for further research in analysing Wikipedia page views for similarly traumatising terrorist attacks in other countries where the great majority of plots are interdicted.

The 22 May anniversary stands out as a key date each year for commemoration of the tragic deaths of 22 mainly young persons, who should not be forgotten. Ariana Grande, with her half a billion social media followers, should be a catalyst for remembering the anniversary for the duration of her stellar career.

Besides the anniversary, new information relating to the case (such as the attack), and the civic response (such as an inquest), will be a sporadic news impulse attracting a cluster of further views of the Wikipedia page.

In years to come, the most significant long-term reminder of the Manchester Arena bombing should be Martyn's Law, named by a mother for her young son Martyn Hett, who never came home on 22 May 2017. Martyn's Law was given the full support of the UK Prime Minister on 19 December 2022, and a draft terrorism (protection of premises) bill was published on 2 May 2023.

Once legislation is passed requiring higher security at major public venues in UK, on a regular basis there should be public interest in finding out more about the untimely death of Martyn Hett.

In the future, as and when visitors to large venues encounter higher security, linked back to 22 May 2017, there should be a stream of views of the Wikipedia page throughout the calendar year. Such an outcome would not only be a fitting tribute to Martyn and the others who died on 22 May 2017, but would also indicate public retention of a basic level of terrorism risk awareness, not just on the anniversary, but on all days. Such a change in the views of the Wikipedia page should be observable by the tenth anniversary of the Manchester Arena bombing in 2027.

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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