The Role of Transport Information in Extreme Weather Events: A Scenario Based Experiment

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Abstract

Extreme weather events present serious threats to existing transport systems. Events such as flooding, extreme heat or cold, heavy snowfalls or high winds, have the ability to destroy, disrupt, and disable vital transport links. Such disruptions can lead to individuals being unable to travel in their normal fashion. Advances in digital technologies, especially smartphone applications and mobile internet, present new opportunities to provide individuals with transport information in the uncertain circumstances caused by extreme weather events. As much of this information collection is either funded by the service provider or by the tax payer, it is important that the largest possible proportion of individuals have access to it and derive a benefit from this information.

This paper presents the results of a survey conducted in the Greater Dublin Area (GDA) to determine what proportion of individuals seek out transport information during extreme weather events, and also to identify where they source it from. The results arising from this research demonstrate both the demand for such information during extreme events, and diversity of sources used to access it. It is also clear that the methods individuals use to source such information differs considerably depending on whether or not they have begun their trip, and whether they tend to seek out information under normal circumstances. From the perspective of service providers and policymakers it is important to consider that how individuals’ access to information may vary with regard to the mode they are using. It is clear, in an Irish context at least, that important transport information is being retrieved from a wide variety of sources, suggesting the need for a more centralised system. While this study specifically examined the role of transport information during extreme weather events, the findings arising from this study can be applied to other events that cause large scale disruptions such as political protests, natural disasters, security disturbances, and transport related industrial action.

1 Introduction

The frequency of severe weather events appears to be increasing due to changes in the global climate (IPCC, 2007). Such events have the ability to place considerable strain upon existing transport networks. Within an Irish context the heavy snowfall arising from the cold weather experienced in winters of 2009-2010 and 2010-2011 caused severe transport disruptions (Met Éireann, 2012). Similarly, heavy rains in 2013 and 2014 (Met Éireann, 2014) lead to major delays on both the road and rail networks within the GDA. Internationally events such as the Queensland (Australia) flooding of 2011-2012, Hurricane Katrina, the Northern European windstorms Lothar and Martin have wreaked havoc upon the transport networks of their respective regions.

Transport disruptions limit individuals’ abilities to make necessary trips due to congestion or unavailable services which can lead to economic losses (Jahn, 2015). Various extreme weather events have the ability to create varying problems for existing systems. Precipitation events can cause routes to become blocked and impassable, extreme low temperatures can freeze surfaces reducing grip for vehicles, while high winds can destroy vital infrastructure such as overhead power lines (Love et al, 2010). While extreme weather events may cause direct impacts to transport systems, human actions, such as deciding to travel or driving in an unsuitable manner for the conditions, can often exacerbate problems (Jahn, 2015). Therefore, it is important that individuals are provided with adequate information to allow them to travel and act in such a manner that enables them to minimize the knock on effects of extreme weather. While research is being carried...
out in this field, passenger adaption and the role of information during extreme events is not yet well understood (Papangelis et al, 2016).

2 Transport Information

With advances in digital technology such as satellite navigation and mobile internet platforms, there now are numerous sources of transport information available to individuals, both before they travel and when they are on the move. These range from traditional sources such as printed timetables and traffic updates via the radio, to newer technologies such as journey planning websites and at stop or on road variable message signs, through to smartphone applications and in car devices. These services are designed to provide individuals with information to allow them to make more effective transport choices. Therefore, it is worth considering how such information may impact upon behaviour in an everyday setting, before considering their role during extreme weather events.

2.1 Role of Transport information

When assessing the role of information is important to understand why it is deployed in the first place. Lyons (2006, Page 200) argues that transport information plays three important roles: “1. make the individual aware of the travel options available to them for a particular journey; 2. Empower the individual to make more fully informed travel choices; and 3. assist the individual in being able to successfully undertake and complete the journey”. While transport information has been available since the days of the earliest printed timetables for steam powered railways, relatively recent advances in digital technologies have opened up a wide range of opportunities to provide individuals with more up to date and route specific transport information. Information relating to public transport, such as online journey planners and transport specific smartphone applications, have the ability to reduce the perceived unreliability of a service (Watkins et al, 2011), reduce perceived waiting times (Warman, 2003), and reduce at stop anxiety (Schweiger, 2003). All of these benefits can be achieved with relatively little in terms of resource outlays (Watkins et al, 2011). Similarly, by providing drivers with real time traffic information it is possible to reduce congestion and the resulting carbon dioxide emissions, without resorting to costly infrastructure investments (Cebon and Samson, 2012).

While the provision of transport information may offer an innovative method of improving transport experiences, it appears that use of such information varies widely across user groups and demographics, with notable difference in information access across age groups (Brazil and Caulfield, 2013). Information may at times not be sought as individuals are engaging in habitual behaviours for trips which they regularly undertake (Kenyon and Lyons, 2003). In such cases there is less of a need to seek out information, as the cognitive effort involved with the process of searching for information outweighs the perceived rewards (Gao et al, 2011). While this may be true for habitual trips such as commuting and shopping trips, where the individual has a good knowledge of the system and there are relatively low levels of variation in travel times, trips taken or planned during extreme weather events can be considered to be outside of the normal range of events by their very definition. In such cases users are unlikely to already possess the necessary information to undertake their trip in the most effective and safest manner, due to the extreme and unfamiliar conditions they may encounter, and the adoptions that may be required of them.

2.2 Role of Weather Information


Previous studies have examined the role that weather information can play on the transport actions of individuals. Kilpelainen and Summala (2007) looked at the role of weather forecast on driver behaviour in Finland and found that drivers who acquired information made more changes to their travel plans. Research by Cools and Creemers (2013) has shown that changes in weather forecasts have the ability to influence individuals travel behaviours and that various media such as internet, television, and radio are used to access such information.

2.3 Information during Disruption

While it has been argued that variability is a characteristic of transport systems in general (Bonsall, 2004), extreme weather can exacerbate this issue by disrupting services or making certain routes impassable. When examining the influences on individuals’ decision making for long distance trips during extreme weather events, Zanni and Ryley (2015) highlighted the role of information sources such as radio, mobile internet, television, and satellite navigation devices. Similarly, work by Zheng et al (2015), analysing the role of transport information during the Brisbane flood of 2011, found that travel information was considered to be important during an extreme weather event, but that in that case, changing mode still remained a difficult task. Other interesting findings from this study were that some individuals switched primary information sources during the event, and the study also highlighted the possibility for extreme events to introduce transport information sources to those who had never previously used them. When examining the role transport information in rural areas during disruptions Papangelis et al (2015) highlighted both the potential role that real time information can play during periods of uncertainty, and also the specific challenges faced by rural areas that often go overlooked.

2.4 Potential Impacts of Information in Extreme Events

As stated previously, the individuals’ behaviour during an extreme event has the ability to exacerbate the impact of extreme events by undertaking unsuitable actions (Jahn, 2015). While transport information may not be able to address the root causes of disruptions, such as flooded train lines or impassable roads, it does have the ability to reduce the indirect effects. Actions that can be taken based upon transport information may include: deciding not to travel, taking an alternative mode or route, deciding to postpone a trip, or being more cautious in their behaviour (e.g. walking, cycling, driving). While this may not be applicable to all cases, as some trips may be unavoidable, it does represent an ability to reduce these impacts, and therefore add more resilience to the system.

2.5 Transport Information in Dublin

To provide context for the research presented in this paper it is important to consider the current transport information landscape within the GDA. At present there are a wide range of sources of transport information available to individuals across multiple platforms. These services are provided by organisations such as local civic councils, road operators and public transport authorities, as well as private sector firms and freelance software developers.

Table 1 outlines some of methods of information provision currently used in the GDA. While this table cannot claim to be an exhaustive list of transport sources, it does highlight that there are many sources of transport information, and that few, if any, are comprehensive in their coverage of all modes.
Table 1: Sources of Transport Information in the GDA

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Remit</th>
<th>Sector</th>
<th>Information Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irish Rail</td>
<td>Commuter and Intercity Rail</td>
<td>Public</td>
<td>Updates on Web Page, Twitter, At Station, Smartphone Application,</td>
</tr>
<tr>
<td>Dublin Bus</td>
<td>Public Buses in the GDA</td>
<td>Public</td>
<td>Web Page, Smartphone Application, At Stop Information</td>
</tr>
<tr>
<td>Bus Eireann</td>
<td>Public Buses outside the GDA</td>
<td>Public</td>
<td>Twitter, Smartphone Application</td>
</tr>
<tr>
<td>Transdev</td>
<td>Light Rail Operator</td>
<td>Private</td>
<td>Website, Smartphone Application, At Stop VMS, Twitter Account</td>
</tr>
<tr>
<td>Dublin City Council and South Dublin City Council</td>
<td>Road Operators with Urban Area</td>
<td>Public</td>
<td>Traffic Cameras Online, Twitter, SMS Service, Roadside VMS, TMC Traffic updates to SatNav, Traffic Updates on Dublin City FM</td>
</tr>
<tr>
<td>NRA</td>
<td>National Roads Operator</td>
<td>Public</td>
<td>Website with journey times and incident reports, Variable Message Signs, Twitter Updates</td>
</tr>
<tr>
<td>The Automobile Association (AA)</td>
<td>Insurance Company</td>
<td>Private</td>
<td>Smartphone Application, Provision of Information for Radio Updates, Twitter Account, Website</td>
</tr>
<tr>
<td>Google Traffic</td>
<td></td>
<td>Private</td>
<td>Estimated real time traffic information</td>
</tr>
<tr>
<td>RTE/TV/Radio</td>
<td></td>
<td>Public</td>
<td>Regular radio updates, television news updates r</td>
</tr>
<tr>
<td>National Transport Authority (NTA)</td>
<td>Transport Authority</td>
<td>Public</td>
<td>Under Transport for Ireland Brand: Online and smartphone application journey planner, website with multimodal transport updates, twitter account</td>
</tr>
</tbody>
</table>

As it is clear from Table 1 that there is no one source of transport information that covers all the transport modes available in the GDA, it was deemed important to gain an understanding of which channels of communication are most frequently used, and how this varies with regard to the characteristic of the traveller and the trip.

3 Methodology

In light of the issues highlighted in the previous sections, as well as recent advances in the provision of transport information, this study was undertaken with three principal objectives in mind:

1. To determine what proportion of transport users access information during extreme weather events
2. To gain an understanding of which methods of information retrieval are most popular with users
3. To examine the role that factors such as mode, demographics, and whether the individuals is already en-route, play in accessing such information

To address these objectives, an internet based survey was designed and distributed to potential respondents via the internal noticeboards and weekly corporate emails of a number of large Irish governmental and semi-state organisations, in March and April 2015. These organisations were based both in the city’s central business district and the suburbs to better capture a wide range of habitual trip types within the sample.
3.1 Sample

The survey was conducted in May 2015 and 447 survey responses were received in total, however, only 405 of these were considered to be complete enough for the purposes of the required analysis. Due to the distribution means it was not possible to calculate a response rate, as this could only be done by calculating the number of responses as percent of the total combined workforce of the combined organisations, as this was viewed to be unrealistic.

The determination of completeness was based upon their completion of the scenarios which formed the principal experiments contained in the questionnaire. Table 2 outlines the demographic characteristics of the sample. Due to the methods used to distribute this survey (the use of work place and college emails), the sample over represents younger people, with very little representation of individuals over sixty years of age. This is also very little representation of individuals who are not currently engaged in employment or education. However, as the scenarios presented are mainly focused on habitual trips such as commuting or trips to education this may not be a substantial bias, in terms of the population the sample aims to represent. Due to the low rates of tele-commuting present in Dublin, this aspect and its impact on responses (O’Keefe et al, 2016) was not considered for the purposes of this analysis.

Table 2: Sample Characteristics

<table>
<thead>
<tr>
<th>Gender</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>54.6% (221)</td>
</tr>
<tr>
<td>Female</td>
<td>44.7% (181)</td>
</tr>
<tr>
<td>No Answer</td>
<td>0.7% (3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>18-29</td>
<td>53.6% (217)</td>
</tr>
<tr>
<td>30-39</td>
<td>14.6% (59)</td>
</tr>
<tr>
<td>40-49</td>
<td>10.1% (41)</td>
</tr>
<tr>
<td>50+</td>
<td>14.8% (71)</td>
</tr>
<tr>
<td>No Answer</td>
<td>4.2 (17)</td>
</tr>
</tbody>
</table>

3.2 Survey Layout

While the optimal method of addressing the research questions outlined in the previous section may be to wait until an extreme weather event occurs, monitor all the channels of possible information, and then assess the number of individuals that were reached, this not very practical. Such an approach would be highly resource intensive. Issues such as resource limitations, data ownership and access to usage data (for websites, apps etc.) convinced the research team that a survey based approach was the most practical means of addressing the questions at hand.

The survey was designed in such a manner as to present respondents with a number of hypothetical scenarios relating to their transport choices when encountering extreme weather. These scenarios were split into on trip and pre trip scenarios, to capture the potential differences that may arise in information retrieval, based upon the individuals’ locations. In these scenarios respondents were asked to consider trips during an extreme weather event, one each for driving, rail (both light and heavy), and bus. These are the three dominant of modes used in the GDA (CSO, 2012), and also those modes for which there was the greatest amount of information available. These scenarios are outlined in Table 2.
Based upon feedback from survey piloting, both sets of scenarios asked respondents to choose an action from a list of possible options. While these scenarios must of course be considered a simplification of the possible actions and individual can take, results from piloting deemed them to be the best for capturing a general sense of how individual might act. As the main focus of this research was to examine the role of information in transport choices, if a respondent stated that they would choose to seek out information, they were asked to state where they would retrieve such information from. For both sets of scenarios, respondents were asked to consider heavy snow as the extreme weather event, as Ireland had suffered major transport disruptions from snow storms in the winters of 2009-10 and 2010-2011 (Met Éireann, 2012), and snow has the ability to impact a wide range of modes across a large geographical area.

In each of the scenarios respondents were asked would they:

1. Proceed as normal
2. Choose not to travel
3. Take another mode
4. Look for transport information, and if so from where

The second set of scenarios were similar, expect in this case respondents were asked to imagine that they had already begun travelling.

Figure 1 provides a sample of the scenarios presented (pre-trip in this case) where respondents were asked to pick one option. While in reality there are wide a range of non-mutually exclusive available to individuals in such situations, these scenarios were designed to examine the role of information retrieval relative to other actions, and to allow for ease of analysis.

Figure 1: Sample Scenario

7. You are either at home or at work/place of education and you are planning to take a trip using your car. You notice that it is snowing heavily. What do you do?

- Proceed as you normally would
- Choose not to travel
- Take another mode
- Look for information about the traffic conditions (if so please specify from where)

To allow for categorical analysis, the survey also collected information regarding the respondents’ demographics, travel characteristics, and whether or not they tend to seek transport information in normal circumstances. While respondents who may not have habitual used a given mode could answer for all scenarios, this was tested for in Chi squared analysis in the results stage.
3.2.1 Scenario Comments

When completing the respective scenarios, respondents were asked to state where they sourced information from, rather than selecting from a predetermined list of information sources to allow for the collection of the widest range of answers. For the purposes of this analysis, the online application Wordle (Feinberg, 2013) was used to create text visualisations. Previous research in the area of text analysis (McNaught and Lam, 2010) has demonstrated the value of this particular application, in terms of examining large bodies of text for patterns and trends. This application analyses the frequency with which a word appears within a body of text, and based upon this, designates the word prominence with regard to other words within the text. Therefore, words which occur more often are displayed as being bigger than those that occur infrequently. This results in a simple but easily understood graphical representation of the underlying trends within the text, however these results should be considered to be more of a visualization than an in-depth analysis.

3.2.2 Overall Comments

The final section of the survey asked respondents if they wished to give any more detailed information about their information retrieval activities during extreme weather events. This was an open question to allow for unstructured responses in which respondents could provide any information that they felt was not covered by the scenarios and questions presented to them in the rest of the survey. This section was primarily exploratory in nature, specifically to provide the research team with an idea of the complexity of the information retrieval process, and the diverse sources that individuals may use.

4 Results

The results presented in this section are present in terms of the pre-trip analysis and the on-trip scenarios, with a comparison of the two settings presented at the end of the section.

4.1 Pre-Trip Scenarios

In each of the pre-trip scenarios, respondents were asked how they would act if the consequences of an extreme weather event were being felt, before they began travelling, based up the preference of taking a given mode. Figure 2 displays the results for each of these scenarios combined for the purposes of comparison. These results are presented in terms of the percentage of respondents who selected a given action for each of the modes under examination.

It is clear that for each of the modes under examination, that, given the occurrence of heavy snowfall, the largest proportion of individuals would attempt to seek information regarding their travel options. Specifically focusing on the role of transport information retrieval during extreme weather events, for both public transport modes, over half of those individuals surveyed stated that they would seek information. This figure is somewhat reduced for the driving scenario.
4.1.1 Pre Trip Demographic Analysis

In order to gain a better understanding of some of the factors that may influence an individual’s decision to seek transport information, it was decided to examine how the respondents’ choices varied with respect to a number of characteristics. As the respondents’ decisions resulted in a categorical outcome, the Chi squared approach was used. Table 3 presents the Chi Squared analysis of the three scenarios, with respect to the age, gender, and transport habits of the respondents (Regular User). As information retrieval is the focus of the study the results of the scenarios were simplified for the purposes of the Chi squared analysis to “Look for Information” and “Do Other”, where “Do Other” was a summation of the selections of other three options for each scenario. For the purposes of this analysis, users who stated that driving, bus, or rail was their primary mode of commuting are defined as regular users. If they did not use one of these three modes for commuting, they were defined as an irregular user. Similarly, respondents were asked if they usually accessed information when undertaking one of the modes under examination. If so, they were classified as regular information users for that mode (Regular Info).

Table 4: Pre Trip Scenarios: Chi Square Tests

<table>
<thead>
<tr>
<th>Mode</th>
<th>Age</th>
<th>Gender</th>
<th>Regular User</th>
<th>Regular Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Trip Driving</td>
<td>24.7 df= 3(0.00)*</td>
<td>4.7 df=1 (0.03)*</td>
<td>18.7 df=1 (0.00)*</td>
<td>20.8 df=1 (0.00)*</td>
</tr>
<tr>
<td>Pre Trip Rail</td>
<td>3.1 df=3 (0.37)</td>
<td>5.8 df=1 (0.016)*</td>
<td>17.4 df=1 (0.00)*</td>
<td>18.4 df =1 (0.00)*</td>
</tr>
<tr>
<td>Pre Trip Bus</td>
<td>0.8 df=3 (0.87)</td>
<td>12.6 df=1 (0.00)*</td>
<td>3.9 df=1 (0.05)*</td>
<td>8.8 df =1 (0.03)*</td>
</tr>
</tbody>
</table>

df=degrees of freedom, figures in brackets indicate associated p-values, *denotes p values less than 0.05

All the cross-tabulations that produced statistically significant Chi Squared values were examined, however, only the results examining the role of gender and pre-trip information retrieval, and the relationship between habitual information access and pre-trip information retrieval are displayed, as the analysis of the other relationships failed to produce any meaningful outcomes.

Figure 3 highlights how respondents stated actions for each of the three pre-trip scenarios varies with regard to gender. These results appear to indicate that, for all modes under consideration, a
higher proportion of females than males are likely to access transport information in extreme weather events.

Figure 3: Gender vs. Pre-Trip Information Retrieval

There was also found to be a clear relationship between how often individuals access transport information under normal circumstances for a given mode, and how likely they stated they would be to access it before during an extreme weather event (Figure 5). For all modes under consideration it is clear that regular users are more likely to access information during extreme weather than those who infrequently use the mode. This would appear to make intuitive sense as such users would already be familiar with the most reliable and up-to-date information provision services for their circumstances.

Figure 4: Normal Information Habit vs. Pre-Trip Information Retrieval

4.1.2 Pre Trip Comments

Respondents who stated that they would seek transport information when presented with the pre-trip scenarios were also asked where they would source such information from. These responses were provided in comment form to allow the respondents to include options that may not have occurred to the research team. The online graphic display tool Wordle (Wordle.net) was used for the
purposes of a quick but effective comparison, and the results are displayed in Figure 6. A separate graphic was produced for the driving, rail, and bus scenarios respectively.

It is apparent that radio still has a major role to play in terms of providing information to individuals undertaking driving trips during extreme weather conditions, as do the traffic updates provided by the insurance company AA (Automobile Association), as part of their AA Roadwatch radio and web based service. For both rail and bus journeys websites appear to be the most prominent sources emerging from the comments, with the names of the principal service providers (Irish Rail and Dublin Bus respectively) in both visualisations. It is clear that there is a notable difference in sources between the driving scenario responses and the public transport options.

Figure 5: Respondent Pre Trip Comments (Left to Right: Driving, Rail, Bus)

4.2 On-Trip Scenarios

The second series of scenarios examined trips where the individual was considered to already be en-route when they encountered delays caused by extreme weather events.

Figure 7 outlines the combined results of these scenarios, in terms of the percentage of respondents who would undertake a given action, for the modes under consideration. Unlike the pre-trip scenarios, a greater level of variation between behaviours for the different modes is observed. In these scenarios only a large proportion of rail users state that they would engage in information retrieval behaviour similar to pre-trip behaviour. It is notable that for the driving scenario a large proportion of respondents stated that they would simply do nothing.
4.2.1 On-Trip Decision Analysis

As with the pre-trip analysis, a categorical Chi Squared analysis was undertaken to assess the factors that may be related to the respondents’ decisions to seek transport information. However, unlike the pre-trip analysis, respondents stated actions were found not to vary significantly with regard to most of variables examined, with the exception of whether or not the respondents accesses information when taking a trip via a given mode under normal circumstances.

Table 5: On Trip Scenarios: Chi Square Tests

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Gender</th>
<th>Regular User</th>
<th>Regular Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>On Trip Driving</td>
<td>34.0 df=3 (0.00)*</td>
<td>0.06 df=1 (0.80)</td>
<td>17.4 df=1 (0.00)*</td>
<td>31.2 df=1 (0.00)*</td>
</tr>
<tr>
<td>On Trip Rail</td>
<td>7.7 df =3 (0.054)</td>
<td>2.6 df=1 (0.10)</td>
<td>0.97 df =1 (0.32)</td>
<td>7.4 df=1 (0.00)*</td>
</tr>
<tr>
<td>On Trip Bus</td>
<td>4.8 df=3 (0.187)</td>
<td>0.15 df =1 (0.7)</td>
<td>0.99 df =1 (0.32)</td>
<td>19.4 df=1 (0.00)*</td>
</tr>
</tbody>
</table>

df=degrees of freedom, figures in brackets indicate associated p-values, *denotes p values less than 0.05

As with the pre-trip scenarios, the frequency with which an individual seeks information during normal circumstances is related to how likely they are to seek it during extreme events (Figure 8).

Figure 7: Normal Information Habit vs. On Trip Information Retrieval
4.2.2 On Trip Comments

As with the pre-trip scenarios, respondents’ comments regarding sources of information were analysed using Wordle. In the case of on-trip scenarios radio appears to be extremely dominant for respondents when engaged in driving trips. However, this may be due to safety issues relating to accessing other media while driving. This would appear to reaffirm the findings of Zanni and Ryley (2015). In the case of bus journeys, while pre–trip information retrieval appeared to be dominated by websites, smartphone applications appear to play a greater role when individuals are on the move. Again this finding can be considered somewhat intuitive as individuals are unlikely to have access to the same computing options as they would either at home or at work, and therefore would be more likely to source their information from such applications. Similarly, pre-trip rail information appeared to be principally sourced from websites (presumably official ones), whereas on-trip information sourcing is more diverse, with increased prominence being given to smartphone applications, as well as websites such as Twitter and Google.

Figure 8: Respondent On Trip Comments (Top to Bottom: Driving, Rail, Bus)

4.3 Information Access Comparison

One point of interest to researchers was how the respondents’ information acquisition behaviour altered with regard to whether or not they had already begun their trip when they became aware of the extreme weather event. Figure 9 provides a comparison of the percentage of respondents who choose to access information both for the pre-trip and on-trip scenarios overall, and for each of the specific modes under examination.

These can be considered to be a comparison of the “look for Information” options for presented in Figures 2 and 6 respectively. This figure also presents an aggregate information retrieval score, labelled “Total”, across each of the modes for both pre and on trip scenarios.

It is clear from this graph that overall respondents are more likely to access transport information before they begin their trip. This would appear to be an intuitive finding, as individuals are likely to both have access to more information sources before travelling, and also to have access to more options once they have received such information, such as choosing a different mode, delaying their trip, choosing not to travel. The greatest difference between pre and on trip information acquisition can be observed for bus journeys.
4.4 Overall Comments

The final section of survey allowed respondents to provide comments on their experiences with information retrieval during extreme weather events. The exact wording of the question was: “If you have any comments about how you access transport information during extreme weather please supply details in the comments below”. These sample comments are provided to help readers understand the wide variety of information sources that are used by respondents, however an in depth analysis of these responses was not the focus of this research.

Table 5 contains a selection of these comments. One theme that emerges is how the perception of sources of information can vary (1) and (2) between users. There was also a juxtaposition between the individuals who appeared to appreciate the new services available (3) and (4), and those who felt that information provision during extreme weather events is still very poor (5), (6), (7) and (8). Comments also reflected users undertaking a multi-source approach to information acquisition (9), and the importance of the user location in terms of which method of information retrieval they undertake (10). One respondent provided a detailed comment outlining the impact that failing to retrieve transport information has had upon their safety, and how these incidents could have been avoided if they had had such information (11). Finally, a number of respondents who either walked or cycled stated that they did not need transport information to make decisions for their modes during extreme weather events (12) and (13).

Table 6: Respondent Comments

<table>
<thead>
<tr>
<th>Comment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>During bad weather I tend to notice that twitter is a good data base for what’s going on</td>
</tr>
<tr>
<td>(2)</td>
<td>I would check official websites, not unreliable tweets from people that I can't be sure of.</td>
</tr>
<tr>
<td>(3)</td>
<td>Don't know how I managed to travel before I had a smartphone - would be lost without it! Maybe an app to link directly to traffic cams would be useful.</td>
</tr>
</tbody>
</table>
I find the AA Roadwatch and Facebook very helpful when weather is very bad and I need guidance on how to get from A to B.

In Ireland the information is very unreliable from my experience so if there is much disturbance to normality.

Experience suggests that if a service is heavily delayed, stopped, one is better off to seek alternative means of transport. Specific information about reasons for delays is rare from whatever source.

Ireland usually shuts down during extreme weather, and information is scattered and not very streamlined. Because it can be difficult to find accurate info, usually I would just aggregate everything I can find and make a somewhat-informed decision.

Experience suggests that if a service is heavily delayed, stopped, one is better off to seek alternative means of transport. Specific information about reasons for delays is rare from whatever source.

Listen to traffic updates on radio and google for information

If at home, by websites/social media of the transport company. If out, using my smartphone.

Will always have radio on in the car for traffic information. On motorcycle I have had times where I abandoned my bike in college because I was caught out by bad weather which was un-driveable, I could have avoided that by checking the weather before I left that morning. I also have crashed on ice before because I ignored the weather and AA advice that warned of ice patches,

Look out the window; if it looks safe to cycle I go out

I mostly walk, so it is rarely too extreme to walk somewhere.

5 Discussion

Extreme weather conditions have the ability to severely hamper individuals’ abilities to undertake trips as they normally would. This tends to happen through the disruption and disablement of services. In many cases, the actions of transport users can actually exacerbate problems as they change their habitual behaviour to attempt to compensate. One method of helping individuals to cope with the delays and safety issues encountered during extreme weather events is to provide them with relevant transport information. The results of the scenarios presented in the previous section help to provide an understanding of how individuals access information during extreme weather events.

The pre-trip scenario results indicate in that a large proportion of respondents would seek information before travelling (over 50% in the cases of car and rail). This demonstrates the importance of transport information in trip planning during periods of uncertainty.
For the on-trip scenarios, where the respondents are considered to be already on route and committed to a mode, there is more variation between the levels of information seeking associated with the respective modes.

For all modes examined, the results demonstrate that respondents would be more likely to access information before travelling than when already on route. This would appear to be an intuitive finding, as more options would be available to them pre-trip, both in terms of sources of relevant information, and also the subsequent adaptive behaviours that they could adopt, based upon such information.

An investigation into how information acquisition alters with regard to the characteristics of the respondents, based upon a chi squared analysis, was also undertaken. For both pre-trip and on-trip scenarios it emerged that, across all modes, individuals who regularly source information for a given mode under normal circumstances, are more likely to do so during an extreme weather event. Again this would appear to be intuitive, as these individuals are already aware of the existing information pathways, and therefore would be more likely to have easy access to this information.

When examining the potential role of other variables, it was found that more obvious patterns emerge with regard to the pre-trip scenarios than the on-trip ones. For all pre-trip scenarios, it was found that women were significantly more likely to access transport information, as were individuals who regularly used that mode.

6 Conclusions and Recommendations for Policymakers

It is clear that in Dublin, as in many other cities, transport information is provided by a number of different stakeholders at varying levels of accuracy, and across differing communication channels, and this is phenomena is clearly seen in the information sources mentioned by respondents. A result of such an arrangement appears to be that transport users do not always have access to the same information and, therefore, management of the behaviour of individuals during an extreme event is likely to be sub-optimal.

The transport information systems that are currently deployed to inform travellers are often funded either directly by the users (and subsidised by government) or are implemented using tax payers’ and passengers’ money. Transport providers and authorities are employing considerable effort to collect and disseminate information to their users, however, the results of this research would tend to suggest that a large proportion of the population are not accessing this information, or are unable to benefit from it to the maximum extent.

Based upon the results of this study, it can be shown that there is a need to get information to individuals as soon as possible, preferably before they begin their trips, as they are both more likely to access such information, and also are less locked into their modes or routes. This study also highlights the role that familiarity with existing sources of information plays in individuals’ likelihood to seek out information during extreme weather events. This suggests a need to increase uptake of available information sources, especially digital ones, to ensure that individuals have access to the such channels of information.

The diverse and diffuse array of information retrieval techniques mentioned highlights the issue of a lack of centralised information gathering and dispersal. While this study looked specifically at this issue in Dublin, it is likely that this is the case in many more urban areas. This problem of multiple non-overlapping information sources, may be considered to be even more acute for individuals how need to undertake multimodal trips, and therefore may need to access multiple information sources,
to understand how an extreme event is likely to impact their travel plans. With increasing levels of smartphone ownership and access to mobile internet technologies, this issue does not appear to be a technological one, rather it concerns how such information is effectively gathered and distributed across communications channels, to ensure that the largest proportion of the population possible has access to what can often be very important information.

It is also equally important that the population are made aware of what information is available to them, that such information is trustworthy and accurate, and that it is relevant to their situation. While this paper dealt with extreme weather, the issues associated with transport information are likely to apply to other events that cause large scale disruptions such as political protests, natural disasters, security disturbances, and transport related industrial action. Further work is required to understand how individuals access information during extreme events, and how this can be optimised for both the user safety, system management, and speedy recovery.

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