Gender Differences in the Journey to Suicide: Comparing distance decay functions of home and found locations in missing person reports to the police

Catherine Stevens BSc
University of Liverpool

Susan Giles PhD
University of Liverpool

Freya O'Brien PhD
University of Liverpool

Email: s.p.giles@liverpool.ac.uk

Abstract

To date, no research has examined the decay models that best describe male and female spatial behaviours whilst missing, particularly of those that demonstrate suicide intent. Such knowledge could help to inform investigative strategies. Three studies were conducted using missing persons data from two police forces. In study 1, ANOVA and Mann-Whitney U tests examined the distance travelled by male (n=158) and female (n=135) subgroups; with respect to the impact of gender, likely suicidal and vehicle possession. Study 2a considers which curve estimate best describes likely and non-likely suicidal males (n=180) and females (n=157) spatial movements whilst missing. Study 2b cross validated suicidal male curves identified in study 2a, using information taken from missing persons cases where the person had been found to have died through suicide (N=24). Vehicle possession increased the distance travelled across all groups. Females travelled further than suicidal males, however, no distance travelled differences were found between suicide and non-suicidal sub-groups. The most significant curve estimate for likely suicidal males and females were the inverse and quadratic models respectively, illustrating exclusive gender movements in journeys to suicide. There are meaningful gender differences in spatial movements when missing. Thus, gender specified search parameters can be generated, potentially aiding quicker detection, prevention and safeguarding of adults at risk of self-harm.

KEY WORDS: *Geographical profiling, distance decay, suicide, gender*

Introduction

Motivated by the high prevalence of missing persons estimates within the UK, the Home Office prioritised the missing persons improvement of policing responses to this matter in 2011. Annually 350,000 people are estimated to go missing (National Crime Agency [NCA], 2017). Whilst many missing people are found quickly or return voluntarily (Tarling & Burrows, 2004), going missing can be a catalyst to endangering individuals predisposing them to becoming a victim of crime or harm. Every week across the UK, 20 missing people are found dead (Fyfe, Stevenson & Woolnough, 2015). Fatal outcomes roughly equate to 0.6-1% of the annual reported missing population (Newiss, 2006). Whilst this is only a small percentage, the cost of missing persons cases are remarkably high. Applying the cost estimate of an average missing person investigation at £1,325 (Shalev-Greene & Pakes, 2013) to the number of cases reported to UK police forces, a simple calculation puts the burden of missing persons investigations at over £400 million per year. If the missing person experiences a fatal outcome these costs rise dramatically. Knapp, McDaid and Parsonage (2011) estimated the national cost of a single outdoor located suicide to be £1,450,000 putting the burden of outdoor suicides in 2011 to over £1000 million (since 10% occur outdoors). Due to reforms and budget cuts, the need for 'investigative competence' (Alys, Massey & Tong, 2013) is crucial to meet the considerable demands that missing persons cases create. Understanding spatial behaviours of missing people and their geographical considerations is one way towards improving efficacy.

Despite the wealth of spatial knowledge and understanding of geographical profiling in the criminal policing domain, its application is yet to be transferred across to missing people. Literature has focused on repeat missing cases and under 18s, due to their disproportionally high risk of going missing (Parr & Fyfe, 2012). There is less research on vulnerable adults in spite of them being the most likely group to experience harm or suffer a fatal outcome (Newiss, 2006). Improving search procedures and preventing fatal outcomes could have important economic and social consequences. According to Shalev, Shaefer and Morgan (2009) understanding missing persons spatial behaviours should be a police and research priority. Identifying such spatial behaviour patterns can help police forces identify and refine likely search areas and potentially locate an individual in crisis before they suffer any harm, thus saving valuable police resources and leading to greater harm prevention.

Literature Review

The following literature review below combines missing persons and suicidal multi-disciplinary knowledge to further understand factors that influence an individuals' journey to suicide.

Newiss (2011) identified suicide as the most common cause of death in missing persons cases. In 2016, suicide attempts led to just under 2,000 missing incidences within England and Wales (NCA, 2016). Additionally, travelling to a distant location in order to commit suicide is one possible motive to go missing (Sveticic, Too & De Leo, 2012). Sveticic et al. (2012) tried to outline the scale of the problem. They found that 2.5% of suicides between 1994 and 2007 were committed by individuals reported as missing. The gender balance within missing persons is fairly uniform with males accounting for 52% (117,402) of all missing incidents (NCA, 2016). However, when isolating fatal outcomes, males have a higher prevalence (Biehal, Mitchell & Wade, 2003; Perkins, 2012; Sveticic, et al., 2012). Newiss (2006) analysed 32,000 cancelled missing persons reports (solved investigations, locating the individual), concluding males were 2.5 times more likely to be at risk of being found deceased, which increased both with age and missing time duration. This pattern matches general suicide statistics, which reflect a 3:1 male-female bias. Within the UK, suicide is the leading fatality cause for males under 45 years old (Office National Statistics [ONS], 2017).

Suicide Locations

The private, secretive nature of suicide often determines an indoor location. However, at least 10% of completed suicides occur outside. With an average of £1,450,000 per case for outdoor suicides as outlined above, the need to intervene and help minimise the financial and human fatality costs in this specific area is demonstrated.

The circle theory in geographic profiling literature, suggested criminals would operate within an offence circle either distinctly outside their home base (commuters) or within it (marauders) to commit crimes (Canter, 1996). Considering suicide spatial behaviours, some individuals exhibit commuter behaviour and intentionally commute further distances to frequently used locations, occasionally referred to as ‘suicide hotspots’ in order to take their own life - a phenomenon labelled ‘suicide tourism’. Identified outdoor high risk suicide locations are waterways, railways, urban centres and woodlands (Hannon, Giles, Deacon & Tocque, 2009). The circle theory illustrates how the consideration of practicalities, presented opportunities and personal significance can determine the variation in suicide location choice.

Gross et al. (2007) found 1 in 10 suicides occurring in New York between 1990 and 2004 were a result of suicide tourism, with 80% of non-residential suicides (suicides by people not living within the area) being amongst males. Within the UK, notorious high risk locations include Clifton Suspension Bridge and Beachy Head Cliffs, with the majority of non-residential people who take their own life in these locations being men (Bennewith, Nowers & Gunnell, 2010; Windfurh et al., 2010). Conversely, Owen, Lloyd-Tomlin, Emmens and Aitken (2009) found only a third of all suicides in Devon occurred in a public place, with 85% being undertaken by county residents. Suicide tourism may therefore be more evident only in particular locations, nonetheless suicidal individuals may still travel to outdoor locations, either

purposefully further afield (in the case of commuters) or perhaps more impulsively, acting on the opportunities presented in surrounding areas (in case of the marauders).

Progressing to research on suicide locations and missing persons, Sveticic et al. (2012) found 58% of reported missing persons suicides in Australia between 1994 and 2007 occurred in natural outdoor settings, compared to 11% in non-missing persons suicide cases. This suggests outdoor locations strongly influence suicidal missing persons spatial patterns, a consideration which needs to be further acknowledged in the literature. In terms of gender differences, missing suicidal males tend to travel to woodland areas and implement more violent suicidal methods, whilst females go to rural spots often near water sources (Gibb & Woolnough, 2007). Recent evidence also suggests that some men may be found in water, although this is based on specific research considering the locations of fatalities of men who go missing 'on a night out' (Newiss & Greatbatch, 2017) which may include those who have committed suicide. It may be possible that the gender distinctions in suicide location and method choice underlie gender differences in spatial behaviours and journeys to suicide; a position this paper aims to examine looking at the distance travelled by suicidal males and females.

Distance travelled

As a relatively new area of research, there is a tendency within the missing persons literature towards descriptive findings, largely focusing on the demographics and motives as to why individuals go missing (Safe on the Streets Research Team, 1999; Biehal et al., 2003). Whilst such information is useful, recognition has grown for the need to understand missing persons spatial patterns among geographical environments. The utility of this practical knowledge would be valuable for police search advisors (PolSA) to aid rapid deployment of target focused search parties during the precious initial investigation stages.

In 2007, the Grampian Police Force (Gibb & Woolnough, 2007) published a statistical aid to understand, plan and respond to a missing person report. The database of profiling guidance notes was the first of its kind to provide distances between last seen and found locations, suggesting gender specific search parameters for different missing persons categories. Findings showed suicidal missing males were three times more likely to take their own lives compared to females, and travel further (50km compared to 44km) when using a motor vehicle. Conversely, females when travelling by foot were likely to be found around three times further away (6.9km) than males (2.4km). The report showed emerging gender themes, and the impact sex and vehicle possession had on the overall distance travelled.

Five years later the Centre for Search Research published the UK Missing Person Behaviour Study report (Perkins, Roberts & Feeney, 2012). Results showed 'despondents' – individuals thought to have deliberately disappeared due to suicide intention, depression or stress – were significantly different from all other missing persons categories. Between 2004 and 2011, collected reports from mountain rescue teams showed despondents (144 females, 243 males) had the highest fatality rates, and the highest

frequency of being found within 0.5kms of their last known point (36% of cases vs 25% of the other missing persons cases). Furthermore, many despondents mentioned the significance of the location they were travelling to, due to its beauty or associated memories. In particular males with significant locations in mind were highly likely to have been found deceased at this chosen location (62% compared with 29% found at other locations). This suggest despondents, who are the most vulnerable group to harm, have shorter and possibly more thoughtful/considered spatial behaviours compared to other missing persons groups.

Further statistical literature supports the view that missing people often do not travel far, Greene, Schaefer and Morgan, (2009) found 40% of their UK 423 missing person sample returned back to their original location, with another 10% being found within a 10km radius. There is yet to be any detailed comparative gender research solely exploring suicidal and non-suicidal missing persons spatial journeys using distance calculations.

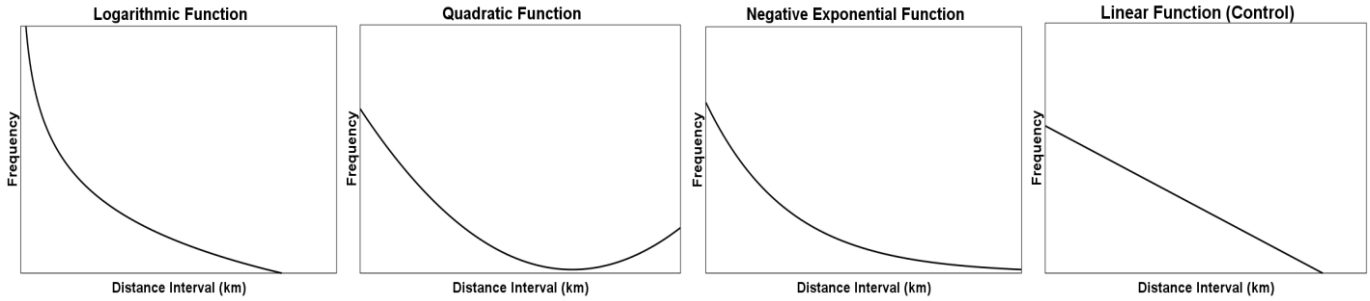
Decay functioning

The study of spatial movements is well established in social geography and criminal offending. Within forensics, geographical profiling is used to model criminal journeys - one of its basic principles acknowledges the reduction in a criminal's predisposition to offend as the distance from their base site increases (Soria & Villalba, 2017). This concept is known as distance decay, which describes the rate of decrease (in a crime occurring) between two spatial points (e.g. an offender's home location and a crime scene) as the distance between them increases. Various mathematical functions/curves differently fit and model the decaying relationship of the frequency and distance travelled in the offender's journey to crime, as explored by Canter and Hammond (2006) using the logarithmic, exponential and quadratic functions in their sample of 96 serial killers. Theories which explained the variation in the respected function decays were the 'Friction Effect' (Canter, 2004) that stated how offender spatial behaviour is impeded by restraining factors such as cost, time and effort. Stevens' 'Power Law' (1961) which highlighted how an offender's perceptions in distance length determined their travel, and Brantingham and Brantingham's (1991) theory which noted location attractiveness or target suitability (Ludrigan & Canter, 2001) or detection avoidance favoured further travel for offenders.

These principles of decay functioning and decision making explanations on journey length variation can be extrapolated to other domains. A new application would be on suicidal missing persons data as a way to try and understand their journeys to suicide and potentially guide and inform police responses. The attractiveness of 'hotspots' producing commuting behaviour, or local opportunities and familiarity encouraging shorter marauder behaviour, coupled with intervening considerations of cost and effort can all be illustrated through the different decay functions.

Therefore, applying the distance decay principle to missing person movements, it can be said that the further the distance from the missing location (i.e. the last seen or known point) a person is, the less likely the individual will be found. Giles et al. (2017) was the first study to explore decay functioning in missing persons. The study followed Canter and Hammond's (2006) methodology and explored the fit of logarithmic, quadratic and the negative exponential decay functions (see Figure 1) on a 5 cluster solution model. The clusters comprised of differing risk (low, medium, high) and age (over 61 years, under 18 years) missing persons groups. Results for the high risk 121 cases cluster (containing likely suicidal missing persons cases), concluded the significance of all three functions, with the logarithmic most appropriately fitting the data, inferring high risk missing persons possess distinct movement habits. Whilst these findings are unique, the effects of gender have yet to be explored.

Figure 1 *– Graphs showing perfect line illustrations for the three decay functions and a linear control, each differently depicting the relationship between being found (frequency) and the distance travelled (km)*



From the aforementioned literature there are various inconsistencies across suicides by missing persons and missing persons movements. Data tends to suggest missing persons do not travel far from their central base, yet conflicting evidence shows suicidal missing persons frequently travel to outside locations, potentially further afield to either woodlands or water sources. No research has comparatively looked at suicidal/non suicidal missing persons and the effect gender and suicidal intent ultimately have on the journey taken and the distance travelled. The purpose of the present study is to examine the influence of gender and likely suicide on the spatial behaviours of males and females, reported missing to the police. Furthermore, these journeys will be examined using decay functions. Such research might indicate tailored search parameters for individuals depending on their gender and likelihood of committing suicide. This paper is a secondary analysis of the data from Giles et al. (2017) which uniquely incorporates additional decay functions using a trial and error approach to identify the most appropriate curve estimation – furthering the use of geographical mapping in the missing persons research domain. By utilising multi-disciplinary knowledge, hopefully future collaborative projects and innovation can be encouraged.

Although the study is exploratory by nature, synthesising the literature suggests some testable hypotheses. It is proposed there will be a significant relationship on the distance travelled with: (1)

gender (2) suicidal likelihood (3) possession of a vehicle. Significant interactions are also expected to occur between: (4) gender and suicidal likelihood, (5) suicidal likelihood and vehicle possession, (6) gender and vehicle possession, (7) gender, suicidal likelihood and vehicle possession; all on the distance travelled.

Method

Study 1

Secondary data was reutilised from Giles et al. (2017), which included all solved cases of missing individuals between January-June 2015 from one Police Force, that met the Association of Chief Police's ([ACPO] 2013, p.5) missing persons description: *"Anyone whose whereabouts cannot be established and where the circumstances are out of character or the content suggests the person may be subject to crime or at risk of harm to themselves or another".* Over one thousand entries were collected (n=1,037), missing data on vehicle possession or distance travelled as well as repeat cases were removed, leaving 351 cases. Since the aim of the study was to investigate spatial movement patterns, 41 cases returning home (with a distance value of 0.0kms) were also excluded. In the interest of analysing the interactions between the variables via parametric tests, outliers with distance values more than 2 standards deviations (99.40km) away from the mean (20.28km) were excluded, leaving a final sample of 293 cases. Two sub-groups were formed and categorised by gender, Table 1 presents the demographic information.

Table 1 *– Sample characteristics for study 1*

	Mean Age (SD)	Suicidal Likelihood (%)		Vehicle Possession (%)	
		Likely	Unlikely	With	Without
Male N=158	38.6 (20.9)	36 (22.8)	122 (77.2)	20 (12.7)	138 (87.3)
Female N=135	31.8 (20.4)	27 (20)	108 (80)	7 (5.2)	128 (94.8)

All the data had previously been coded by Giles et al. (2017), with distance travelled (km), gender, suicidal likelihood, vehicle possession and age being the only examined variables.

The study used an independent groups design, examining the differences in distance travelled (dependant variable, DV) across three independent variables (IV) gender, likely suicidal and possession of a vehicle. A 2 (gender) x 2 (suicidal likelihood) x 2 (vehicle possession) between groups analysis of variance (ANOVA) was conducted in order to determine any significant main effects or interactions between distance travelled and the three IVs.

The ANOVA assumptions of normality and homogeneity of variance (HOV) were tested. The data was not normally distributed (see Table 2 for statistics), with histograms showing a positive skew. Despite the normality violation, Schmider, Ziegler, Danay, Beyer and Bühner (2010) state when non-normal distributed data is applied to ANOVAs, "α and β stay constant" (p.149) making the ANOVA robust and tolerant to normality violations. The equality of variances Levene's test was significant (.021), violating the homogeneity of variance (HOV) assumption. Kim and Cribbie (2017) identified traditional HOV tests to be ineffective at determining when it is acceptable or not to conduct an ANOVA procedure due to the inflated type I error rates they so often create. Levene based approaches explore the "differences in

the population parameter of interest" (p.3), however Hoekstra, Kiers and Johnson (2012) highlighted that in a sample, by definition, the population is not known. Therefore, the exact variance in the sample's population is usually not possible to determine, meaning the HOV assumption of establishing the equality of two population variances can rarely ever be satisfied. Despite the violations, consideration of the supporting literature justified running the ANOVA analysis.

Table 2 - *Skewness, Kurtosis and mean distance variable statistics for each variable*

Variable		Skewness (SE)	Kurtosis (SE)	Mean km (SD)
Vehicle Possession	Yes (n=27)	1.80 (.45)	3.25 (.87)	17.16 (19.77)
	No (n=266)	2.52 (15)	7.81 (.30)	9.44 (13.89)
Gender	Male (n=158)	2.49 (.19)	7.19 (.38)	10.99 (16.32)
	Female (n=135)	1.96 (.21)	3.17 (.41)	9.16 (12.42)
Suicidal likelihood	Likely (n=63)	1.93 (.30)	2.97 (.60)	9.06 (12.89)
	Unlikely (n=230)	2.50 (.16)	7.44 (.32)	10.45 (15.11)

Study 2A

Study 2a used the same secondary data as study 1. From the 1,037 entries, removing repeats, returned home and missing distance values left a sample of 337. Four sub groups were formed comprising of likely and unlikely suicidal males and females (see Table 3). An additional 'distance interval' variable was created, which grouped distance values into the appropriate interval spanning from 1 (0-0.5km) to 80 (40.1+ km) ascending in 0.5km increments (Kent, 2003; p.63). The distances travelled ranged from 0.1-323km.

Table 3 *- Frequencies and median distance (km) travelled by each sub group*

	Suicidal Likelihood			
	Likely		Unlikely	
	Km (SD)	n	Km (SD)	n
Male N=180	2.72 (26.72)	42	4.77 (52.38)	138
Female N=157	4.46 (50.82)	33	4.12 (51.59)	124
Total N=337	3.15 (39.10)	75	4.41 (51.92)	262

A descriptive observation design was used examining the distance decay functions of non/suicidal gendered sub-groups (see Kent, 2003 for a detailed methodology). The goodness of fit in six decay models on the relationship between the distance intervals (IV) and their frequencies (DV) in each sub group was analysed via nonlinear regression curve estimations.

A curve estimation analysis was conducted to determine the most applicable decay functions for each subgroup. The R^2 coefficient produced, ranging between 0-1, indicated the goodness of fit through closer values to 1, signifying a better match to the dataset. The data was tested against six functions: quadratic, exponential, logarithmic, inverse, cubic and linear. The relationship between the distance intervals, i.e. the distance travelled, and the frequency of being found was differently characterised by each function with an explanation and definition below.

Polynomial functions:

Linear: $y=x$. A simple negative decreasing function, suggesting the probability of being found (y) decreases at a constant rate to the increase in distance travelled (x). The function was used as an experimental control (Canter & Hammond, 2006), since models of human spatial behaviour are rarely constant, with likely fluctuations in the rates of decrease.

Quadratic: $y=x^2$. A basic 'U' shaped curve either opening up or down, varying in width and steepness (Sterling, 2010). Displays the frequency of being found to rapidly decline with the distance travelled then levelling out, however after a turning point the found frequency increases again (Canter & Hammond, 2006), with missing individuals now being located a noticeable distance away from their last seen location. This might be anticipated in the case of those individuals 'commuting' to a suicide location.

Cubic: $y=x^3$, illustrates a basic pattern of increase, followed by a decrease, leading to another increase (Elliot, 2017). In relation to distance travelled the function represents multiple turning points where the found frequency either rises or falls; representing an oscillating relationship.

Exponential *function:* $f(x)=a^x$, is an arc shaped curve, increasing or decreasing infinitely as the function gets closer to the x axis (Kelley, 2006). A negative exponential function denotes the frequency of being found is initially high around the base location, but declines at a constant rate with the distance travelled towards the infinite unlikelihood of being found (Canter & Hammond, 2006).

Inverse functions:

Logarithmic: $y=\log_a(x)$, inverse of the exponential function. Illustrates a quick decline in the found frequency, then gradually evens out as the distance increases (Giles et al., 2017).

Inverse: $f^{-1}(x)$, models reversal effects, with the x and y variables being reversals of each other (Kelley, 2006). Therefore, the steep decrease in found frequency is inversely related to the distance travelled. The inverse function is associated to location attractiveness, with the distance travelled being inversely proportional to the impedance - the resistance factors to travelling further afield. (Chin & Wen, 2015).

The steepness/gradients of the functions suggest the significance of the 'base' location (Eldridge & Jones 1991). Shallow, slow decaying functions infer the base site holds little significance to the individual, unrestricting their spatial movements, thus implying a larger search parameter will be needed to find the individual.

Study 2B

A cross validation measure for 2a, which explored the practical application of the likely suicidal groups' significant decay functions on found male missing persons cases who had deceased through suicide (definite suicidal). Secondary data was utilised from a second police force (Giles & O'Brien, 2014), comprised of 24 cases (see Table 4). The data was transformed into an SPSS dataset, and grouped by gender, with distance intervals again being calculated and examined along with the distance travelled and gender variables.

Table 4 *- Frequency and distance travelled (km) statistics for suicidal females and males*

	Distance travelled (km)			
	Median (SD)	Minimum	Maximum	Range
Male N=20	6.20 (356.27)	.60	1604.17	1603.57
Female N=4	8.95 (31.77)	3.10	70.20	67.10
Total N=24	6.55 (325.10)	.60	1602.17	1603.57

A nonlinear regression curve estimation was firstly ran on the distance intervals (IV) and their frequencies (DV). A descriptive observation then followed, comparing the distance decay functions from study 2a with 2b. Curve estimations could not be conducted for the female sub-group due to its small sample size, however it was possible for the male group, therefore the procedure followed study 2a's. The significant likely suicidal male functions from 2a were then mapped onto the plots and functions derived from this study.

Results

Study 1

Parametric Results: A 2x2x2 Between Subjects ANOVA was conducted to explore the differences in the distance travelled dependent on gender, suicidal likelihood and vehicle possession. Table 5 illustrates the means and standard deviations produced showing greater distances are travelled when in possession of a vehicle. There was a significant main effect for vehicle possession $F(1, 285) = 5.16$, $p=.024$, $\eta^2=.18$, observed power .62. Missing individuals who had possession of a vehicle travelled significantly further (M=17.16±19.77) than those not in possession (M=9.44±13.89). Main effects for gender $F(1,285)=.09$, $p=.764$, $\eta^2=.000$, observed power .06 and suicidal likelihood $F(1,285)=1.87$, $p=.173$, $\eta^2=.007$, observed power .28, did not reach statistical significance.

The interaction effect between all three variables was not statistically significant $F(1,285)=.15$,

p=.701, η^2=.001, observed power .07 (Appendix D). The interaction between vehicle possession and gender *F*(1,285)=.31, *p*=.58, η^2=.001, observed power .09, gender and suicidal likelihood *F*(1,285)=.32, *p*=.575, η^2=.001, observed power .09 and suicidal likelihood and vehicle possession *F*(1,285)=.52, *p*=.47, η^2=.002, observed power .11 were also not significant. Interpretation of these results should be taken with care, since non-significant results with an observed power of less than .80 (Pallant, 2013) have an elevated potential of a type II error (falsely accepting the null hypothesis). Figure 2 displays the interaction effects, between the variables. Despite the findings being non-significant the scatterplots show interesting trends among the interactions.

Table 5 *- Means and Standard Deviation (±) for Distance Travelled*

Gender	Suicidal likelihood	Vehicle possession	Distance travelled (km)	
			M	SD
Male N=158	Yes	Yes (n=13)	14.36	17.66
		No (n=23)	5.20	9.05
		Total (n=36)	8.51	13.35
	No	Yes (n=7)	22.65	27.08
		No (n=115)	11.05	16.22
		Total (n=122)	11.71	17.08
Female N=135	Yes	Yes (n=2)	11.86	6.09
		No (n=25)	9.62	12.90
		Total (n=27)	9.79	12.47
	No	Yes (n=5)	18.86	19.95
		No (n=103)	8.53	11.93
		Total (n=108)	9.01	12.46

Through wanting to explore variable interactions on the distance travelled, the decision was taken to run parametric tests with caveats. Supplementary non parametric Mann Whitney U tests were conducted to compensate for the previous assumption violations and to explore the scatterplot interactions by investigating gender, suicidal likelihood and vehicle possession effects on the distance travelled.

Non Parametric Results: A Mann-Whitney U test revealed there was a significant difference in the distance travelled between suicidal males (median=1.51, n=50) and females (median=3.15, n=35), *U*=630.5, z=-2.18, *p*=.029, r=.24. Supporting Figure 2A's, suggested interaction. No significant difference was found between the non (median=3.22, n=300) and suicidal (median=2.36, n=85) subgroups in the distance travelled, U=12046, z=-.78, p=.437, r=.04. These comparisons infer that whilst suicidal individuals do not tend to travel less or more than non-suicidal individuals, there is tendency for suicidal males to travel less than suicidal females.

A Mann-Whitney U test found a significant difference between the distance travelled and by those with (median=9.93, n=31) compared to those without possession (median=2.73, n=320) of a vehicle across

the whole data set, U=3442, z=-2.81, p=.005, r=0.15, partially supporting Figure 2E. Subsequent Mann Whitney U test analyses revealed a significant difference in the distance travelled depending on whether suicidal males had possession (median=7.05, n=14) or not (median=.83, n=31) of a vehicle, U=117, z=2.46, p=.014, r=.37. For suicidal females no significance was found between vehicle possession (median=7.55, n=3) or not (median=2.83, n=27) and distance travelled, U=38, z=-.17, p=.86, r=.0.03,

Study 2A

Suicidal males: Four functions were found to be significant, the inverse had the highest significance, R^2=.779, F(1,18)=63.61, p<.001, followed by logarithmic, R^2=.407, F(1,18)=12.37, p=.002, quadratic, R^2=.374, F(2,17)=5.08, p=.019 and cubic R^2=.433, F(1,18)=4.07, p=.198. The remaining functions were found to not fit the data as well: exponential, R^2=.090, F(1,18)=1.79, p=.198 and linear, R^2=.085, F(1,18)=1.68, p=.212. (see Figure 3a)

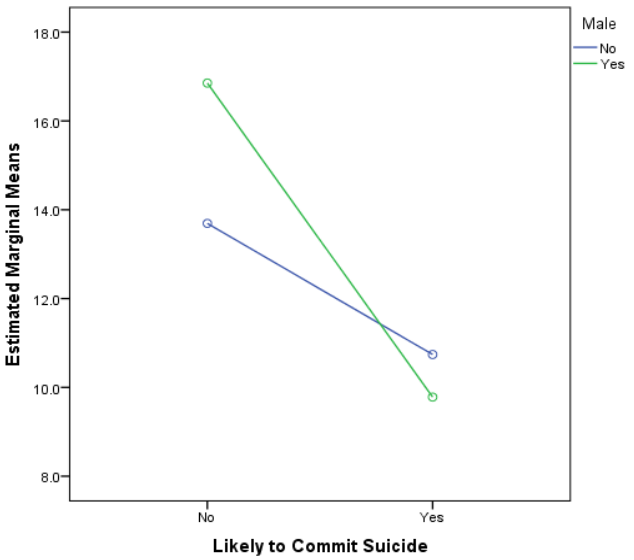
Suicidal females: Four functions were significant, the quadratic R^2=.509, F(2,18)=9.33, p=.002, cubic, R^2=.515, F(3,17)=6.01, p=.006, logarithmic, R^2=.135, F(1,19)=2.95, p=.102 and inverse, R^2=.130, F(1,19)=2.85, p=.108. The exponential, R^2=.003, F(1,19)=.24, p=.633 and linear, R^2=.005, F(1,19)=.10, p=.758 functions were not significant. (see Figure 3b)

Unlikely suicidal males: Every function was significant bar the linear control: R^2=.057, F(1,41)=2.48, p=.123. The most appropriate function was the cubic, R^2=.550, F(3,39)=15.87, p<.001, followed by quadratic, R^2=.544, F(2,40)=23.86, p<.001, inverse, R^2=.427, F(1,41)=30.58, p<.001, logarithmic, R^2=.302, F(1,41)=17.76, p<.001, and the exponential, R^2=.127, F(1,41)=5.99, p=.019 (see Figure 3c).

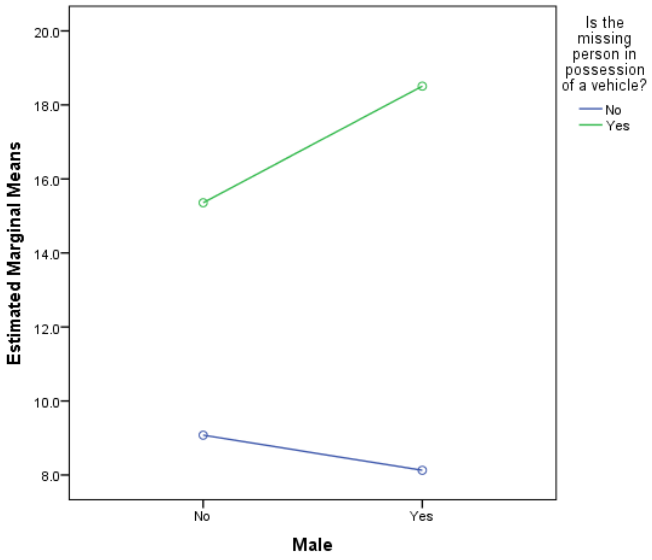
Unlikely suicidal females: The most significant fitting function was the cubic, R^2=.578, F(3,34)=15.53, p<.001, then the quadratic, R^2=.560, F(2,35)=22.23, p<.001, inverse, R^2=.500, F(1,36)=36.06, p<.001, logarithmic, R^2=.375, F(1,36)=21.63, p<.001, and the exponential, R^2=.220, F(1,36)=10.14, p=.003. Similarly to the unlikely suicidal males, the only non-significant function was the linear control, R^2=.080, F(1,36)=3.15, p=.084 (see Figure 3d).

Figure 2 - Graphs displaying the ANOVA interaction effects between gender, suicidal likelihood and vehicle possession. *(a) suicidal likelihood and gender (b) gender and vehicle possession (c) suicidal likelihood and vehicle possession (d) 3 way interaction, between having possession of a vehicle with gender and suicidal likelihood (e) 3 way interaction, between no vehicle possession with gender and suicidal likelihood*

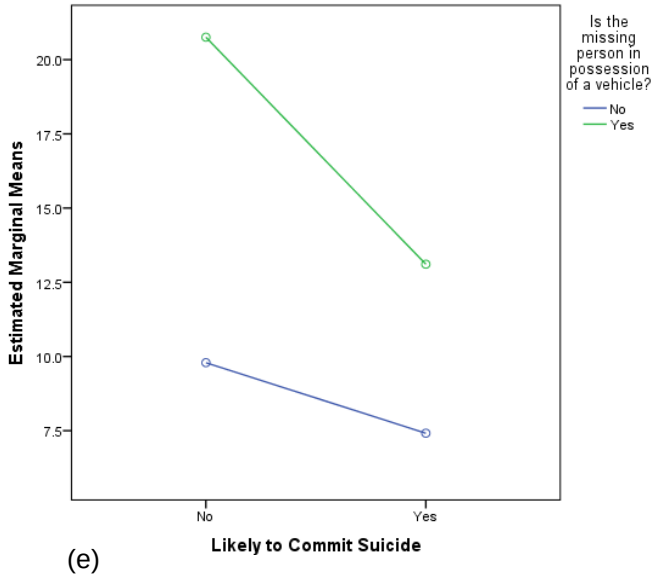
(a)



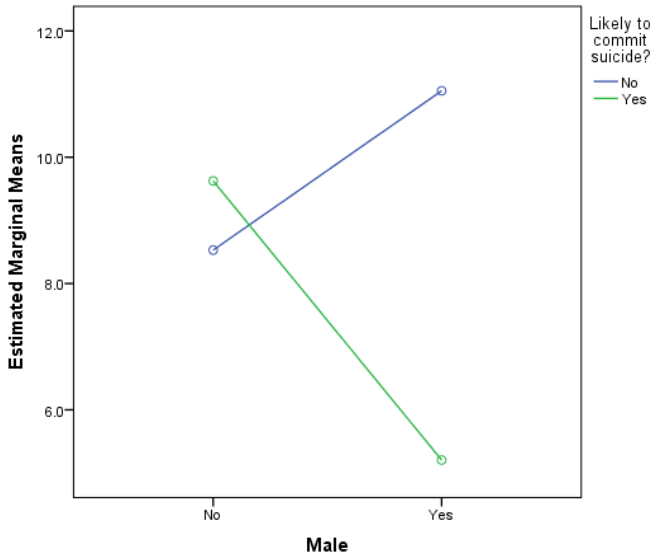
(b)



(c)



(d)



(e)

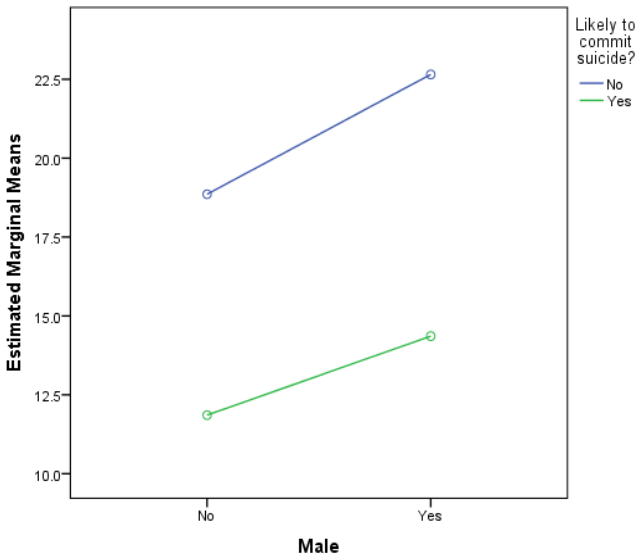
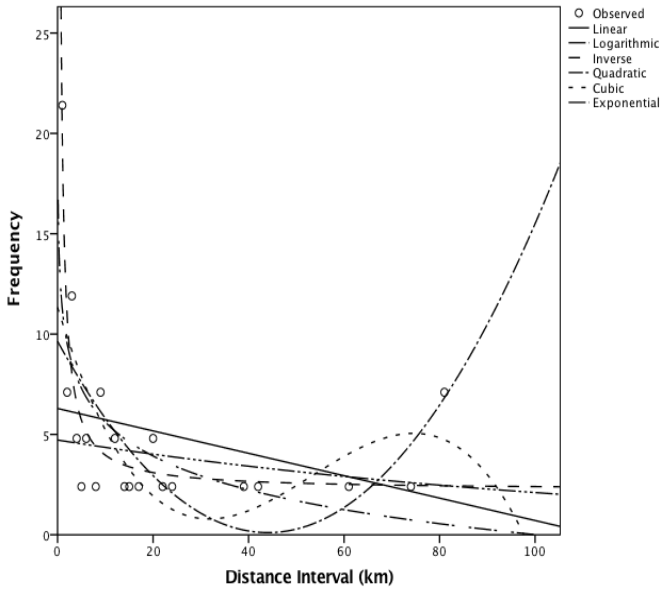
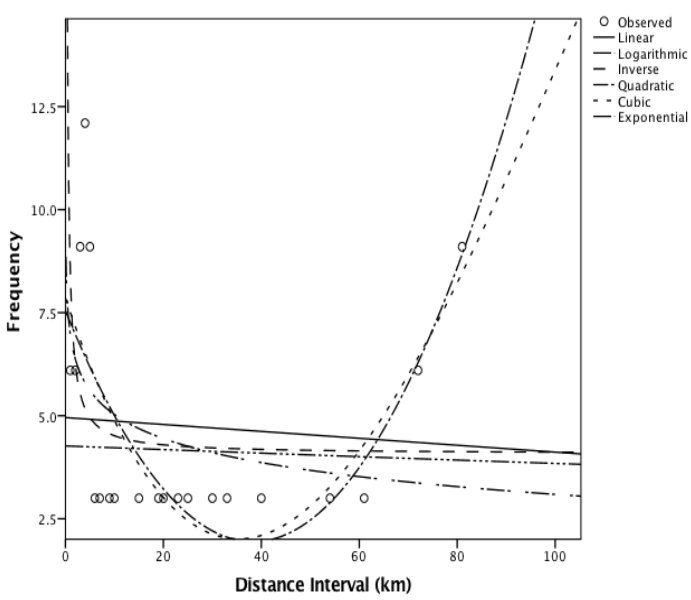


Figure 3 *– Graphs displaying the six distance decay functions calibrated against the distance travelled in the non/suicidal gendered sub-groups (a) suicidal males (b) suicidal females (c) unlikely suicidal males (d) unlikely suicidal females*

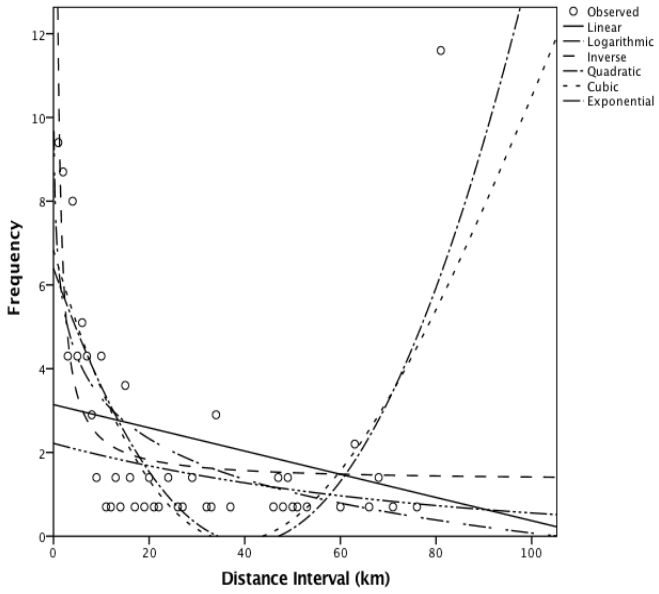
(a)



(b)



(c)



(d)

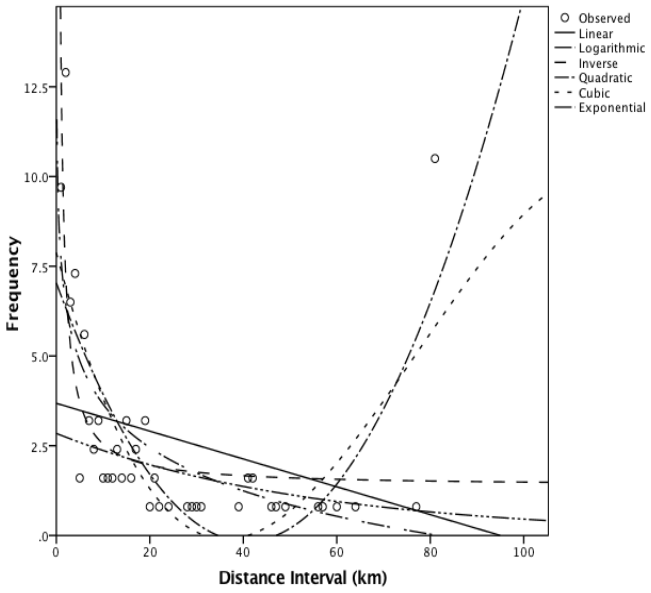
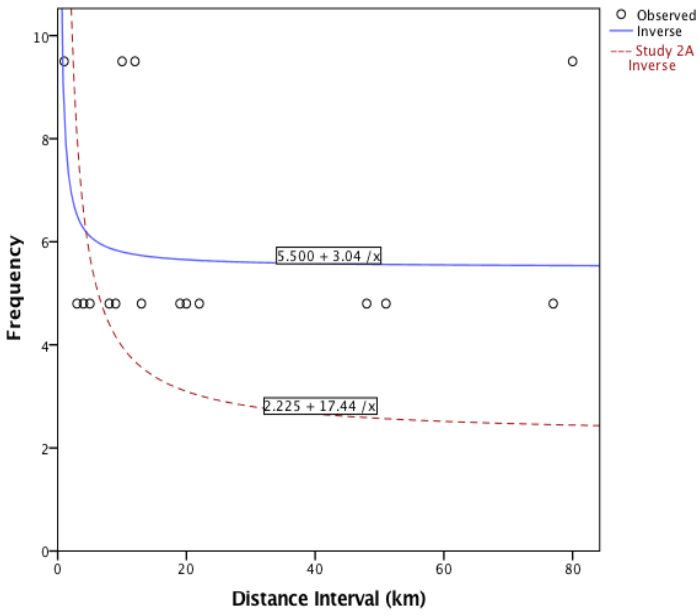
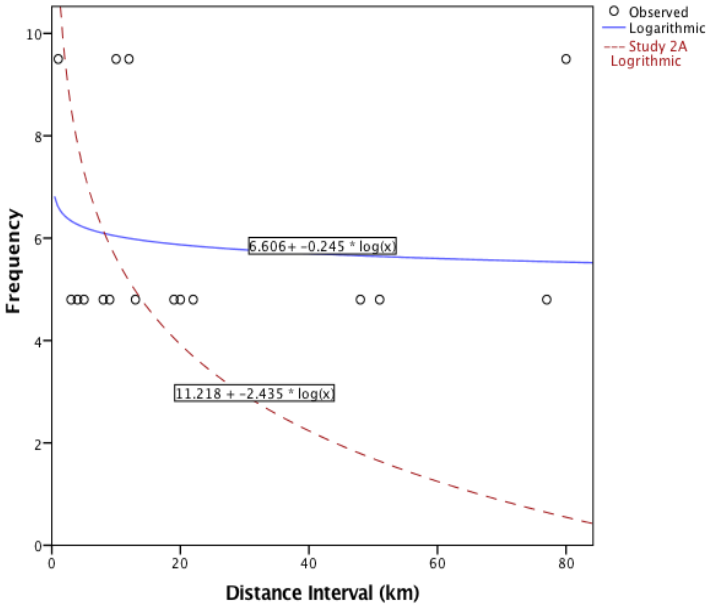


Figure 3 – Comparison graphs displaying the significant likely suicidal male functions found in study 2a, against the same functions generated for suicidal males in study 2b (a) inverse function (b) logarithmic function (c) quadratic function (d) cubic function

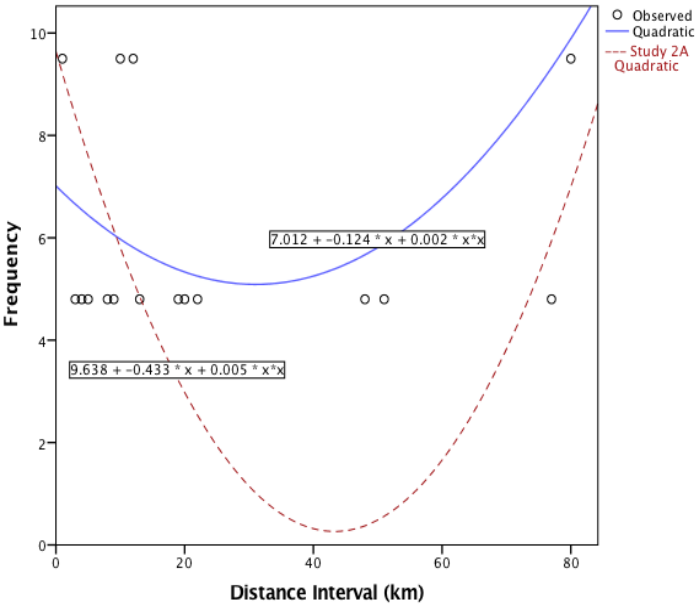
(a)



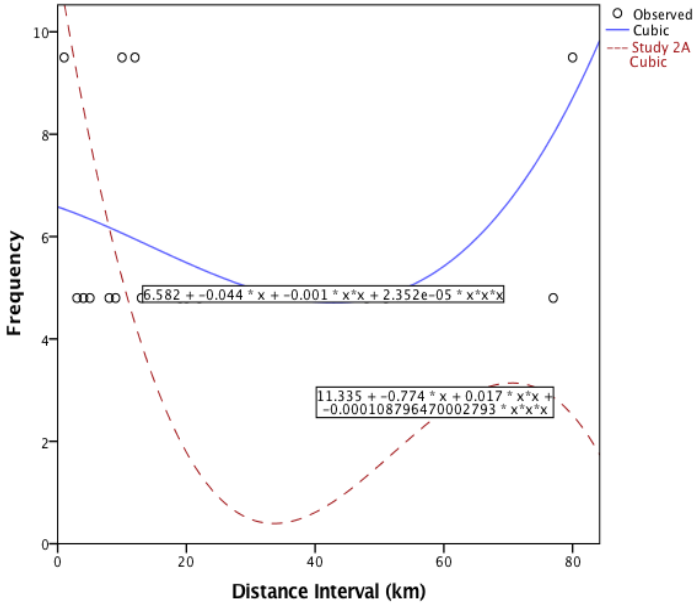
(b)



(c)



(d)



Study 2B

The significant likely suicidal male functions from 2A (inverse, logarithmic, quadratic and cubic) were mapped onto the plots and functions derived from this study.

No function was found to be significant in the curve estimation for suicidal males, however the inverse function had the smallest p value: R^2=.124, F(1,14)=1.97, p=.182, followed by the quadratic, R^2=.149, F(2,13)=1.13, p=.352, cubic, R^2=.162, F(3,12)=.77, p=.531, logarithmic, R^2=.020, F(1,14)=.29, p=602, exponential, R^2=.002, F(1,14)=.03, p=.873, and the linear control, R^2=.002, F(1,14)=.03, p=.873, (see Appendix G).

Figure 4 illustrates the comparisons between the functions from the two studies. As a whole the function gradients of the suicidal males were a lot shallower, with higher frequencies of being found further away from their last seen location compared to the likely suicidal male group; supporting Eldridge & Jones' (1991) previously mentioned function gradient observation. These interpretations suggest suicidal males travel further compared to males who are likely to take their lives, but may not necessarily do so. The practical implications of these findings are considered in the discussion.

Discussion

Two different spatial behaviour analyses were explored in this paper on missing persons. The first identified the effects and interactions of gender, suicidal likelihood and vehicle possession on distance travelled. As predicted there was a significant relationship between vehicle possession and distance travelled, with individuals in possession travelling further. Contrary to predictions no other significant relationship or interaction was found. The ANOVA main effects and interaction scatterplots did however display some noticeable trends, indicating the possibility for significant interactions between the variables, particularly for gender and suicide likelihood. The trend indicated non-suicidal males would be located further away than non-suicidal females, however suicidal males would be located within a shorter distance parameter from their last seen location compared to their female counterparts. Existing literature does provide evidence for this interaction to be viable, therefore in light of these trends, follow up studies would be useful to explore the interactions with a larger, gender balanced dataset. The significant vehicle possession main effect supports previous research (Gibb & Woolnough, 2007) on its impact on missing persons journey distances. Interestingly, the scatterplot (2e) illustrating the 3 way interaction with individuals in possession of a vehicle suggest suicidal males travel the shortest distance with a car out of the four subgroups and non-suicidal males travelled the furthest. Suggesting the main effect was grounded in the non-suicidal groups rather than the suicidal intent groups. Contrastingly, interviews with missing person by Stevenson, Parr, Woolnough and Fyfe (2013) found only 18% of missing persons cases used a car, parking it soon after leaving, due to the danger of driving in a

heightened state of arousal. The most used mode of transport was foot (49%), indicating car possession may not necessarily invoke its use when leaving to go missing, and if so, it may not be to a distant location – a precaution that police officers should keep in mind to refrain from over expenditure when investigating cases.

The non-parametric finding in this study is that suicidal females travelled further than their male counterparts, supports the Grampian Report (2007) which stated when travelling by foot females journeyed further. The idea of elongated travel is associated with suicide tourism, which is predominately undertaken by males; therefore the non-parametric test finding does contradict this idea. However, when in possession of a vehicle compared to those without male missing person travelled further, no effect was found for females. This effect showed vehicle possession facilitated travel to further destinations, possibly ones which the missing male was not a resident of, thus aligning with wider male majority non-residential suicide findings.

The second analysis explored the suitability of distance decay models on each subgroup's journey to suicide. The likely suicidal male functions were further cross validated on a definite suicidal sample; found male missing persons cases who had deceased through suicide. The findings show that likely suicidal missing persons gender groups differ in the functions best describing their suicide journeys, suggesting that genders have different spatial patterns. Fewer significant functions for the likely suicidal groups compared to non-suicidal missing person groups were found suggesting suicidal missing persons may have more specified and focused spatial movements. This idea aligns with the high risk and significant location literature stipulating suicidal individuals travel to predetermined locations. Furthermore, Stevenson et al. (2013) found individuals who had gone missing with the intention to commit suicide in their sample all had a definite planned destination in mind, sometimes decided well in advance before they went missing.

The quadratic, very closely followed by the cubic, were the closest approximate functions matching the distribution of the likely suicidal female missing persons group. Both functions shared the commonality of having turning points where the frequency subsequently rose, which implied females were found at greater distances away from their last seen location. This finding suggests that larger search parameters should be considered when investigating suicidal missing females. Furthermore, these functions are associated with the decisions to travel further due to the attractiveness or suitability of the location (Ludrigan & Canter, 2001). So the consideration of commuting behaviour to high risk or significant locations is advised. For likely suicidal male missing person the inverse was the most significant function exhibiting a sharp initial drop in frequency then gradually tailing off, with the following significant log function illustrating similar patterns. The severe gradient decrease indicates local spatial movements supporting missing persons literature in minimal journey lengths. Steven's power law (1961) and the environmental theory of the Least Effort Principle (Rossmo, 2000) can also explain this spatial mapping. Commuters optimise their travels via the most effective feasible means, thus avoiding unfamiliar or lengthy routes - directly applicable to the short, direct, close to home journeys observed in

male missing persons spatial behaviours. These outcomes encourage shorter, more local search practises compared to female investigations. Furthermore, as Kent (2003) notes these male pathways will be selected and optimised via their subjective perceptions of their landscape. Police should therefore aim to seriously consider the surrounding missing persons environmental terrain and understand the daily journeys and activities a missing person partakes in, to tap into their journey perceptions and help to locate the individual.

Compared to the definite suicidal male decay functions, likely male functions illustrated steeper, shorter spatial journeys. This observed difference could be mediated by a variety of confounding factors such as the degree of suicide ideation, access means and environmental surroundings, all of which are beyond the scope of this paper but useful to acknowledge in future research.

Limitations

Several of this study's limitations were linked to its data. Using secondary data meant control over data recording was lost, meaning distance travelled values were unable to be calculated for numerous cases due to police recording inconsistencies. Many of the ANOVA findings indicted a low observed power (possibly due to the low sample sizes in some of the sub-groups) meaning the possibility of a type II error was high, therefore suggesting the rejection of a significant finding could have occurred. Furthermore, the plots displayed trends towards significance however none were discovered, potentially due to floor effects in the distance travelled variable (DV). This effect arose through the disproportionality in gender groups, which although being reflective of the gender prevalence, limited the study since the male shorter distance values clustered around the home 'base', creating a strong positive skew. This potentially limits the findings. Future studies should aim towards equal gendered samples to try to avoid this problem. Finally, single cases of extreme distance values can distort the data and inferential statistics, producing vast variances and standard deviations.

Since hybrid research of missing persons, suicide and geographic profiling is still in its infancy, the need for its continuing development is important. Future studies should use longitudinal designs, as opposed to a cross sectional design used in this study. This will observe the ongoing impacts of gender and suicidal likelihood on missing persons movements and to recognise if safe guarding approaches and policing procedures are effectively being achieved. As demonstrated by the Least Effort Principle, human spatial behaviours are subjective with environmental factors and architecture often dictating the route of travel. Traditional profiling models are generated by Euclidean distances - a straight line pathway directly from A to B, mapping "as the crow-flies" distances (Kent, 2003) but fail to account for the actual/realistic commuter pathway. Suggestions on the usage of software which takes into account this issue are needed; future research would be facilitated using this advanced software to drive the understanding of gender differences in suicidal missing person journeys.

Conclusion

The study was the first of its kind to explore gender specific journeys in non-suicidal / suicidal missing persons. Despite the data limitations, the findings showed likely suicidal female missing persons travelled further than their male counterparts, and the possession of a vehicle influenced the distance travelled, particularly for males. Distinct gender differences were illustrated by decay functions showing suicidal female missing persons are possibly influenced by location attractiveness and suitability determining further spatial movements. Whereas functions for suicidal male missing persons suggest journeys are more locally bound. Furthermore, the impact of environmental factors and psychological biases may be significant in determining spatial movements, which should be investigated. As a whole, the findings suggest police should use gender tailored search parameters when looking for suicidal missing persons with the possibility of aiding faster detection, limiting expenditure and most importantly safeguarding vulnerable individuals.

About the authors

Catherine Stevens holds a First Class BSc in Psychology and is currently an Investigative and Forensic Psychology MSc student at the University of Liverpool. She hopes this study, which she completed as her undergraduate research project, and her masters research on reflective logging within the emergency services can inform real world practice and enhance individual and organisational performance. Her further interests lie in critical decision making and helping vulnerable groups.

Susan Giles is a Lecturer in Psychology at the University of Liverpool, where she teaches on the MSc Investigative and Forensic Psychology. She has received funding to evaluate dedicated missing person police units and to develop the Tackling Online Grooming (TOG) Toolkit for front line police officers. Susan is the principle investigator for the CASPER project and was awarded funding by HEFCE's Police Knowledge Fund to undertake 'proof of feasiblity' studies with colleagues in Computer Science and Mathematics at Liverpool John Moores University.

Freya O'Brien is a Senior Lecturer at the University of Liverpool. She researches a wide range of issues regarding missing, including memory for missing person appeals, risk of harm when missing, and the spatial behaviour of missing people. Freya also researches modern day slavery, human trafficking and exploitation, and the relationship between these offences and missing. She is currently working on a project examining why modern day slavery cases drop out of the criminal justice system.

References

Carter, J. (2011). Minister of Civil Defence statement to Parliament that state of national emergency declared *Speeches.* Retrieved from http://www.beehive.govt.nz/speech/minister-civil-defence-statement-parliament-state-national-emergency-declared.

Alys, L., Massey, K., & Tong, S. (2013). Investigative decision making: Missing people and sexual offences, crossroads to an uncertain future. *Journal of Investigative Psychology and Offender Profiling, 10*(2), 140-154.https://doi.org/10.1002/jip.1382

Association of Chief Police Officers & National Policing Agency (ACPO), (2013). Interim Guidance on the Management, Recording & Investigation of Missing Persons. College of Policing. London: College of Policing. Retrieved from http://www.acpo.police.uk/documents/crime/2013/201303-cba-int-guidmissing- persons.pdf.

Bennewith, O., Nowers, M., & Gunnell, D. (2010). Suicidal behaviour and suicide from the Clifton Suspension Bridge, Bristol and surrounding area in the UK:1994-2003. *The European Journal of Public Health*, ckq092.

Biehal N., Mitchell F and Wade J (2003). *Lost from View: A study of missing people in the United Kingdom*. Bristol: Policy Press.

Brantingham, P. J., & Brantingham, P. (1981). *Environmental criminology.* Prospect Heights, Illinois: Waveland Press Inc.

Canter, D. (1996). The Environmental Range of Serial Rapists. In: *Psychology in Action.* Dartmouth Benchmark Series. Dartmouth Publishing Company, Hantshire, UK, pp. 217-230. ISBN 1855213656.

Canter, D. (2004). *Mapping murder*. London: Virgin Books.

Canter, D., & Hammonds, L. (2006). A comparison of the efficacy of different decay functions in geographical profiling for a sample of US serial killers. *Journal of Investigative Psychology and Offender Profiling*, 3, 91-103. DOI:10.1002/jip.45

Chin, W., & Wen,T. (2015). Geographically modified PageRank algorithms: Identifying the spatial concentration of human movement in a geospatial network. *PLoS ONE*, 10(10). 1-23. doi:10.1371/journal.pone.0139509.

Eldridge, J. E., & Jones, J. P. (1991). Warped space: a geography of distance decay. *Professional Geographer*, *43*, 500–511.

Elliot, A.E. (2017). Changing crime mix patterns of criminal careers: Longitudinal latent variable approaches for modelling conviction data in England & Wales and the Netherlands. *MSc thesis: Lancaster University.*

Felson, M. and Clarke, R., (1998). Opportunity Makes a Thief, Practical theory forcrime prevention. *Police Research Series, Paper 98.* Home Office, Policingand Reducing Crime Unit, Research, Development and Statistics Directorate, London.

Ffye, N.R., Stevenson, O., & Woolnough P. (2015). Missing persons: The processes and challenges of police investigation. *Policing and Society, 25*(4). 409-425. http://dx.doi.org/10.1080/10439463.2014.881812.

Gibb, G., & Woolnough, P. (2007). *Missing persons: Understanding, planning, responding.* Aberdeen: Grampian Police.

Giles, S., Jarman, I., Reily, D., Etchells, T., Giles, L., Bayly,J., & Wren, C. (2017), *'Proof of feasibility' studies to develop an interactive geo-spatial decision support system for police forces (CASPER).* Research Synthesis. The University of Liverpool, Eleanor Rathbone Building, Bedford Street South, L697ZA.

Giles, S., & O'Brien, F. (2014). Proof of concept studies for CASPER system. *The University of Liverpool*, Eleanor Rathbone Building, Bedford Street South, L697ZA.

Greene, K.S., & Pakes, F. (2013). The cost of missing person investigations: Implications for current debates. *Policing: A Journal of Policy and Practice,8*(1), 27-34. doi:10.1093/police/pat036.

Gross, C., Piper, T.M., Bucciarelli. A., Tardiff, J., Vlahov, D., & Galea, S. (2007). Suicide tourism in Manhattan, New York City, 1990-2004. *Journal of Urban Health: Bulletin of the New York Academy of Medicine, 84*(6), p.755-766.doi:10.1007/s11524-007-9224-0

Hannon, K., Giles, S., Deacon, L., & Tocque, K. (2009*). Suicide in the North West: A review of non-residential and outdoor suicide locations.* Retrieved from: http://www.nwph.net/nwpho/publications/SuicideintheNW.pdf

Henderson M, Henderson P. (1998). Missing People: Issues for the Australian Community. Canberra: Commonwealth of Australia, 1998.

Hoekstra, R., Kiers, H. A., & Johnson, A. (2012). Are assumptions of well-known statistical techniques checked, and why (not). *Frontiers in Psychology*, 3, article 137. https://doi.org/10. 3389/fpsyg.2012.00137

Home Office, (2011). *Missing children and adults. A cross government strategy.* Home Office.

Kelley, W. (2006). *The complete idiot's guide to calculus* (2nd ed.). New York, NY: Penguin Group.

Kent, J. (2003). Using functional distance measures when calibrating journey to crime distance decay algorithms. *MSc thesis: Louisiana State University*.

Kim, Y.J., & Cribbie. R.A. (2018). ANOVA and the variance homogeneity assumption: Exploring a better gatekeeper. *British Journal of Mathematical and Statistical Psychology*, *71*, 1-12. DOI:10.1111/bmsp.12103

Knapp, M., McDaid, D., & Parsonage, M. (2011). *Mental health promotion and prevention: The economic case.* Retrieved from London School of Economics Website: http://www.lse.ac.uk/businessAndConsultancy/LSEEnterprise/pdf/PSSRUfeb011.pdf

Lundrigan, S., & Canter, D. (2001). A multivariate analysis of serial murderer's disposal site location choice. *Journal of Environmental Psychology*, *21*, 423-432.

National Policing Improvement Agency (NPIA). (2011). *Missing persons: Data and analysis* 2010/2011. London: NPIA.

National Crime Agency. (2017). *UK Missing Persons Bureau: Missing persons data report 2015/16*. Retrieved from http://nationalcrimeagency.gov.uk/publications/876-missing-persons-data report-2015-2016-1/file

Newiss, G. (2006). Understanding the risk of going missing: Estimating the risk offatal outcomes in cancelled cases. *Policing; An International Journal of Police Strategies & Management, 29*(2), 246-260. https://doi.org/10.1108/13639510610667655.

Newiss, G. & Greatbatch, I. (2017). *Men missing on a night out: Exploring the geography of fatal disappearances to inform search strategies*. Retrieved from http://www2.port.ac.uk/media/contacts-and-departments/icjs/csmp/MONO-Report-101217.pdf

Office for National Statistics (ONS), (2017). *Suicides in the UK: 2016 registrations.* Retrieved from https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/suicidesintheunitedkingdom/2016registrations

Owens, C., Lloyd-Tomlins, S., Emmens, T., & Aitken, P. (2009). Suicides in public places: findings from one English county. *The European Journal of Public Health*, *19*(6), 580-582. doi: 10.1093/eurpub/ckp052

Pallant, J. (2013). *SPSS survival manual: a step by step guide to data analysis using IBM SPSS* (5th ed.). Berkshire, England: McGraw-Hill.

Parr, H., & Fyfe, N. (2012). Missing Geographies. *Progress in Human Geography*, *37*(5), 615-638.

Perkins, D. (2012). *Fatal and non-fatal outcomes: an investigation into some differences in relation to the august 2011 report from the UK missing person behaviour study*. Retrieved from The Centre for Search Research (CSR): http://www.searchresearch.org.uk/downloads/ukmissingpersonbs/1268811232502b97a8 5005.pdf

Perkins, D., Roberts, P., & Feeney, G. (2012). *The U.K. missing person behaviour study*. Retrieved from Mountain Rescue UK Website: https://www.mountain.rescue.org.uk/.../MissingPersonBehaviourStudyReport 011.pd

Safe on the Streets Research Team (1999). *Still Running: Children on the Streets in the UK*. The Children's Society, London.

Schmider, E., Ziegler, M., Danay, E., Beyer, L., & Bühner, M. (2010). Is it really robust? *Methodology European Journal of Research Methods for the Behavioural and Social Sciences, 6*(4), 147-151.

Shalev, K., Schaefer, M., & Morgan, A. (2009). Investigating missing person cases: how can we learn where they go or how far they travel? *International Journal of Police Science & Management, 11*(2), 123-129. DOI: 10.1350/ijps.2009.11.2.116.

Sterling, M.J. (2010). *Algebra II essentials for dummies.* Hoboken, NJ: Wiley Publishing, Inc.

Rossmo, Kim D., (2000). *Geographic Profiling*. CRC Press, Boca Raton, FL.

Soria, M.A., & Villalba, D. (2017). Review: Principles of geographical profiling. *Journal of Forensic Biomechanics, 8*(1), 1-3. DOI: 10.4172/20902697.1000133

Stevens, S. S. (1961). To honor Fechner and repeal his law. *Science*, *133*, 80–86.

Stevenson, O., Parr, H., Woolnough, P., & Fyfe, N. (2013). *Geographies of missing people; processes, experiences, responses*. The University of Glasgow. ISBN: 978-0 85261- 936-0.

Sveticic, J., San Too, T. & De Leo, D. (2012). Suicides by persons reported as missing prior to death: a retrospective cohort study. *BMJ Open.* 2: e000607.doi:10.1136/bmjopen-2011- 000607

Windfurh, K., Bickley, H., While, D., Williams, A., Hunt, I.M., Appleby, L., & Kapur, N. (2010). Nonresident suicides in England: A national study. *Suicide and Life Threatening Behaviour, 40*(2), 151-158.