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The Journal of Search and Rescue (JSAR) is an open access peer-reviewed electronic journal for the collation and distribution of original scholarly material on search and rescue (SAR).

It is being supported by the in-kind work and contributions of the Editorial Board. There is currently need for a dedicated journal serving those with a direct interest in all disciplines of search and rescue including: rope rescue, water (flat, swift and marine), ice rescue, wilderness search and rescue, structural collapse rescue, trench collapse rescue, cave rescue, dive rescue, motor vehicle extrication, canine search, technical animal rescue, air rescue, search theory, search management, and mines rescue. JSAR exists to fulfil that need.

Article submissions from these and other SAR disciplines are welcome. Launching this journal on the internet offers a relatively cost-effective means of sharing this invaluable content. It affords the prompt publication of articles and the dissemination of information to those with an interest in SAR.

JSAR will provide a forum for the publication of original research, reviews and commentaries which will consolidate and expand the theoretical and professional basis of the area. The Journal is interested in theoretical, strategic, tactical, operational and technical matters.

Advertising within JSAR will be considered in the future to ensure sustainable funding is available to enhance and continue the work of the journal. The publication of an article in the Journal of Search and Rescue does not necessarily imply that JSAR or its Editorial Board accepts or endorses the views or opinions expressed in it.

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Editorial

Welcome to this edition of the journal of search and rescue. The breadth and diversity of the research showcased in the issue demonstrates what a broad church our sector is, and demonstrates how rewarding working in SAR research can be. As I write this, there are severe floods in the UK and extreme fires in the US and Australia, with SAR teams forming part of the response, demonstrating the requirement of operational teams remains high. The sector continues to expand, as do the roles within it, and accordingly the research expands to reflect that. I note that within the UK a reform agenda for improved governance of voluntary teams is maturing, and hope that this continues and that teams reflect the trust put in them by families, casualties and the statutory authorities through their policies and behaviour. No-one wants to see another “post rescue organisation” (see Vol2, Issue 1).

Our first paper in this Issue discusses consent and capacity in rescue, which I found especially timely after an experience operationally in the last month which proved challenging to say the least. Rossmo et al continue our Journal’s contribution to evidence-based, robust spatial enquiry into the nature of SAR, implications and Stevens et al provide a crucial addition to missing person’s literature, describing the possibility of finer, more accurate profiles for missing persons using gender specified search parameters.

We have papers in review for the next Volume, and Dr Koester continues to work on the conference special edition, but we continue to seek papers, and welcome any offers for volunteers to help with the review and production process. We have plans for a presence at conferences and to run our own conference sessions, so hopefully we will either hear from you, or see you at an exercise, conference or incident.

Stay safe, and we wish you the best of luck with your service and research.

Dr Ian Greatbatch

Water Rescue within UKSAR: consent, capacity and necessity

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Abstract

For Search & Rescue Operators providing pre-hospital care and rescue within an aquatic environment, difficulties arise not only from the logistics of performing these interventions, but also obtaining consent from casualties. A great proportion of UKSAR operatives are volunteers, nevertheless, the law expects them to provide the same standard of care as a professional. Consequently, this high standard, combined with the proliferation of operations concerning mental health and the supposed "litigation culture", leaves these volunteers in a uniquely difficult position. This paper aims to provide a guide, for those operating in and around water, on law regarding consent, capacity and necessity in England & Wales.

KEY WORDS: *Mental Capacity*, *Water Rescue, Mental health*

Introduction

For a UK Search and Rescue Operator ("SAR Operator"), water environments are perhaps one of the most challenging places to work. Not only are Operators subjected to the multitude of natural hazards that accompany an aquatic environment, but also to the behaviour of those they proport to rescue. In recent years, a "*mental health crisis*" has arisen within the United Kingdom ("UK"), and SAR Teams, including those operating in water environments, spend a great deal of operational time handling mental health related incidents (Prothero & Cooke, 2016). Consequently, SAR Operators providing pre-hospital care to patients with mental disorders are inevitably placed in a position where they are required to make judgments as to whether a patient has mental capacity to consent to intervention.

SAR within the UK is facilitated by the United Kingdom Search and Rescue ("UKSAR") framework and this provides land, maritime and aeronautical cover across 2 million square miles (United Kingdom Search & Rescue, 2017). The ultimate operational authority in SAR incidents lies with statutory bodies, however, these government agencies rely heavily on volunteers who make up a considerable proportion of SAR Operators (See Figure 1).

Figure 1- UKSAR Operational Framework

Statutory authorities responsible for co-ordinating responses to SAR incidents*

Police	HM Coastguard
Responsible for land-based SAR operations above the mean high-water spring	Any coastal area below the mean high-water spring tides and includes sea cliffs, shoreline and other littoral areas.

Organisations who may be tasked to SAR incidents

Statutory agencies	Voluntary Organizations
- Fire & Rescue Service** - Ambulance Services - Military of Defence (including all military assets) - UK SAR Helicopter Service	- Mountain Rescue Teams - Lowland Rescue Teams - Cave Rescue Teams - Coastguard Rescue Teams - Royal National Lifeboat Institution - Independent Lifeboats - Lifeguarding and Surf Life Saving organisations - Other independent SAR Teams

*For more information see United Kingdom Search & Rescue, 2017 (as above)

**Note that the Fire & Rescue Service's involvement will depend on the type of incident and resources of the particular Service. Some Services are fully equipped to deal with water related incidents and may operate without the assistance of voluntary SAR assets, while others have very limited resources in regard to flood or water rescue (Department for Environment, Food & Rural Affairs, 2019). It should also be noted that in some areas, the Fire & Rescue Service play lead role in co-ordinating flood and water rescue operations (Chief Fire & Rescue Adviser, 2010)

Despite the status of “volunteers” these individuals are held to the same standards as professionals working in the same position (Nichols, Goel, Nichols & Jones, 2014). Consequently, a SAR Operator, volunteer or not, found to have treated or rescued a patient without consent, absent of a legal defence, faces civil liability or, in extreme cases, even criminal culpability. The *supposed* growth of “litigation culture” within the UK, combined with the challenging environment water presents, leaves volunteers in a uniquely difficult position not encountered by other elements of UKSAR (Hand, 2010).

With this in mind, it is the purpose of this paper to attempt to give legal and medical clarity to SAR Operators, particularly non-medical professionals, on obtaining consent and determining mental capacity of patients within a water rescue environment. The first part focuses on the legal position within England & Wales (“E&W”), and explores the law surrounding patient consent and the rescuing team making a mental capacity assessment. It also seeks to outline circumstances where obtaining consent or assessing mental capacity is not necessary. The latter half of this paper addresses common medical conditions encountered in water related operations, and how they may affect a casualties’ ability to consent to treatment or rescue.

It should be noted that this article focuses only on those subject to the Mental Capacity Act 2005 (“MCA”) being those 16 years of age and over. The law surrounding consent and capacity of children is beyond the scope of this paper.

Consent, legal liability, mental capacity and necessity

Consent (the “general rule”)

The idea of “consent”, within a medical context in its legal form, is complex and fluid, subject to frequent judicial and statutory modification (McGuire & Beskow, 2010). Legal questions regarding consent are predominately dealt with by the Court of Protection- a specialist court created by the MCA, dealing with the rights of people considered “vulnerable”. This includes patients within the National Health Service (“NHS”) or within the care of another state-run body (Lush, 2005). However, in the context of SAR Operations, the legal minutiae of consent and *best interests* has little impact on the care provided by Operators, as these legal decisions mainly apply to hospital settings (Clough, 2016). On this basis, “consent”, in the context of SAR Operations, is perhaps better understood as a rule that:

“An Operator must seek permission from a casualty before he/she performs any medical or rescue intervention”

While at face value this rule seems simple, it has various exceptions, as we shall explore below. As the law places a particularly high value on the need for consent, it is worth examining the underlying *principle of autonomy*.

<u>Principle of autonomy</u>

At the heart of consent, both legally and ethically, is the right to bodily integrity, and to ultimately decide whether to consent to treatment- this is known as the *principle of autonomy* (Entwistle, Carter, Cribb, McCaffery, 2010). This is considered to be a fundamental right and is enshrined in both the law of the European Union (see Article 3.2(a) Charter of Fundamental Rights of the European Union) and the European Convention of Human Rights ("ECHR") (See the European Court of Human Right's ("ECtHR") decision in *Glass v United Kingdom* [2011] ECHR 1664 in interpreting Article 8(1) ECHR")), both of which are binding on the UK. At national level, Lord Donaldson sitting in the Court of Appeal of E&W in *Re T (Adult)* [1992] 4 All ER 649 defined it as:

"An adult patient['s]*…absolute right to choose whether to consent to medical treatment."*

The extent and importance of this right is far reaching, as illustrated in *St George's Healthcare NHS Trust v S* [1998] 3 All E.R. 673. Here, a patient known as "S" was 36 weeks pregnant and had developed life-threatening pre-eclampsia, requiring an urgent caesarean section to save the life of both herself and her unborn child. "S" continually refused to consent and, while the lower courts (namely the High Court) initially approved the treatment contrary to her wishes, on judicial review, the Court of Appeal held, irrespective of the risk to her own life and that of her unborn child, "S" had the right to refuse treatment. Lord Donaldson continued in *Re T (Adult)* (as above) to state:

"This right of choice is not limited to decisions which others might regard as sensible. It exists notwithstanding that the reasons for making the choice are rational, irrational, unknown or even non-existent."

It is seen here that the law regards a person's right to choose what happens to them, in the context of medical treatment, as fundamental. Any breach of this attracts potentially both criminal and civil liability.

<u>Obtaining Consent</u>

Legally, to obtain "consent" from a casualty, the following 3 elements must be present (Grubb, 2004):

(i) The casualty must have mental capacity; and
(ii) The consent must be "informed"; and
(iii) The consent must be voluntary and made without duress or influence of another.

Determining mental capacity is dealt with in detail below, but for the purposes of consent, unless one of the "3 triggers of capacity" (below) is present, capacity may be assumed, because S.1(2) MCA states:

"A person must be assumed to have capacity unless it is established that he/she lacks capacity."

The concept of "informed consent" under (ii) simply requires a patient be informed of the material risks of any treatment they receive and if possible, have alternatives presented to them (*Montgomery v Lanarkshire Health Board* [2015] UKSC 11). A typical example arises in a hospital, where a patient requires major surgery which inevitably entails risk. In such circumstances, a medical professional would need to disclose the risks involved in the procedure and outline any alternatives. Case law suggests the "material risks" should not be limited to what is considered a risk by the medical professional, but should also include factors which may be viewed as a risk by a reasonable patient and those which would affect their decision making (see *Mrs A v East Kent Hospitals University NHS Foundation Trust* [2015] EWHC 1038).

The law on what should be disclosed is extensive, fluid and subject to both legal and ethical debate (Gold, 2004 and see discussion in *Chatterton v Gerson* [1981] QB 432); however, in its simplest form: the riskier the procedure, the greater the need for disclosure (see *Pearce v United Bristol Healthcare NHS Trust* [1998] EWCA Civ 865). For most SAR Operators, the treatment provided in an aquatic environment will likely be limited to basic care, due to the safety, logistical and practical limitations on performing advanced medical interventions. Consequently, disclosure may be satisfied by simply asking the casualties' permission to perform specific actions, for example an Operator may say "*I just want to put a bandage on that wound, if that's okay?*". Following this, a simple rule can be formed:

A SAR Operator must tell the Casualty what they are going to do for each intervention (whether it be performing a rescue manoeuvre (e.g. a hoist) or medical procedure)

From this, the Operator can judge whether the casualty consents to treatment or rescue. It is important to stress that this should be done for *each* intervention/manoeuvre, as consent is a continuing process and consenting to one treatment does not guarantee consent to another. For example, a patient may consent to having a wound bandaged, but refuse the insertion of an Intra-venous (IV) cannula, thus, continuing this treatment without gaining consent could result in liability. Following this rule not only discharges the legal burden of obtaining informed consent but is also good clinical practice in helping the patient to remain at ease.

Under requirement (iii), the consent must be voluntary. In simple terms, this means the decision must not be obtained through improper influence or coercion from a 3rd party, or through deception of the medical professional seeking consent (Pattinson, 2017). For example, in *Re T (Adult)* (as above) the Court of Appeal held that pressure exerted by a mother, a Jehovah's Witness, on her daughter, a patient at a hospital, over a blood transfusion invalidated the daughter's ability to consent, as it would not be "voluntary". This is unlikely in a water environment, but if suspected, steps should be taken to limit the effect of suspected improper influence.

Liability

In the words of Lord Scarman in *Sidaway v Board of Governors of the Bethlem Royal Hospital Governors* [1985] AC 871:

"[He who treats] *without the consent of his patient, save in cases of emergency or mental disability, is guilty of the civil wrong of trespass to the person; he is also guilty of the criminal offence of assault."*

A casualty's right to decide their treatment is fundamental, and breaching this could potentially attract both criminal and civil liability.

<u>Criminal Liability</u>

Criminal prosecution resulting from medical treatment is rare, and most reported criminal cases involve *not whether* the patient consented, but rather *what* a patient can consent to as a matter of public policy (see *R v Brown* [1994] 1 AC 212). However, providing training is followed, no treatment rendered by a SAR Operator will fall outside the scope of what a person can consent to, as it will fall within generally recognised medical practice (see *Airedale NHS Trust v Bland* [1993] AC 789).

However, treating a patient without consent technically could amount to a criminal offence, carrying the potential for a criminal record and other criminal sanctions. If such a complaint was made, the matter would be investigated by the Police, and the ultimate decision on charging would lie with the Crown Prosecution Service ("CPS") (see S.29(1) Criminal Justice Act 2003). Before the CPS makes a decision to charge an individual(s), under the Code for Crown Prosecutors ("the Code"), a 2 stage test must be applied:

i. Is there sufficient evidence to provide a realistic prospect of conviction of each suspect on each charge (4.6-4.8 of the Code)
ii. Is it in the public interest to bring a prosecution (4.9-4.13 of the Code)

Whether this test is satisfied depends on the facts of the case. However, criminal law is often described as "a law of last resort" and requires that any criminal charge be proven beyond all reasonable doubt (see *Woolmington v DPP* [1935] 1 AC 462 and Husak, 2014). For the CPS to bring a charge against a SAR Operator for breaching consent would take an exceptionally rare case, requiring extensive fault or gross-negligence (Husak, 2014). Consequently, even if they are found to have treated a patient in violation of consent, providing an Operator follows their training, the likelihood of criminal charges is very small. If an Operator was charged with a criminal offence during the course of an operation, specialist advice from an accredited criminal law practitioner should be sought.

<u>Civil liability</u>

Conversely, a SAR Operator facing a claim for a civil wrong (known as a "tort") is much more likely. The supposed rise of the "compensation culture", is subject to considerable discourse in the media, the judiciary and the Law Society (Dyson, 2013); however, regardless of this debate, civil liability remains a sobering possibility (Hyde, 2018).

The types of torts that could be brought against a SAR Operator can generally be split into 2 types:

i. Claims based on trespass to the person; and
ii. Claims based on negligence.

Trespass to the person (or intentional torts) claims are similar to their criminal counterparts, but they impose an obligation to pay monetary compensation (known as “damages”), rather than criminal sanctions (Resuscitation Council, 2018). Relevant intentional torts are summarized in Figure 2. Damages for intentional torts are recoverable, even if no actual injury occurs (known as “nominal damages”) or is proved. However, modern legal practice seemingly indicates claimants are more likely to rely on a claim based on negligence than trespass to the person (Patterson, 2014)

Unlike criminal claims, the burden of proof is “on the balance of probabilities”, which in simple terms requires the claimant to prove it was more likely than not that the defendant committed the tort (*In re H and others (Minors)* [1998] AC 72).

The law of negligence liability is one of the most extensive areas of law, and its intricate detail is beyond the scope of this article, but to establish a *prima facie* negligence claim a claimant must prove:

i. That the defendant owed the claimant a duty of care
ii. That duty was breached by the defendant
iii. The defendant’s negligence caused *actual* injury to the claimant

Negligence liability in regard to consent normally arises from failure to inform a patient of the risks of the treatment, invalidating the consent as it was not informed (*Montgomery v Lanarkshire Health Board* (as above)). Most of these cases arise from a complication from surgery that the patient was not aware was a risk (Dawson-Bowling, 2011). Given the acute nature of pre-hospital care, and practical limitations on what medical interventions may be performed in an aquatic environment, providing the guidance above on obtaining consent is followed (or an exception applies), the possibility of a SAR Operator facing a negligence claim based on lack of informed consent is extremely unlikely. Negligence liability, however, may still arise from negligent actions, which is examined below.

All applicable steps should be taken to obtain consent or establish that an exception exists. However, inevitably, things go wrong, and it is strongly advised that all SAR Operators participating in live operations are covered by an appropriate insurance policy indemnifying against prospective litigation.

Figure 2- Intentional Torts

Tort	**Legal Provision**	**Requirements for a *prima facie* case**	**Defences**	**Practical example**
Assault	*Stephens v Myers* (1840) 4 C&P 349	- An act by the defendant; - Intended; - To cause the immediate apprehension of; - Harmful or offensive contact.	- MCA - Necessity - Privilege (self-defence/defence of another/ legal authority)	Threatening to use physical force with an uncompliant patient.
Battery	*Collins v Wilcock* [1984] 1 WLR 1172	- An act by the defendant; - Intended to cause harmful or offensive contact; - Actual harmful or offensive contact.	- MCA - Necessity - Privilege (self-defence/defence of another/ legal authority)	Physically treating a patient without consent.
False Imprisonment	*Bird v Jones* (1845) 7 QB 742	- a complete restriction on the claimant's freedom of movement; and - the absence of legal authorisation.	- MCA - Necessity - Privilege (self-defence/defence of another/ legal authority)	Physically restraining a patient.
Negligence	*Donoghue v Stevenson* [1932] UKHL 100)	- The defendant owed the claimant a duty of care; - That duty was breached by the defendant; - The defendant's negligence caused *actual* injury to the claimant.	- Contributory Negligence	Failing to properly secure patient to a stretcher which results in injury.

Mental Capacity (Exception 1)

The law recognises there are situations where a person is either unable to make a decision (e.g. through loss of consciousness) or incapable of making a decision for themselves (e.g. suffering from a mental health illness). The ability to make a decision is referred to as *mental capacity* and is required for a patient to be able to consent to treatment. As mental capacity is generally presumed, a SAR Operator need only make an assessment if one of the “3 triggers of capacity” are present:

a) A casualty rejects help (i.e. does not consent); or
b) A casualty does not give an answer to an offer to help; or
c) The casualty makes a decision which the SAR Operator believes is adverse to their interests:

The law governing mental capacity in E&W is predominantly contained in the MCA, which lists a set of principles to be applied when considering capacity (S.1), and criteria required for establishing if a person has capacity (ss 2&3). Where the criteria are not met, a person does not have mental capacity (and thus is unable to give valid consent), and the law allows those coming to their aid to commence treatment in the casualty’s *best interests* (S.4) while they lack capacity. Thus the following rule may be formulated:

If one of the “3 triggers of capacity” is present, then a SAR Operator must take all reasonable steps to carry out a mental capacity assessment.

Again, whether this is possible wholly depends on the situation, and if there is no time to carry out such an assessment then the necessity exception may apply (see below).

<u>Making a mental capacity assessment</u>

When making a mental capacity assessment, a SAR Operator needs to consider 2 stages (The Department of Constitutional Affairs, 2007):

1) Does the casualty have an impairment of, or a disturbance in the functioning of, their mind or brain (S.2(1))?

For most SAR Operators undertaking aquatic operations, detailed analysis of the impairment of mental function is of little use, given the practicalities and safety of handling patients in and around water. Instead, it is perhaps more beneficial that SAR Operators are familiar with frequently encountered conditions which have the potential to inhibit mental capacity, prompting the second stage of the mental capacity assessment. The latter half of this paper addresses common conditions encountered on operations which may lead to a SAR Operator questioning a patient’s capacity.

2) Does the disturbance in mental function mean that the casualty is unable to make a specific decision in regard to rescue or treatment? (S.3(1)(a)-(d))

Having ascertained that a casualty's mental function is potentially impaired, an Operator must assess whether this prevents them from making a decision. To assess this the Operator, when seeking consent to a specific course of treatment or rescue, must decide if the casualty satisfies the following 4 criteria. Regarding information about a course of treatment or rescue, can the casualty:

i. **Understand** the information?

Their ability to understand the information given to them regarding treatment. This includes understanding reasonably foreseeable consequences of making (or not making) that decision about the treatment or rescue.

ii. **Retain** the Information?

Can the casualty retain the information long enough to make a decision?

iii. **Weigh up** the information?

Their ability to consider the information given and weigh up the consequences, both benefits and risks, of their decision.

iv. **Communicate** the information?

The ability to relay the information given and communicate their decision.

It is imperative that these criteria are applied to *each* course of treatment for two reasons. Firstly, it is possible a patient is able to consent to one course of treatment but not another, as the greater the gravity of the decision, the more capacity is required (See *Re T* (as above)). A course of treatment with little risk requires a lower standard of capacity (e.g. dressing a wound or warming up a casualty) than a course of treatment/rescue where the risks are potentially life-changing (e.g. deciding between a high risk extraction, likely resulting in permanent damage to a limb; or a delay, potentially preserving the limb but increasing the threat to life). Secondly, capacity is *transient*, in the sense it may fluctuate over time (e.g. a patient's level of consciousness may increase and decrease throughout the rescue), making it necessary to reassess capacity to obtain consent for further treatment.

<u>The Principles of *mental capacity*</u>

In assessing a casualty's mental capacity under the MCA, it is also necessary to:

1) assume a casualty has capacity until it is established they have not (S.1(2));
2) take all steps, as is reasonably practical, to help the casualty make a decision (S.1(3)); and
3) acknowledge that, just because an unwise decision is made, does not mean a person lacks capacity (S.1(4)).

The presumption of capacity under S.1(2) is dealt with above. Regarding the requirement under S.2(3), situations may arise where it initially appears the patient lacks capacity, however, after some assistance in satisfying the 4 criteria, valid capacity may become apparent (Zuscak, S.J., Peisah C., and Ferguson, A. (2016)). For example, a patient apparently suffering from the effects of drugs or alcohol (which brings capacity into question), as well as aphonia (a condition causing a bilateral disruption of the recurrent laryngeal nerve leading to an inability to produce vocal sounds), *prima facie* may appear to lack capacity (e.g. through an inability to communicate); however, a SAR Operator may find it is possible to communicate using alternative methods (e.g. sign language or non-verbal communication). In this case the patient may in fact possess capacity. Given the nature of operating in and around a water environment, the extent to which an Operator can assist the casualty in regard to consent may be limited, but as a general rule:

A SAR Operator must consider if there is anything he/she can practicably do in the circumstances which would assist a casualty in meeting the mental capacity criteria.

Finally, as mentioned above, if a casualty makes a decision seemingly averse to their interests, it may call into question their mental capacity. However, if a casualty is found to possess capacity then, applying the principle of autonomy, regardless of how the decision appears to the Operator it must be respected.

<u>Best Interest</u>

In the event a casualty does not possess capacity, under S.1(5) a SAR Operator may treat them in what they *reasonably believe* to be in that casualties' *best interest*. In exercising its *parens patriae* jurisdiction, the Court of Protection has produced a plethora of jurisprudence defining what constitutes "best interests" in a range of circumstances (Cough, 2016). For SAR Operators, these decisions are of little relevance, given the acute nature of the care they provide, but what is well established is that actions "*must be such as a reasonable person would* [take] *in all the circumstances"* (per Lord Goff in *F v. West Berkshire HA* [1989] 2 W.L.R. 1025. and S.4(2) MCA).

Consistently, the courts have held that following a *responsible and competent body of relevant professional opinion* satisfies the *reasonable person* test (*Re A (Male Sterilisation)* [2000] 1 F.L.R. 549 at 78). Thus, for a SAR Operator, following established rescue/pre-hospital care guidelines, proliferated by competent bodies (e.g. Resuscitation Council (UK), The Royal College of Surgeons Faculty of Pre-hospital Care, guidance on flooding protocols by the Department for Environment Food & Rural Affairs, Royal Life Saving Society, British Canoe Lifeguards, Royal National Lifeboat Institute and operational guidance provided by Fire & Rescue Services), will nearly always constitute the best interests of a patient. It should be noted that this treatment should be limited only to preserving life or mitigating serious injury. The law also requires under S.4(4), even if a person does not have capacity, the patient should be involved as much as possible, thus, as a general rule:

When treating a casualty without mental capacity, SAR Operators should follow their medical/rescue training to the extent of preserving life, making every effort to involve the casualty insofar as possible in his/her treatment (e.g. telling the casualty what is happening and accommodating reasonable requests)

Involving the casualty (regardless of capacity) is important for ensuring patient co-operation, which will consequently reduce risk to Operators. Furthermore, studies show that even comatose patients can detect auditory stimuli (Sission, 1990 and Asanini, 2009). Given the positive relationship between continual communication with a patient and improved outcome, communicating, even with seemingly unresponsive patients, is recommended (Sission, 1990 and Asanini, 2009).

Necessity (Exception 2)

Under the Doctrine of Necessity (sometimes called the Doctrine of Emergency), the common law recognises that situations may arise where, given the imminent threat of death or serious injury, an individual may essentially dispense with the need to obtain consent, in order to prevent immediate harm (see *A (Children*) [2000] EWCA Civ 254).

<u>Treatment without consent</u>

At common law, treatment or rescue may be administered without consent if (*F v. West Berkshire HA* (as above)):

a) there is a necessity to act when it is not practicable to communicate with the assisted person; *and*

b) the action is such as a reasonable person would in all the circumstances take, acting in the best interests of the assisted person.

Unfortunately, there is a dearth of jurisprudence as to what might constitute a *necessity to act*, but Lord Goff suggested (at para 35.6) in *West Berkshire* (as above) that:

"*a man who seizes another and forcibly drags him from the path of an incoming vehicle, thereby saving him from injury or even death, commits no wrong"*

Drawing on this, it is suggested that SAR Operators adopt a common sense approach, only considering it necessary to act when (Scannell, 2007):

i) there is an immediate threat of death or serious injury to a casualty; and

ii) the time critical nature of the threat means it is impossible to communicate or obtain consent before the harm occurs.

It is imperative to note that the intervention must be limited to preserving life or mitigating serious injury and, as soon as the casualty is out of imminent danger, the MCA will apply and the SAR Operator must obtain consent or carry out a mental capacity assessment as soon as possible and treat accordingly (The Royal College of Emergency Medicine, 2017). Thus, the following rule may be formulated:

A SAR Operator may treat a casualty without consent and dispense with a capacity assessment if there is an immediate threat of death or serious injury, and it is impractical to communicate or obtain consent prior to the harm occurring. The Operator must limit the interventions to the extent needed to preserve *life or mitigate serious injury and must attempt to obtain consent or make a capacity assessment as soon as the crisis has passed.*

Finally, it must be stressed, from the little case law available, the courts have generally taken a narrow approach to the Doctrine of Necessity, only allowing intervention without consent in truly dire and time-critical circumstances (see *ZH v The Commissioner of Police for the Metropolis* [2012] EWHC 604 (QB))

Use of restraint

Situations may arise where SAR Operators are faced with a combative patient, and while most of these circumstances can be defused verbally, some patients may become physically aggressive or hostile.

Here, the safety of the Operators must take priority, even at the expense of the casualty's care. If it is suspected the casualty may become combative, it is highly recommended that Police support is sought, as they are trained to de-escalate conflict and possess explicit powers of restraint and detention (if necessary) under the Police and Criminal Evidence Act 1986 and Mental Health Act 1983.

While the authors strongly advocate that SAR Operators avoid situations where physical aggression becomes an issue, given the unique operational capabilities and remit of Water Teams within UKSAR, facing a physically aggressive patient with no immediate Police support is not beyond comprehension. For this reason, the authors make the following three recommendations:

1) SAR Teams likely to encounter physically aggressive patients have robust operational and management procedures in place. These protocols should be evidence-based and follow best practice guidelines. Their objective should be to reduce the risk of being forced to use physical restraint, but also include contingency plans if such an incident were to occur.
2) These operational procedures should be supported by appropriate risk assessments, insurance, incident report mechanisms and policies. It is recommended that appropriate specialist advice is sought here.
3) Where possible, SAR Operators should be trained in the management of aggression. This needs to include guidance on relevant medical complications which can arise when from the use of restraint, particularly given that there is a plethora of evidence to suggest use of improper or inappropriate physical restraint techniques may cause serious injury or, in some circumstances, even death (Berzlanovich, Schöpfer & Keil, 2012). Finally, while a simple outline of the law regarding physical restraint is outlined below, *it is vital that SAR Operators and Managers seek up to date specialist legal advice on this*.

Regarding non-police personnel lawfully using physical restraint, such powers either derive from the MCA or the common law (encompassing the Doctrine of Necessity and Self-defence).

In regard to the MCA, under ss.5 and.6 MCA, the law provides legal protection for those who restrain (including both verbal threats constituting an assault, and physical restraint constituting a battery or false imprisonment) a patient in the course of treatment/rescue, when it is deemed that the patient lacks capacity and restraint is in their best interests (Owino, 2008). All force used under the MCA must be proportionate to the likely harm to the patient and only used for as long as is necessary for that person's protection (S.6 MCA). Any restraint, verbal or physical, exceeding a proportionate and necessary response is considered unlawful and may attract civil or even criminal liability. For example, in *ZH v The Commissioner of Police for the Metropolis* (as above), Police Officers were found to have acted unlawfully after removing and restraining a 16 year old patient with severe autism, after he jumped into a swimming pool when transfixed by the water.

At common law, while there is some uncertainty as to the extent of the Doctrine of Necessity, it is suggested that using force to prevent a patient from committing a serious act of self-harm will likely fall within its ambit, providing the above-mentioned requirements are met (Hale, 2017). Additionally, it is also suggested, under the Doctrine of Self-Defence, encompassing the defence of others, force may be used against a physically combative patient if they pose an immediate physical threat to a SAR Operator, his/her colleagues and other members of the public (see College of Paramedics, 2013 and *R. v Owino* (1996) 2 Cr App R 128). Like the MCA, only "proportionate" or "reasonable" force is permitted, whether under the Doctrine of Necessity or Self-Defence, and such force should be limited to the extent needed to prevent harm (Elliot, 2015).

Treatment, rescue and negligence

A detailed analysis of the law surrounding negligence is beyond the scope of this article, but it is important that SAR Operators understand that any treatment or help rendered to a casualty must be performed with care, or the risk of a negligence claim arises.

When assessing the standard of care required by a SAR Operator, the courts apply the "*reasonable person test*", which for our purposes asks "*what would a reasonable SAR Operator have done in the circumstances?* (*Bolam v Friern Hospital Management Committee* [1957] 2 All E.R. 118)*"*. The "*reasonable SAR Operator*" is ultimately a person with the same qualifications and training as the one being sued for negligence. Controversially, no account is taken of the SAR Operator's personal lack of experience or knowledge, thus even during an Operator's first ever live deployment, he or she is still capable of acting negligently (*Nettleship v* Weston [1971] 3 WLR 370).

In terms of legal protection for SAR Operators, the common law has offered a degree of protection to those engaged in socially desirable activities (Goudcamp, 2018). However, in recent years Parliament have enacted two statutes designed to provide some clear and explicit protection for those engaging in "good Samaritan acts", including acts of voluntary rescue (Partington, 2016). Firstly, S.1 Compensation Act 2006 stipulates that the court *may* consider when assessing a breach of duty, whether imposing such a standard may deter or prevent others from engaging in socially desirable activities. For example the court is unlikely to find negligence liability in a situation where it would deter others from joining or forming SAR Teams. Secondly, S.2 and S.4 Social Action, Responsibility and Heroism Act 2015, states that when assessing whether there is a breach of duty, the court *must* consider whether the act was for the benefit of society or was performed in an emergency to assist an individual in danger.

These statutes have yet to be fully judicially tested and academic opinion has been mixed, as many feel in practice these acts do little more than restate the common law and more comprehensive protection is required (for discussion see Goudcamp, 2018 and Mulheron, 2017). Despite this academic discourse, there is a clear Parliamentary intention to provide legal reassurances to those who do act for the good of society. SAR Operators can work in the knowledge that the Courts will consider the altruistic context of rescue operations when assessing a claim (Goudcamp, 2018).

However, as with any affliction, prevention is better than cure, and thus 2 rules are suggested. Firstly:

SAR Operators should take care to ensure they are up to date with and follow, insofar as possible, clinical and practice guidelines within their competencies when providing medical or performing rescue interventions.

Following these guidelines will, in the vast majority of cases, defeat any negligence claim, although in rare circumstances the courts have chosen to ignore established guidelines and impose negligence liability on the basis that there is no logical basis for the guidance, but this is rare in practice (see *Bolitho v City & Hackney Health Authority* [1997] 3 WLR 1151). Secondly:

SAR Water Teams should ensure their personnel are adequately trained to recognised standards and ensure that they only perform operations which are within their competence. Furthermore, they should wherever possible, make provisions for inexperienced Operators to be adequately supervised.

Ensuring adequate training and supervision is vital, not only for protection against liability, but also for the safety of the SAR Operators themselves.

Water related conditions & capacity

Introduction

As explored above, anything with the potential to impair any aspect of the outlined decision-making process will result in a person lacking capacity to consent. It is imperative that casualties are assessed holistically on their ability to make decisions, by applying the four-stage test outlined above. Nevertheless, a knowledge of conditions likely to be encountered and their effects on capacity may prompt a SAR Operator to question the casualty's ability to consent, and whether capacity needs to be assessed.

Mental Health Conditions

Between 2003 and 2013, in the UK, 18,220 people ended their own lives (University of Manchester, 2015). Furthermore, in 2017 there were 5,821 completed suicides registered by the office for national statistics; of these, 249 people completed suicide by drowning (Suicides in the UK - Office for National Statistics, 2019).

Depression

Depression remains the predominant mental health problem worldwide, closely followed by anxiety, schizophrenia and bipolar disorder. It is impossible within the remit of this article to consider every specific mental health illness affecting capacity, however, it is important to recognise, just like physical illness, seemingly stable mental health illnesses can quickly become unstable and decision-making ability can therefore become impaired. For example, someone who is actively depressed may not be able to weigh information in a way that would give them a positive outcome for the future, leading them to refuse life-saving treatment – or indeed they may, due to their psychopathology, wish for a negative outcome, leading to undue weight on this in the decision-making process.

Bipolar disorder

Bipolar disorder is '*a brain disorder that causes unusual shifts in mood, energy and activity levels...*' (National Institute of Mental Health, 2016). As a result, people can experience a very low mood or 'depressive episode', similar to that mentioned above, or they can experience a 'manic episode' i.e. elation or euphoria associated with disconnected thoughts and/or poor judgement. Consequently, people experiencing manic episodes may put more weight on positive aspects of treatment, which may be unrealistic.

Schizophrenia

Schizophrenic disorders involve the distortion of thought and perception. For example, a few characteristics include (a) 'delusions of control', i.e. they may feel they are being controlled by '*a higher power*' for example, which makes them perform certain activities; (b) 'thought withdrawal' or 'insertion', i.e. thoughts being placed into or withdrawn from their heads; and (c) auditory hallucinations, i.e. voices commenting on the patient (often derogatory) in the third person. As a consequence of disordered thought and/or perception, people can struggle to understand and retain information, as concentration is often impaired, as well as weighing the information, due to delusions of the 'higher power' over-ruling any decision.

Dementia

Dementia is a progressive disease of the brain, leading to disturbed higher functioning in areas such as memory, comprehension, judgement, thinking, orientation and language. SAR Operators may encounter dementia patients with memory impairment and disorientation. It is important to recognise that, despite a person having a known dementia diagnosis, capacity must still be assessed. All 4 domains of capacity are likely to become affected in moderate to severe forms of dementia, as comprehension, memory, thinking and language impairment all contribute to aspects of understanding, retention, weighing and communicating information.

Physical Health Conditions

Mental capacity can also be affected by other more physical issues sustained for example by an accidental fall into water. Immersion is the 3rd leading cause of unintentional death worldwide (World Health Organisation, 2014). Common medical problems related to immersion encountered by water rescue teams are cold shock response, hypo and hyperthermia, head injuries and drug overdose/ intoxication, to name a few.

Cold water Injuries

Cold shock response (CSR), caused by cold water immersion (CWI), has psychophysiological components. The physiological components are important, as CSR peaks within the first minute of CWI and hyperventilation occurs, leading to aspiration (i.e. breathing in the water) and ultimately death; however, this can partially be controlled psychologically. Anxiety can have a massive predictor on CSR and survival. Barwood *et al* (2018) noted that anxiety levels predicted respiratory response and, as a result, hyperventilation was less likely with lower anxiety levels. The psychological aspect of CSR is often paired with acute stress reaction or ‘psychological shock’. It is important to recognise, that elements of psychological stress can include ‘dissociative symptoms’, such as dissociative amnesia. Here, patients may struggle to concentrate and remember information. Therefore, during a capacity assessment, they could fail in areas of understanding and retention.

Hypothermia

Bierens *et al* (Bierens, Lunetta, Tipton & Warner, 2016) note that hypothermia *‘affects cellular metabolism, blood flow and neural function’*. The severity of symptoms usually correlates with temperature. Mild hypothermia at 35^{o}C can cause some confusion, affecting a person’s understanding during the capacity assessment, however, as the temperature drops further to 34^{o}C, the person may experience amnesia which can affect their ability to retain information. Loss of consciousness can occur at temperatures around 30^{o}C. At this point, patients should be treated in their best interests until capacity can be properly assessed when they regain consciousness.

Hyperthermia and dehydration

Hyperthermia is classified as a temperature greater than 38.5^{o}C. Like hypothermia, it ranges from heat stress, which is relatively mild, to severe heat stroke, depending on the degree the temperature deviates from the normal range. With hyperthermia comes a spectrum of symptoms. As a result of slight increases in temperature, the body adapts in several ways, including sweat production as a means of evaporative cooling, however, the complication of this is dehydration. From early stages in hyperthermia, both physiological and psychophysical effects are noted. Akerman *et al* (Akerman, Tipton, Minson & Cotter, 2016) note the synergistic effects of dehydration and hyperthermia (particularly core hyperthermia) on reduced cerebral perfusion. This can cause confusion, irritability or loss of consciousness. As above, at this point the Operator should treat the patient in their best interests until capacity can be formally assessed.

Head Injuries

Head injuries are another potential injury encountered by SAR Teams, particularly those involved in Swift Water Rescue. Head injuries can cause concussion, which is defined by the American Academy of Neurology as *"a clinical syndrome of biomechanically induced alteration of brain function, typically affecting memory and orientation, which may involve loss of consciousness*" (Giza *et al*, 2013). Based on this, it can be assumed there is a high possibility, although often transient, that any of the 4 elements of capacity could be affected. As this is often temporary, it is particularly important to carry out a continuous capacity assessment.

Drug or alcohol intoxication

The last common scenario for SAR Teams is drug or alcohol intoxication. Again, these effects are often temporary and so the rescuer must be aware of potentially rapid changes in capacity. Intoxication, i.e. administration of a psychoactive substance, can have many psychophysiological responses, including alteration of a person's cognition, perception or judgement, which may lead them to endeavour in risk taking behaviour, such as that involving water bodies.

Conclusion

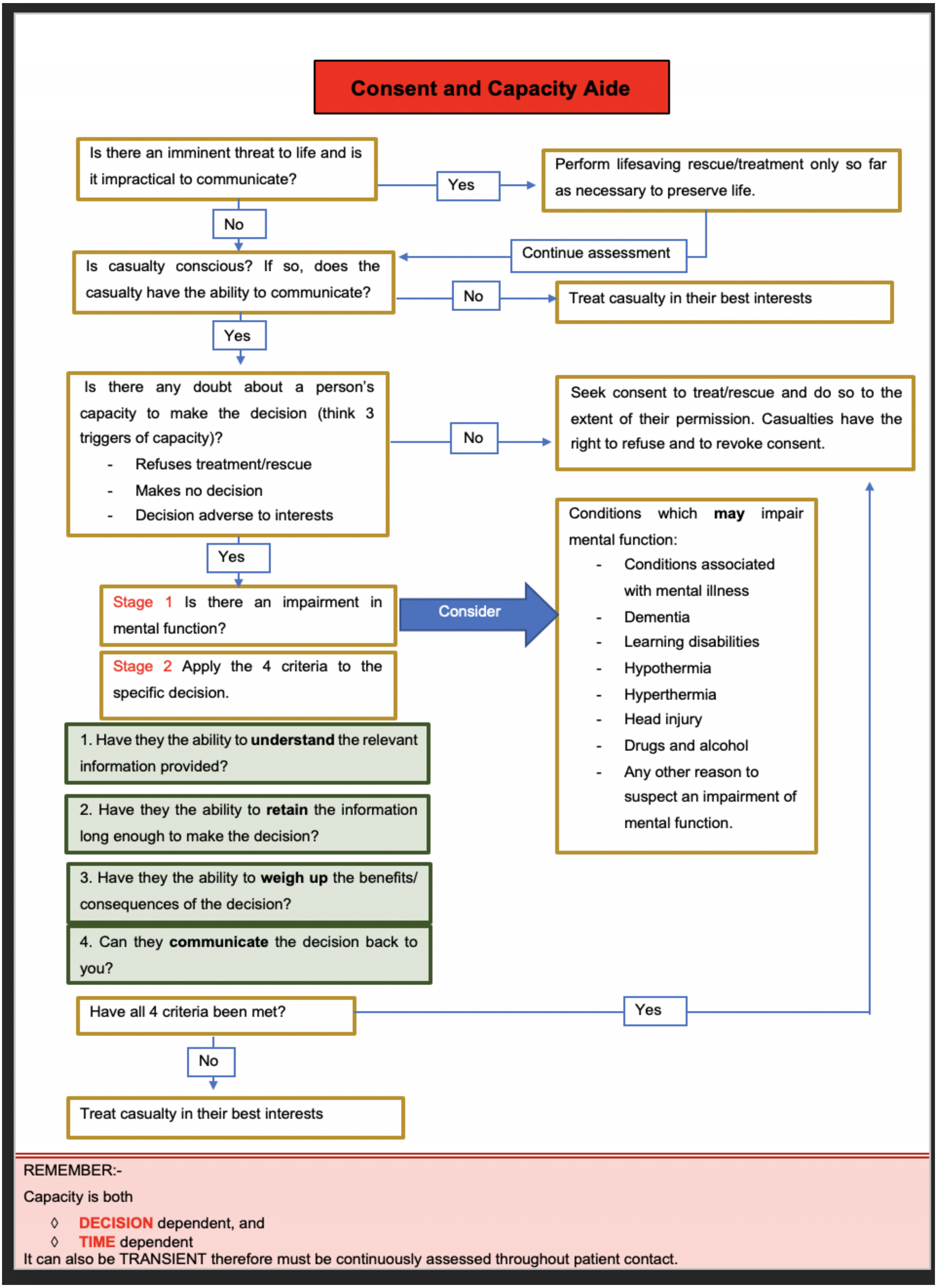
From this article, what is perhaps apparent is that the law surrounding consent, capacity and necessity is complex and sometimes unclear. Professionals often grapple with definitions of the aforementioned concepts, furthering confusion amongst those with no formal training in applying these principles. Throughout this article, the authors have attempted a balance, giving the reader a technical insight into the law, while also trying to provide some practical advice on its application by formulating a series of rules, which are summarized as follows:

1) *An Operator must seek permission from a casualty before he/she performs any medical or rescue intervention*
2) *"A person must be assumed to have capacity unless it is established that he/she lacks capacity."*
3) *A SAR Operator must tell the Casualty what they are going to do for each intervention (whether it be performing a rescue manoeuvre (e.g. a hoist) or medical procedure)*
4) *If one of the "3 triggers of capacity" is present, then a SAR Operator must take all reasonable steps to carry out a mental capacity assessment*
5) *A SAR Operator must consider if there is anything he/she can practicably do in the circumstances which would assist a casualty in meeting the mental capacity criteria.*
6) *When treating a casualty without mental capacity, SAR Operators should follow their medical/rescue training to the extent of preserving life, making every effort to involve the casualty insofar as possible in his/her treatment (e.g. telling the casualty what is happening and accommodating reasonable requests*)

7) *A SAR Operator may treat a casualty without consent and dispense with a capacity assessment if there is an immediate threat of death or serious injury, and it is impractical to communicate or obtain consent prior to the harm occurring. The Operator must limit the interventions to the extent needed to preserve life or mitigate serious injury and must attempt to obtain consent or make a capacity assessment as soon as the crisis has passed.*
8) *SAR Operators shall always place the safety of themselves, their colleagues and members of the public above the safety of the casualty.*
9) *SAR Operators should take care to ensure they are up to date with and follow, insofar as possible, clinical and practice guidelines within their competencies when providing medical or performing rescue interventions.*
10) *SAR Water Teams should ensure their personnel are adequately trained to recognised standards and ensure that they only perform operations which are within their competence. Furthermore, they should wherever possible, make provisions for inexperienced Operators to be adequately supervised.*

We have also included a simple flowchart (see Figure 3) which may be used on operations as a simple prompt to the *10 Golden Rules for consent capacity and necessity*.

Figure 3- Consent and Capacity Aid mem



Disclaimer: While every effort has been made to ensure that the information in this article is correct at the date of publication, both the law and medical guidelines change. This article does not constitute proper legal or medical advice and it is for academic purposes only.

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Abbreviations

- E&W “England & Wales”
- ECtHR “European Court of Human Rights”
- ECHR “European Convention on Human Rights”
- CSR “Cold Water Response”
- CWI “Cold Water Immersion”
- MCA “Mental Capacity Act 2005”
- SAR “Search & Rescue”
- UKSAR “United Kingdom Search & Rescue”
- NHS “National Health Service”
- The Code “The Code of Crown Prosecutors”
- IV “Intra-venous”

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Optimizing Wilderness Search and Rescue: A Bayesian GIS Analysis

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Abstract

Wilderness search and rescue operations function under critical time pressures and resource constraints. For optimal deployment, personnel must be assigned to prioritized search areas following some form of probability map. Incident commanders often have to generate such maps from different sources of information, some of which may be incomplete or imperfect. Here, we use a case study of the search for a lost person in Joshua Tree National Park in Southern California to illustrate how various types of evidence – previous search tracks and a cell phone tower ping – can be integrated, using Bayes' theorem, into an optimal probability search map.

KEY WORDS: *Wilderness Search and Rescue, Lost Persons, Bayesian Analysis, Resource Optimization*

Introduction

Wilderness search and rescue efforts regularly operate under critical time pressures and resource constraints. The risk of death due to exposure or thirst makes it vital to find the lost person as quickly as possible. It is therefore essential that personnel be deployed in the most effective and efficient manner possible. To prioritize search areas, incident commanders must generate probability maps from various sources of information, some of which may be incomplete or imperfect.

Here, we use a cold case study involving the search for a lost person in Joshua Tree National Park in Southern California to illustrate how various types of evidence can be combined into an optimal probability assessment. Prior search tracks, the location of a cell phone tower pinged by the subject's mobile phone, the distance range of that ping, and a viewshed analysis based on terrain altitude were geocoded using a geographic information system (GIS). These various data sources were then integrated in a Bayesian analysis to create a probability map for follow-up search efforts.

Literature Review

Wilderness search and rescue (WiSAR) operations often have to function in large areas with limited resources. An incident commander must therefore rely on a distribution map showing the most likely locations in which to find the missing person in order to efficiently allocate resources, direct search efforts, and coordinate rescue workers (Lin & Goodrich, 2010). Bayes' theorem provides a means for generating such probability maps (Eddy, 2004). Thomas Bayes was an 18th-century English statistician and minister who formulated a theorem describing how to update beliefs when new evidence arises (Iversen, 1984). The equation is:

$$P(A|B) = \frac{P(B|A)\,P(A)}{P(B)}$$

where: $P(A|B)$ is the conditional probability of event *A* given event *B*;
$P(B|A)$ is the conditional probability of event *B* given event *A*;
$P(A)$ is the probability of event *A*; and
$P(B)$ is the probability of event *B*.

Bayesian models are well suited for prioritization analyses. A search region can be divided up into thousands of grid cells, each of which is assigned a probability based on how likely the missing person will be in that location. This *prior* probability, while initially equal over the entire search area, is then adjusted up or down depending on the presence of various attributes ("new evidence") in the grid cell, to create the *posterior*. Some examples of such evidence include proximity from origin or destination, slope incline, density of vegetation, and the location of a discarded water bottle. GIS programs and modern laptop computing power allow for the rapid calculation of updated probabilities even in remote field settings.

Bayes' theorem has been applied in a number of search optimization tasks, including strategies to rescue lost ships (Richardson & Discenza, 1980), locate submarines (McGrayne, 2011; Richardson & Stone, 1971), and find lost treasure (Stone, 1992). Lin and Goodrich (2010) modeled lost-person behavior in wilderness areas with a Bayesian approach using data on terrain features – topography type, vegetation, and local slope. Here, we use the locations of prior search tracks and radius data for a tower ping from the subject's mobile phone to prioritize areas for follow-up search efforts.

Case Study

William Ewasko was a 65-year-old businessman from Marietta, Georgia, who regularly hiked Joshua Tree National Park (JTNP) in Southern California (see Figure 1). On June 24, 2010, he went on a day hike in JTNP, planning to be finished around 5:00 pm. The first location on the planned itinerary he left with his fiancée was Carey's Castle, an ambitious hike for that time of year because of the heat (Mahood, 2012). While arguably not wild or remote, the 1,240 square mile (3,213 km^2) park can still be dangerous, with large rocks, deep canyons, and abandoned mine shafts (Manaugh, 2018). Ewasko was a strong hiker who navigated by map and compass rather than by GPS (global positioning system).

Figure 1: Joshua Tree National Park.

Ewasko failed to call his fiancée that evening; the next morning, park rangers checked the trailhead for Cary's Castle but found no sign of his rented car. They then checked the other locations on Ewasko's itinerary. On the afternoon of June 26th, a California Highway Patrol helicopter spotted his vehicle at the Juniper Flats Trailhead parking area, a common jumping off point for hikers heading to Quail Mountain, also listed on the itinerary.

The search focused on Quail Mountain and other areas reachable from this trailhead. Then, at 6:50 am, Sunday, June 27th, Ewasko's mobile phone registered ("pinged") with a cell phone tower on Serin Drive, Yucca Valley, just to the northwest of JTNP. This contact suggested he had traveled well beyond Quail Mountain. Searchers redeployed in response but were unable to find any trace of Ewasko.

The official search continued until July 5th and involved hundreds of personnel, search and rescue teams from all over Southern California, dogs, horses, helicopters, and a fixed-wing aircraft. A number of additional searches were later conducted by experienced volunteers with substantial training in search and rescue techniques and backcountry travel. While the first group of searchers focused on a common area, these later efforts covered several additional locations. JTNP management was supplied with electronic copies of the GPS tracks so the search file would contain a complete record. To date, there is a reported total of 1,772 person-miles (2,852 km) of search tracks.

The failure to find Ewasko was unexpected. JTNP is lightly forested and the terrain is fairly easy to survey. There are no remaining viable theories as to his whereabouts. People follow certain travel patterns and rarely move in a truly random manner (Koester, 2008; Robbins, 1977; Rossmo, 2000). What they do and where they go makes sense to them at the time (this is why people generally follow the easier option of walking downhill). Subjects who are not quickly found by search and rescue personnel have usually done something unanticipated, such as traveling further than estimated and leaving the designated search area. They may also head in an unexpected direction for reasons that, while logical to them, are not known to searchers. It is likely that something like this happened in the Ewasko case (Mahood, 2016).

Method

Bayes' theorem provides a method for combining different types of evidence to produce an optimal search strategy for WiSAR operations. The sources of available information employed in the Ewasko analysis include the areas that had already been searched, the location of the Serin Drive tower, the radius of the mobile phone ping, and terrain features that would have blocked cell phone coverage (Mahood, 2018). The mathematical details of our Bayesian analysis are provided in the Appendix.

The boundaries for the analysis are shown in Figure 2. This region was determined by such factors as the location where Ewasko's vehicle was recovered, park borders, roads and trails, maximum possible distance hiked, major terrain discontinuities, and other relevant features. The assumption here is that the region covers the entire area (within reason) where Ewasko might be located.

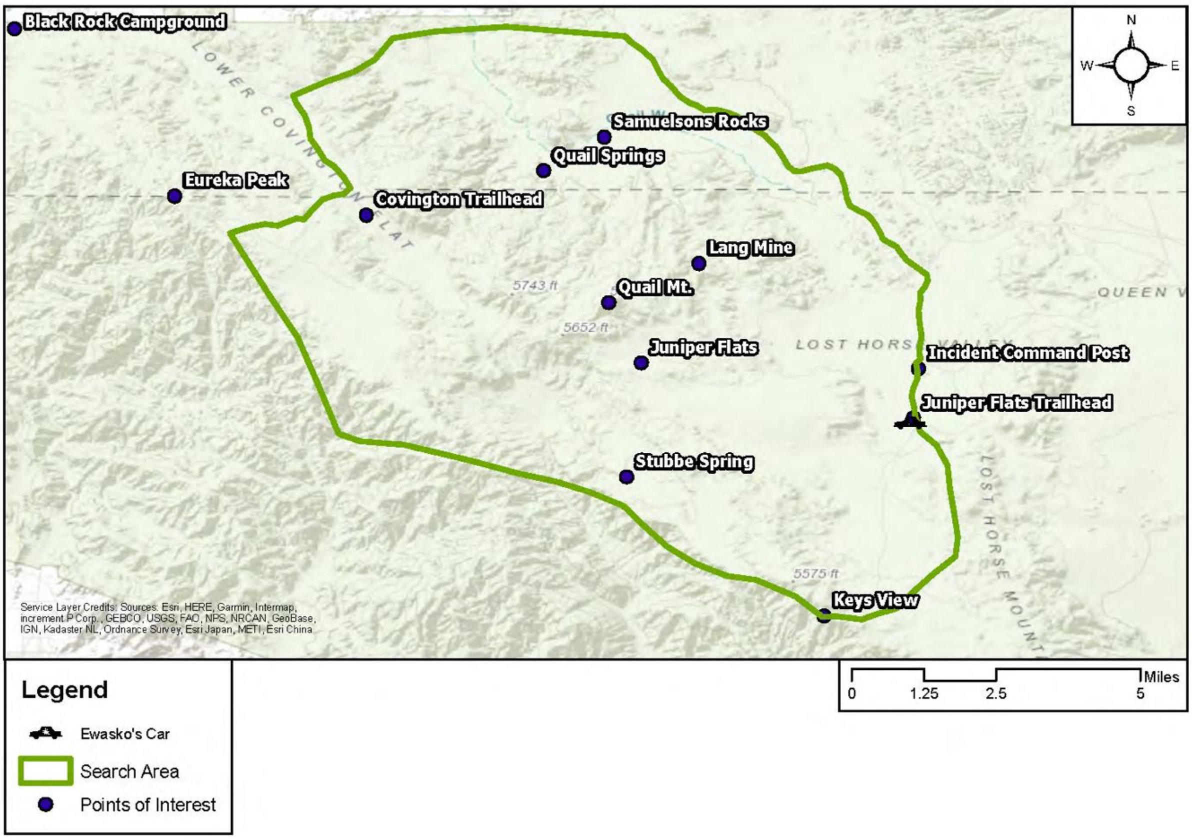

Figure 2: Search Area Boundaries for Bayesian Analysis

This region encompassed 184,857 grid cells, each 100 feet (30.5 m) by 100 feet, or 10,000 square feet (929 m^2), for a total area of approximately 66 square miles (172 km^2). The probability of each grid cell was adjusted based on the following evidence:

1. Search tracks: The JTNP master file contains electronic GPS tracks for the official and volunteer searches for Ewasko (see Figure 3). These were downloaded into ArcGIS so the length of any search track(s) in a given grid cell could be determined. The tracks were given a 50-foot (15.2 m) buffer radius, representing a conservative estimate of the range of a searcher's field of vision. The total length of the tracks was multiplied by 100 (the total buffer width, 50 feet + 50 feet) and divided by 10,000 (the grid cell area size, 100 feet x 100 feet) to give an estimate of the proportion of the grid cell area covered by the search. This value was then subtracted from 1 to calculate the grid cell probability. A search track through the exact middle of a grid cell would result in a probability of 0, while a search track through only a corner would produce a proportionately higher probability. If a grid cell contained multiple search tracks, all were considered in the probability calculation. JTNP is close to both Los Angeles and Palm Springs, with millions of visitors annually, so areas immediately next to commonly used trails and roads were considered "cleared."

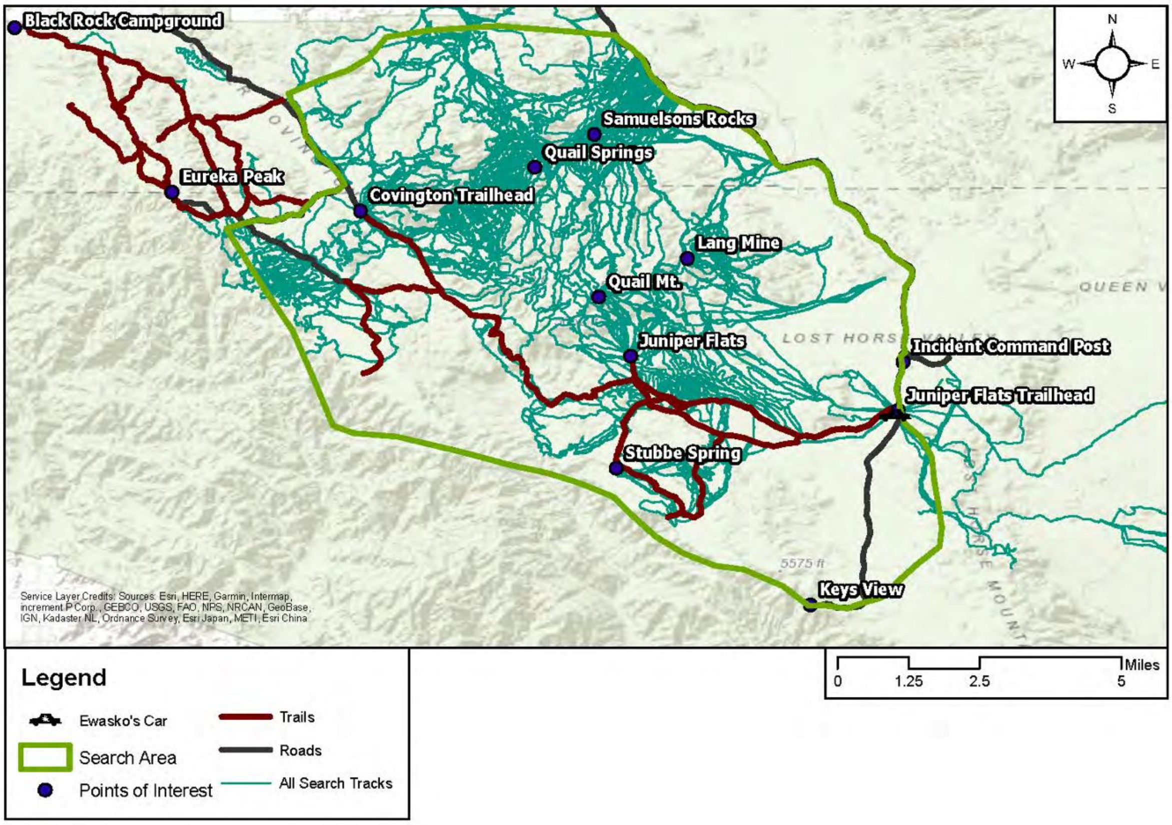

Figure 3: Search Tracks, Trails, and Roads

2. Distance from Serin Drive cell phone tower: The radial distance from Ewasko's Verizon mobile phone to the tower when it pinged was estimated to be 10.6 miles (17.1 km). As the exact position of the Serin Drive tower is known, the distance to a given grid cell can be readily calculated and the probability estimated from a Gaussian (normal) distribution. Bayes' model can handle "error rates" and analyze a band of possibilities (Blair & Rossmo, 2010). This tower was omnidirectional and not equipped to provide bearing data; however, based on the known facts of the case, the direction was almost certainly to the southeast. Figure 4 illustrates the range of the ping distance estimate. Figure 5 displays the southeast arc of the 10.6-mile probable distance radius from the Serin Drive cell phone tower (located off the map to the northwest).

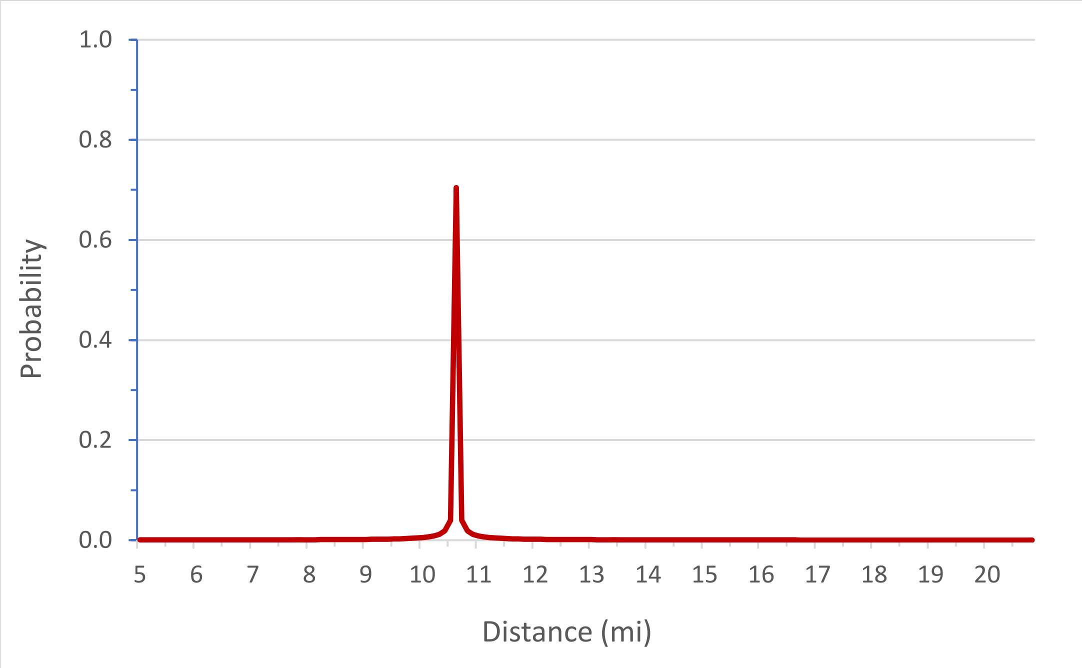

Figure 4: Probability of Distance from Serin Drive Cell Phone Tower

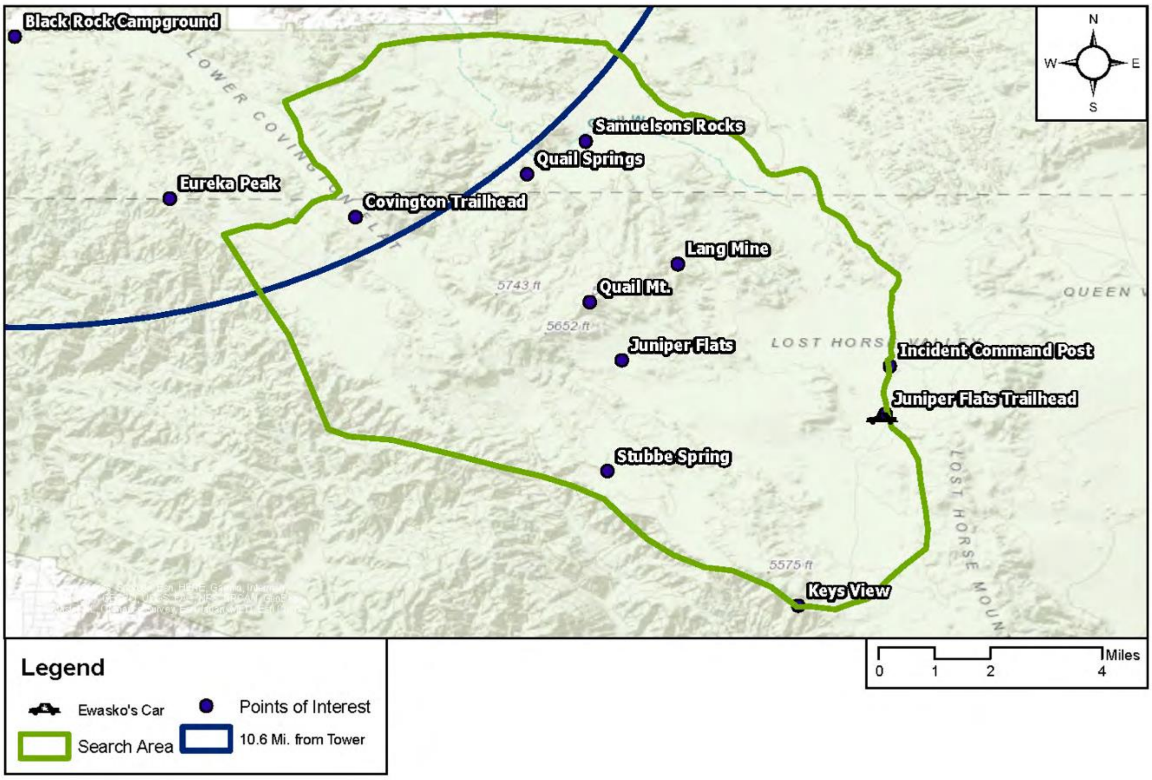

Figure 5: Southeast Arc of Serin Drive Cell Phone Tower 10.6-Mile Ping Radius

3. Viewshed: A viewshed analysis was calculated in ArcGIS against a digital elevation model (DEM) based on the U.S. Geological Survey National Elevation Dataset (NED). The resolution

for JTNP was one third arc-second (~10 meters). Locations from which the line of sight to the Serin Drive cell phone tower was blocked due to other terrain (i.e., impeding areas of higher altitude) were identified, and grid cell probabilities reduced accordingly. To be conservative, the height of the tower (100 feet, 30.5 m) was doubled in the analysis. Geodesic and planar methods produced similar results. Figure 6 shows the areas in the search region with cell phone coverage.

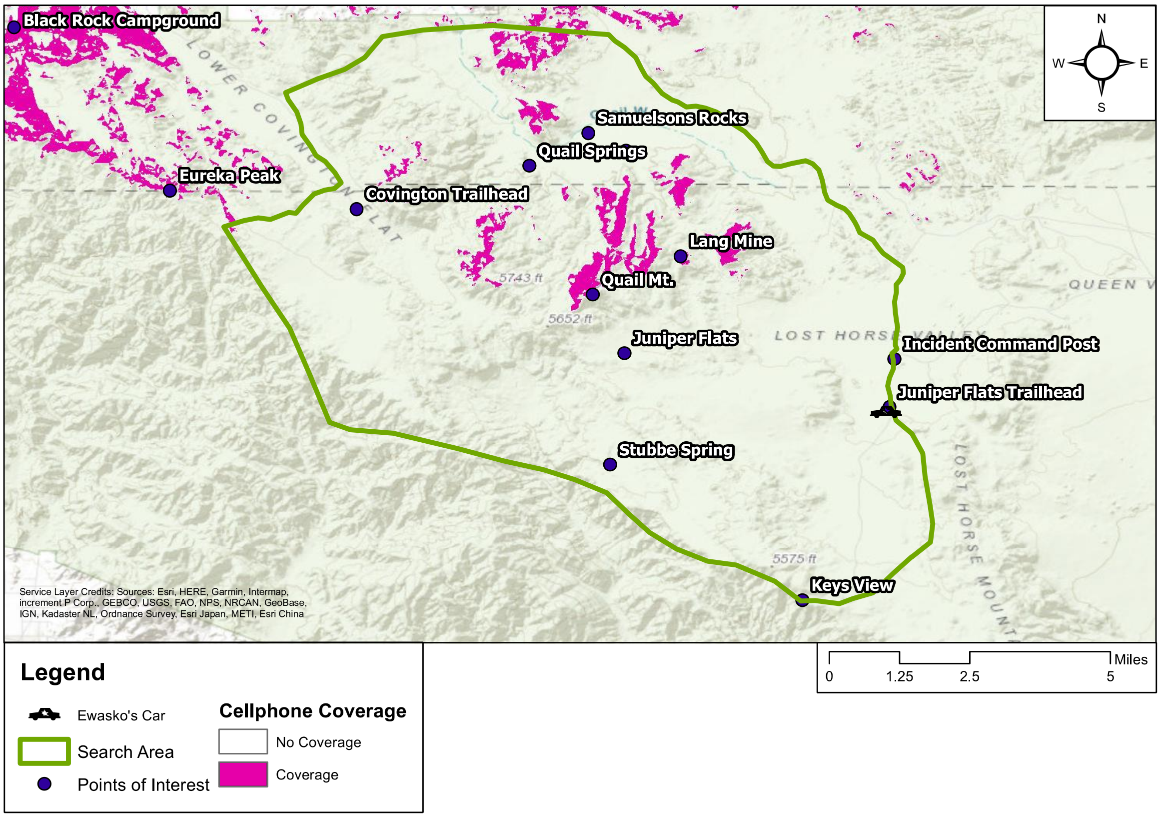

Figure 6: Areas with Cell Phone Coverage

Results

The optimal search map generated by our analysis is shown in Figure 7. Colors, ranging from blue to red, represent the various probabilities for finding Ewasko (the probability color scale in the legend lists relative numbers, not specific probabilities). The peak areas are all to the north of Quail Mountain and generally fall within a two-mile (3-km) radius of the now dry Quail Springs. These areas are not coterminous, but rather group roughly into seven different zones. The inset map depicts the zone of highest probability. These results could be further modified by such factors as a particular location's physical inaccessibility.

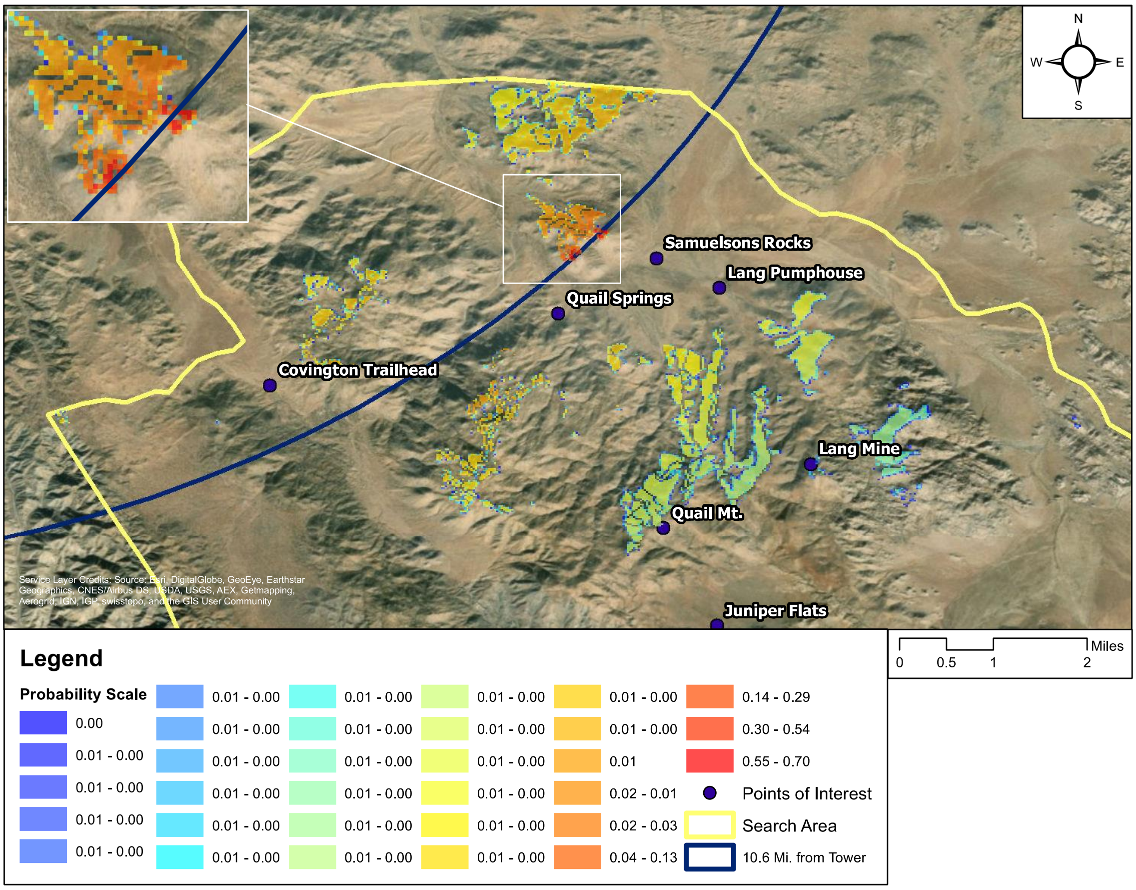

Figure 7: Optimal Probability Search Map

Optimal search areas, ranked by colour scale, shown in relationship to JTNP landmarks and 10.6-mile ping radius from Serin Drive cell phone tower. Inset box at upper left magnifies highest probability region.

Discussion

Incident commanders establish search priorities based on knowledge, experience, and local geography. Resources are reallocated accordingly when new information emerges and as areas are cleared. Here, we discuss how that process can be formalized using a Bayesian approach. Incorporating all available evidence reduces the chance of locations being overlooked even if their initial probability assessment was inaccurate (Lin & Goodrich, 2010).

Bayes' theorem also allows for the encoding of both expertise and uncertainty. Knowledge and experience of lost person behavior and local terrain characteristics should naturally inform a search and rescue mission (see Koester, 2008). However, the ability to handle uncertainty is also needed as missing person cases often involve a number of "maybes" and "possibilities." For example, one searcher found a bandana in JTNP which may, or may not, have belonged to Ewasko. A Bayesian model can appropriately incorporate such findings (e.g., to the degree it is believed the found item belonged to the missing person).

Our analysis was of a cold case with stable information; however, information is dynamic in the early days of a search and rescue mission as new findings and negative search results flow into the incident command center. The probability map requires constant updating, a task this model can quickly accomplish with GIS software and GPS inputs. Responsive functionality is important when time is a pressing concern.

Limitations

All search and rescue efforts involve assumptions, which should be carefully evaluated as they may undermine the conclusions if invalid. The following limitations of this analysis should be noted:

- The boundaries in Figure 2 outline the area within which Ewasko would be found. Even if these borders are not completely accurate, the effect on the outcome is minimal as the goal was to identify and prioritize remaining search areas, most of which were not located near the region's edges.
- Searchers would have seen Ewasko's body if it was within 50 feet of their track. The rocky areas in JTNP contain caves and canyons, however, that are difficult to search (Manaugh, 2018). Additionally, decomposition and animal scavenging quickly disarticulate human bodies, the remains of which may become distributed over large areas (Haglund & Sorg, 1997). This produces smaller body parts (sometimes buried by animals), but also more of them for searchers to discover.
- Signal-propagation physics is reasonably precise, so the distance estimate for the Serin Drive cell phone tower ping is thought to be 90% accurate (given no unusual atmospheric thermal conditions).
- The rate of distance drop-off from the cell phone tower was equal for both nearer and further positions, as shown in the graph in Figure 4. This may not be completely accurate as shorter distances sometimes appear to be longer due to reflection from rock faces. To partially compensate for this, the height of the tower was doubled in our calculations on the grounds that it was better to be more inclusive than exclusive.

Finally, it should be recognized that this is a simplified model, based on a limited number of factors. In reality, other variables may also be important considerations.

Future Research

Bayes' theorem provides the foundation for incorporating a wide variety of information sources. Here, we used prior search tracks and cell phone data (tower location, ping radius, and viewshed). Lin and Goodrich (2010) analyzed topography, vegetation, and local slope. Other factors that could be integrated into a WiSAR framework include direction of travel, weather conditions, seasonality, recovered clothing/water bottles, and so on – anything of material relevance. Research on missing persons, the development of lost-person-behavior algorithms, and the use of individual profiles can further inform an analysis (Koester, 2008; Lin & Goodrich, 2010; Velarde, Etlinger, & Rossmo, 2019). It may even be possible, with further research, to construct Bayesian networks that model sets of relevant variables and their conditional dependencies, allowing for a more powerful and holistic approach to optimizing WiSAR operations (Taroni, Aitken, Garbolino, & Biedermann, 2006).

Conclusion

"If you haven't found them, then they're someplace you haven't looked yet" (Pete Carlson, Riverside Mountain Rescue Unit, quoted in Manaugh, 2018). This observation raises the issue as to where one should look next. The purpose of our analysis was to answer that question by illustrating how Bayes' theorem can be used to generate prioritized search maps.

The Bayesian analysis for the Ewasko case was completed in August 2018. The results were posted by coauthor Thomas Mahood, who has written about the search over several years, on his blog (OtherHand.org). The prioritized areas have yet to be extensively searched, so the accuracy of the map in Figure 7 cannot yet be evaluated. Obviously, the utility of this analysis would have been greater if it had been done at the start of the search, then regularly updated.

This was a cold case, but the same techniques can be applied in search and rescue operations for missing persons who are hopefully still alive. One of the advantages of the approach is its ability to continually integrate new information (e.g., item recovery, negative searches, etc.) into the search plan in real time in order to optimize resource allocations. The ultimate goal is to improve WiSAR efficiency and effectiveness and help save lives (Lin & Goodrich, 2010).

Appendix

Data inputs

Data inputs for this Bayesian analysis include:

1. estimated distance from cell phone tower (10.6 miles) = *D*
2. cell phone coverage (no buffer) = *C*
3. previous search tracks (50-foot buffer) = *S*

Prior Probability

$P_{\text{prior}} = \frac{A}{10{,}000}$

where *A* = total search area (in square feet)

However, as we are only interested in prioritizing search areas, not in estimating actual probabilities, the prior can be ignored as it is equal for each cell.

Probabilities

Distance

Dx = from Serin Drive cell phone tower

$p(Dx)$ = from Gaussian distribution; exponent = 1.2 (see graph in Figure 4)

Coverage Area

$C_x = \frac{ca}{10{,}000}$

$p(Cx) = Cx \, / \sum_{i=1}^{N} Ci$

where: ca = cell phone coverage area (in square feet) within cell x

$N = 10{,}000$

Search Tracks

$S_x = 1 - \frac{100P}{10{,}000} = 1 - \frac{P}{100}$

$p(Sx) = Sx \, / \sum_{i=1}^{N} Si$

where: P = length of search track (in feet) within cell x

$N = 10{,}000$

Bayesian Probability

$$LR_{Tx} = (LR_{Dx})(LR_{Cx})(LR_{Sx}) = \frac{p(Dx)\ p(Cx)\ p(Sx)}{[1-p(Dx)][1-\mathrm{p}(Cx)][1-\mathrm{p}(Sx)]}$$

where: LR_{Tx} = total likelihood ratio for cell *x*

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Abbreviations

DEM	digital elevation model
GIS	geographic information system
GPS	global positioning system
JTNP	Joshua Tree National Park
NED	National Elevation Dataset
WiSAR	wilderness search and rescue

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

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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.

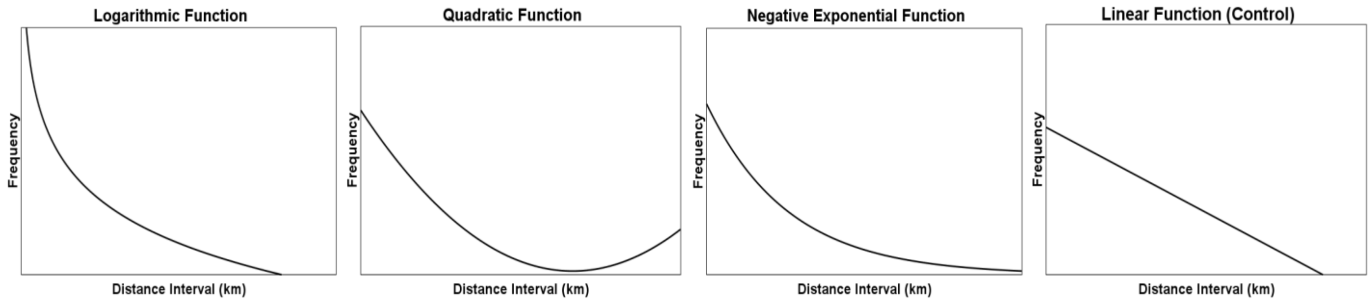
Decay functioning

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, η^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, η^2=.000, observed power .06 and suicidal likelihood $F(1,285)$=1.87, p=.173, η^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*

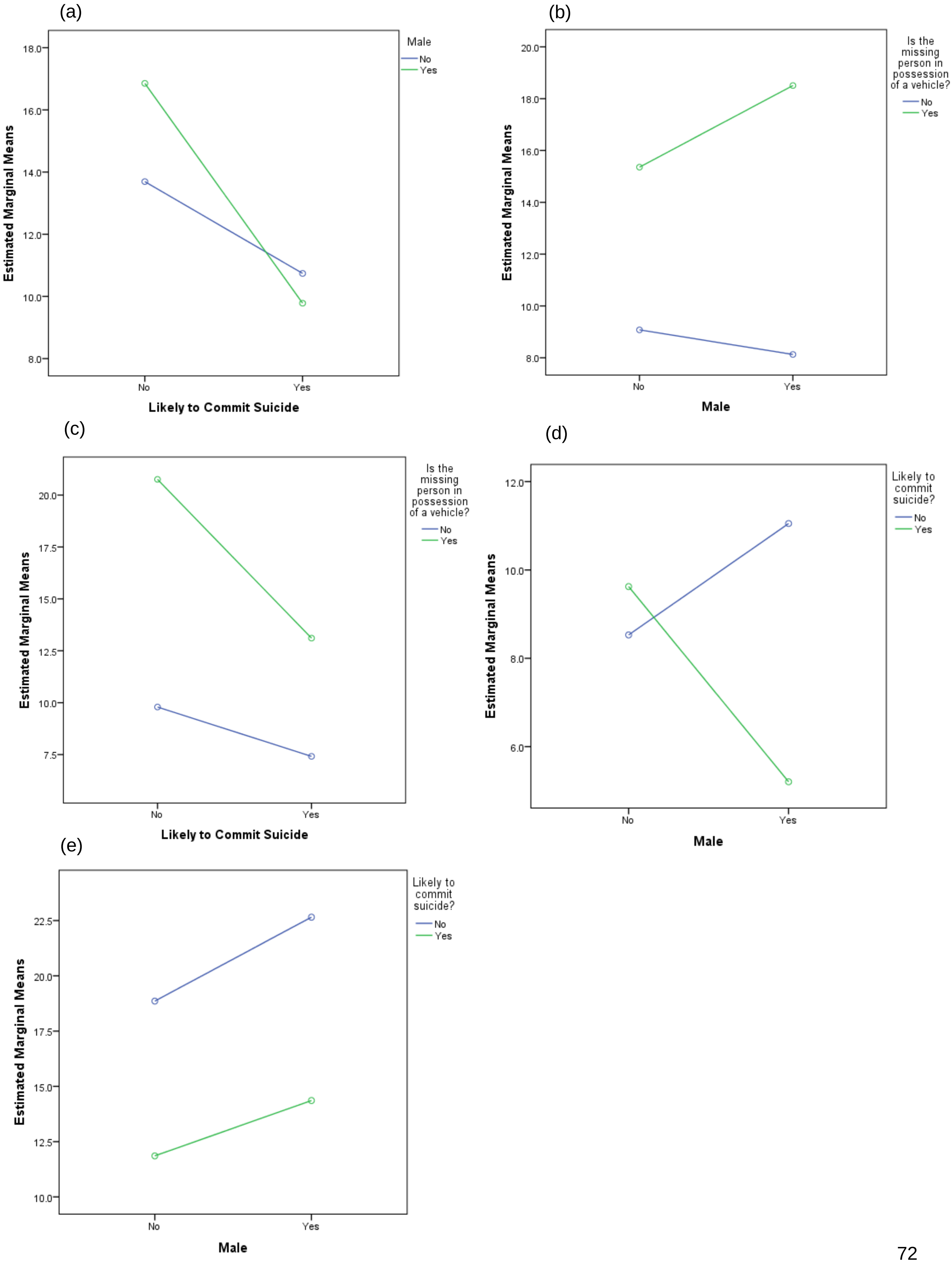


Figure 3 *– Graphs displaying the six distance decay functions calibrated against the distance travelled in the non/suicidal gendered sub-groups (a) suicidal males (b) suicidal females (c) unlikely suicidal males (d) unlikely suicidal females*

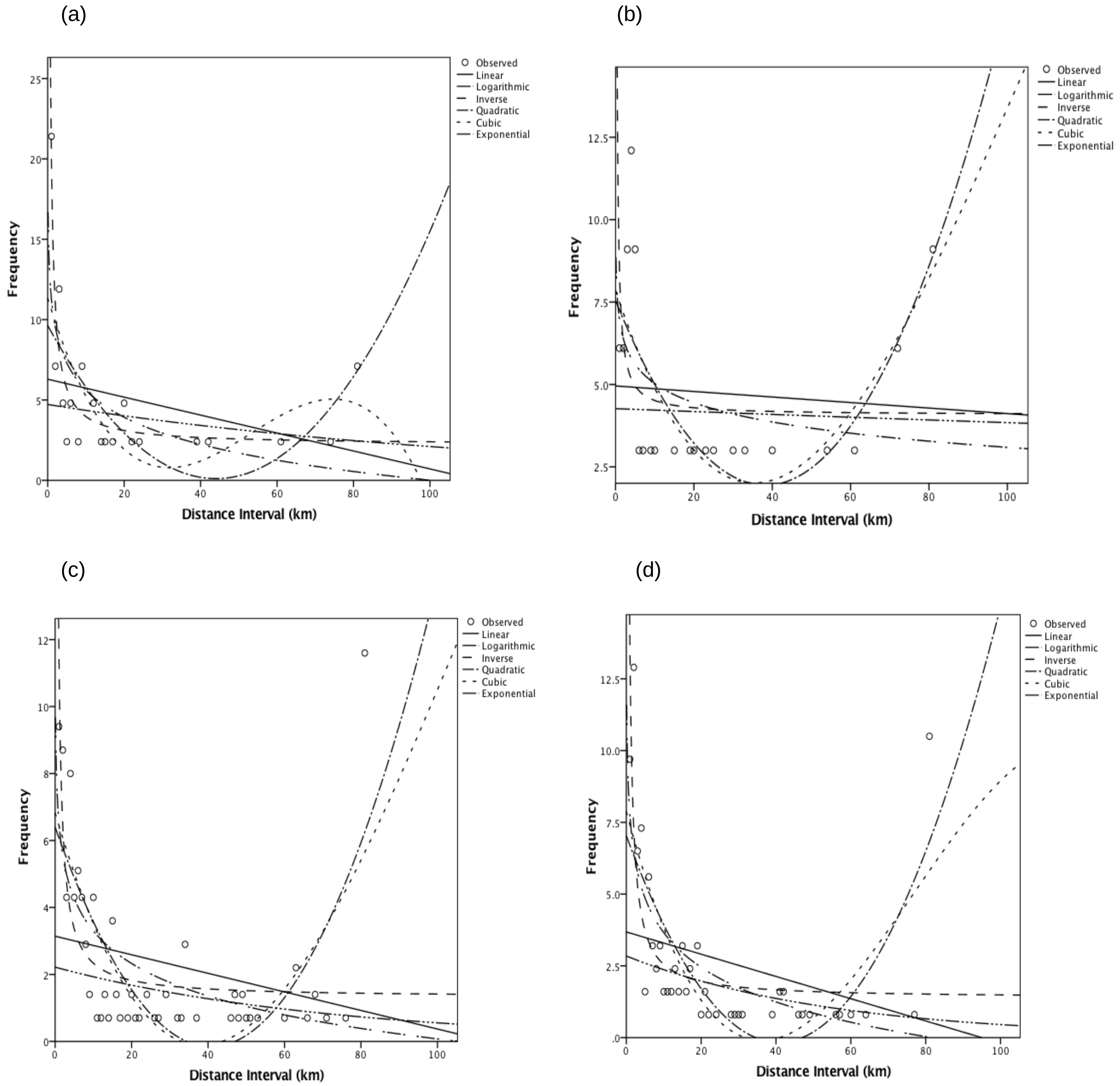
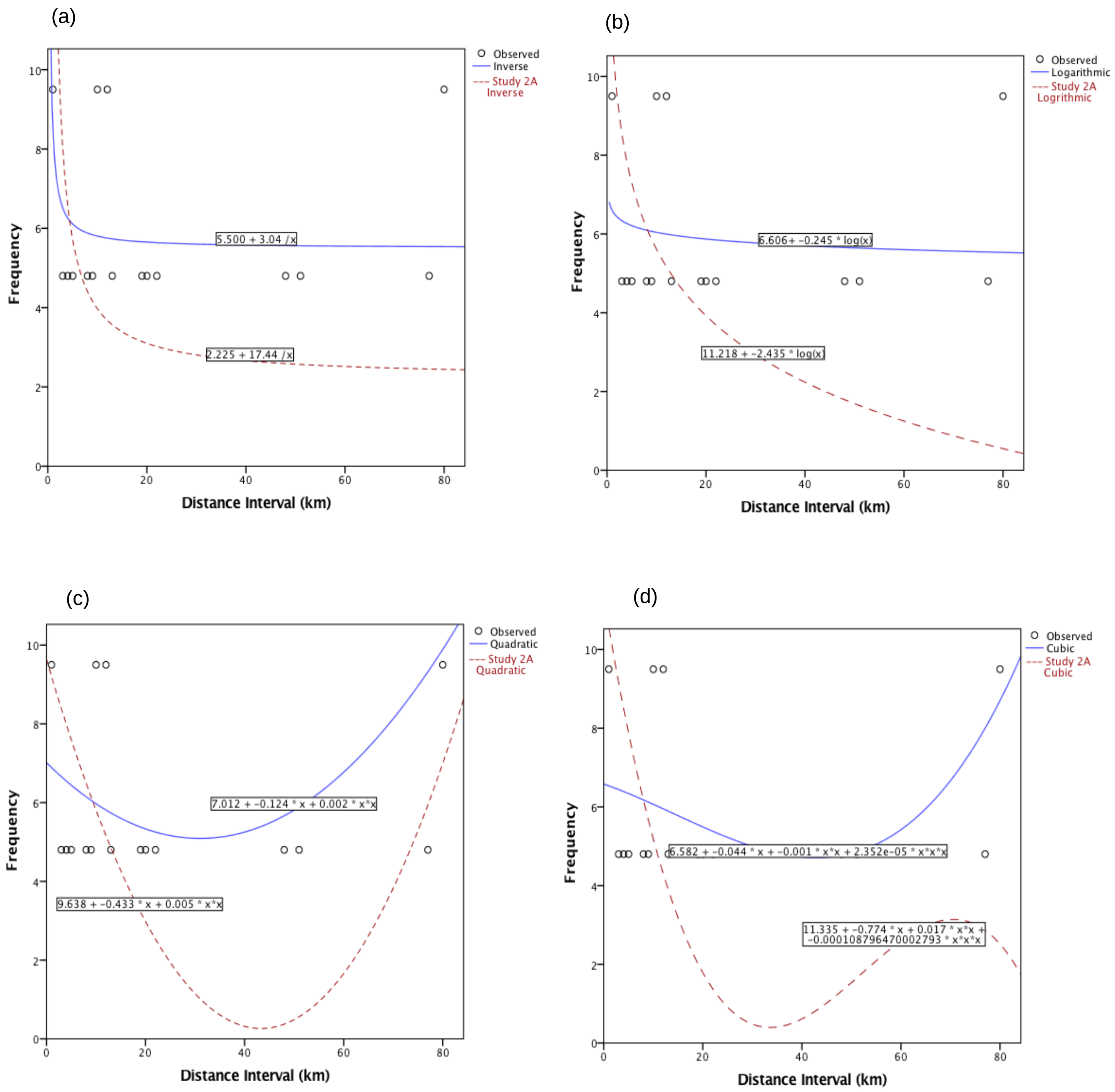


Figure 3 – Comparison graphs displaying the significant likely suicidal male functions found in study 2a, against the same functions generated for suicidal males in study 2b (a) inverse function (b) logarithmic function (c) quadratic function (d) cubic function



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.

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