Intuition, the Accimap, and the question “why?” Identifying and classifying higher-order factors contributing to road traffic collisions

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Abstract
Although the physical and environmental factors contributing to road traffic collisions are often the most straightforward to identify, they may not necessarily be the most useful in terms of guiding road safety intervention design. From a socio-technical systems perspective, it is the higher system factors that, if addressed, would provide the widest-reaching benefits to system outcomes. That said, the identification of these higher-order factors often requires a level of intuition or imagination; they are not always objectively obvious given the facts of a particular case. Here, we argue for the use of the Accimap approach to accident (or collision) analysis, supplemented with a modified version of the five whys causal analysis technique, for the support and structuring of this intuiting process. We use an analysis of a fatal motorcycle collision to illustrate how coroners in the United Kingdom could be supported in their task of identifying and summarizing factors in accordance with the levels of the Accimap, and according to a categorization scheme indicating how abstract those factors are (i.e., immediate, proximal, or distal). Our analysis identified 21 immediate, 12 proximal, and 33 distal factors contributing to the collision. It is these distal factors that are most likely to lead to longer-term road safety improvements.

KEYWORDS
Accimap, collision database, contributory factors, sociotechnical system, traffic safety

1 | INTRODUCTION

The under-reporting of road collisions is a well-known issue, one that exists (to varying degrees) across the majority of, if not all nations (e.g., Abegaz et al., 2014; Bhatti & Salmi, 2012; Chokotho et al., 2013; Janstrup et al., 2016; Periyasamy et al., 2013; Puvanachandra et al., 2012; Watson et al., 2015; Yannis et al., 2014). Furthermore, there is a widely recognized issue with the differences in data collected by emergency departments, ambulance crews, and police, both in terms of the numbers of casualties recorded (e.g., Abay, 2015; Bhatti et al., 2011; Dandona et al., 2008; Ward et al., 2002), and the classification of injury severity (e.g., Couto et al., 2016; Ferreira et al., 2017, 2015; Schmitt et al., 2015; Van Belleghem et al., 2016). Nevertheless, such databases are unlikely to undergo significant changes in the near future. Collecting, collating, and publishing data recorded by police at the scene of an incident is...
by far simpler and more practical (given the available resources) than attempting to synthesize precrash driver responses to environmental stimuli, detailed witness and casualty interviews, and in-depth black-box data for every vehicle involved into detailed reports that can be made available, in full, to the interested researcher or policymaker.

For the collection of data to be “successful,” it must be done so in terms of its intended application, hence data quality is not objective, but dependent on how appropriate that data is within the context of how it is to be used (e.g., Juran & Godfrey, 1999). It follows, therefore, that how a data set is to be used should be the primary factor in determining the content, structure, and organization of the collection activity. In a road safety context, our aim is to reduce or eliminate harm. As such, one purpose of the traffic incident data collection exercise is to provide information that supports and informs the design of road safety interventions that reduce the potential for that incident to happen again in the future. Unfortunately for road safety researchers, high-quality data that support these aims is not always forthcoming.

The road transport statistics database in the United Kingdom, a country with some of the safest roads in the world (e.g., WHO, 2018), is one of the longest-running traffic collision data collection and publication systems of any country; since 1949, road collision details have been recorded by the police using the STATS19 system (see ADLS, 2018). Although the form used has been subject to a number of investigations and undergone several alterations over the years (e.g., Hickford & Hall, 2004; Lupton, 2001; Neilson & Condon, 2000; Smith et al., 2015) it has undoubtedly provided continuity of data, from which much has been learned. Nevertheless, its utility in supporting remedial measures has had a long history of being called into question (e.g., Saunders, 1987).

Broadly speaking, the primary function of the STATS19 form (just as with many other road traffic incident recording frameworks) is to record the five “W’s:” where, when, what, who, and why (see e.g., Imprialou & Quddus, 2017). This information is used in a variety of ways, by a variety of individuals and organizations, including the police themselves (those responsible for data collection), politicians, insurance specialists, traffic planners, engineers, lawyers, and the general public (not to mention road safety researchers; Baguley, 2001). The idea is that from such information we can learn from incidents to prevent or, at the very least, reduce the likelihood of similar incidents occurring in the future. Of course, a detailed database provides utility at the national level, in guiding policy, the regional level, in supporting decision making, and locally, in identifying black spots and determining specific remedial measures (e.g., Baguley, 2001); however, there is a question about whether or not the STATS19 data has reached the limit of its potential, at least in terms of its utility in supporting effective road safety research and intervention design. Despite continued efforts, we appear to have reached a plateau in terms of the effectiveness of the road safety interventions that have been enacted in recent years (e.g., DfT, 2019a).

Though the United Kingdom saw a 68% drop in road fatalities between 1980 and 2010 (despite a population increase of 15%), since 2010 there has been little change (DfT, 2018); around 1700–1800 people lose their lives on the roads in the United Kingdom every year, with road traffic collisions representing the 12th leading cause of death (ONS, 2017). The stagnation since 2010 is mirrored across some of the best-performing countries in Europe (i.e., the Netherlands, Sweden, and Luxembourg), while across the European Union (EU) as a whole, rates have remained static since 2013 (ETSC, 2018). Worldwide, figures have also changed little over the past decade; given increasing motorization rates and population growth in low- and middle-income countries, raw fatality figures may even be increasing in these countries (GRSF & IHME, 2014). A potential explanation for this is that traditional approaches to collision investigation (STATS19 included), approaches that focus on the immediate surroundings of, and end-users involved in a given collision, are no longer sufficient to inform the design of effective road safety interventions (e.g., Salmon, McClure et al., 2012; Stanton, et al., 2019). New approaches are necessary, ones that go beyond the data recorded at the scene of an incident.

Mirroring work in other safety-critical domains, road safety researchers have increasingly begun to adopt sociotechnical systems-based approaches. The philosophy, as applied to traffic safety, has risen to prominence in the academic literature over the past 10 years or so (e.g., Larsson et al., 2010; McIlroy et al., 2019; Salmon, McClure et al., 2012), and has several core tenets with regard to safety that differentiates it from the causal chain or end-user focussed approaches. For example, rather than focus on components, it is the whole system that is taken as the unit of analysis (e.g., Read et al., 2013). Further, it holds that systems can be modeled as hierarchically organized structures (e.g., Rasmussen, 1997), and that safety (or the lack thereof) is an emergent property, arising from the interactions between components across all levels of that system (e.g., Leveson, 2004). Additionally, taking this perspective one would argue that focussing on “human error” is not useful, rather performance variability (which is not inherently negative) should be expected in complex systems (e.g., Hollnagel, 2016). This is not meant as a complete list or description of the aspects of systems approaches to analysis (see Read et al., 2013, for more detail); however, all share a similar fundamental principle. To fully understand system failures, and subsequently be able to design interventions that address those failures, we must look beyond the discrete actions or decisions made by end-users and the immediate surroundings in which that action or decision was made. Attempting to single out individually “broken” components as the “root causes” of system failure (Dekker, 2011) is not a useful philosophy.

As described above, the structure and content of road traffic collision data in the United Kingdom are based on the STATS19 form (see DfT, 2019b). Although it encourages (albeit limited) consideration of wider contributory factors (Hickford & Hall, 2004), it cannot be said to allow for the reporting of higher system factors. The STATS19 database does not, however, contain all of the information gathered during the investigation of all road traffic incidents. For all collisions in the United Kingdom involving fatal or life-changing injuries, a detailed investigation is undertaken. The police are the lead
organization in this process, with responsibility discharged to various individuals and organizations, including the coroner (College of Policing, 2019). The coroner, an independent judicial office holder who is usually a lawyer, medical doctor, or both (Ministry of Justice, 2009), leads the investigation to establish how, when, and where a person died, collating information from a variety of sources, often including (but not necessarily limited to): police collisions investigator and forensic expert reports, pathology and toxicology reports, hospital reports, witness statements, court proceedings, media reports, and insurance company communications. Crucially, when a coroner’s inquest is undertaken, it is not about assigning criminal blame (they do not prosecute or defend), but about discovering the facts of the death (Ministry of Justice, 2009). After the process is complete, case records are stored in archives and are, in some cases, available for review, given permission from the coroner. In contrast to the limited STATS19 data, complete reports are not contained in online databases, and are not immediately, publicly accessible.

Coroners in the United Kingdom, according to the Coroners and Justice Act of 2009, have a responsibility to consider the factors that contributed to a death. Although it is not uncommon for such investigations to include distal factors such as policy and resource allocation decisions, it is not a requirement for coroners to include these aspects. Legally, factors that “might arguably have contributed to” the death must be included (Dolan, 2016, no pagination); the specificities of this are open to the coroner’s interpretation. Distal factors can be included in this; however, the proximal causes are those that are more easily identified, and which are more easily argued to have contributed directly to a collision. This bias towards proximal factors is also evident in published road safety reports and research outputs (Salmon, McClure et al., 2012). The focus on the “sharp-end” is likely to be at least in part due to the fact that the distal causes are less obvious; they require a greater degree of inference on the part of the analyst, involving further extrapolation from published or recorded data, to identify or suggest. Nevertheless, addressing the distal factors would have more profound effects on whole-system outcomes than focussing on proximal causes. A significant challenge to this is finding the balance between sticking so closely to the “facts” of a particular case that one misses the wider system factors, and extrapolating to such a degree that identified factors arise from no more than analyst speculation. If we fall prey to the former, opportunities will be missed for safety improvements; to the latter, and road safety interventions can no longer be said to be evidence-based (RoSPA, 2017).

We propose here that the Accimap methodology, an accident analysis framework (or collision analysis, to use road safety language) rooted in systems-thinking, can be used to structure the inductive reasoning required to identify the higher-order factors that contribute to road traffic collisions such that clear pathways can be drawn from the recorded information to the identified distal factors. We also suggest that the five whys technique (albeit with important and fundamental caveats) can help in the creative thinking process required to identify these higher-order factors. Finally, we argue that the contributory factors represented in the resulting Accimap can be categorized into three orders: immediate, proximal, and distal. These different orders of contributory factors could be included in road traffic collision databases such that they could be analyzed, with findings contributing to systems-based road safety interventions. We will introduce the Accimap and five why approaches in turn, then use the analysis of a fatal motorcycle collision that occurred in the United Kingdom to illustrate our arguments.

### 1.1 Accimaps

A sociotechnical systems model that has proved particularly influential in the last two decades is Rasmussen’s (1997) risk management framework (RMF). In its original form, it describes systems in terms of six levels of organizational abstraction, from end-users and equipment at the bottom, to central government at the top. It graphically represents systems as hierarchies of equipment, individuals, and organizations. In applying the framework to the driver distraction domain, Parnell et al. (2017) expanded the discussion to include two additional, higher levels; national committees and international committees. The Accimap methodology (Svedung & Rasmussen, 2002) is the accident analysis method associated with the RMF system representation. A completed Accimap graphically represents the decisions and actions (or other failures) that contributed to the system outcome, across the RMF levels, providing a structural map of the accident (hence the method’s name). Of particular importance is that it draws attention to the connections across and within levels of the wider sociotechnical system within which the event occurred. As such, it is possible to link the proximal causes of an accident (or collision, e.g., the inattention of a driver) to the distal factors that allowed that proximal cause to be released (e.g., the lack of legislation against 17-inch touchscreens for driver use; e.g., Tesla, 2019).

The method has seen greater attention than other systems thinking-based approaches in the road safety literature (e.g., Hamim et al., 2020a; McIlroy et al., 2019; Newnam & Goode, 2015; Parnell et al., 2017; Salmon et al., 2013; Scott-Parker et al., 2015; Talbot et al., 2016; Young & Salmon, 2015), partly through its relative ease of use and low application time, the minimal resources required to perform it, the low training time necessary, and the existence of good evidence for its practical impact (compared to other systems and accident analysis methods such as STAMP, EAST, FRAM, and so forth; Stanton, 2019, though see also Filho et al., 2019). As yet, however, uptake has been seen primarily in the academic domain; use by those routinely involved in road traffic collision analysis outside the academic realm has yet to be seen, at least in the UK. This could be partly due to the skill and domain knowledge required from the analyst; although the Accimap can provide a comprehensive, rich picture of an accident (or collision or event), there is little in the way of assistance (in the method itself) provided to support identification of contributory factors.
1.2 | The Five Whys

The “Five Whys” technique was first used to identify the root causes of problems in manufacturing and production at Toyota (Ohno, 1978). Starting with a problem, the analyst asks “why?” five times to arrive at a root cause. In healthcare, the following example is provided, starting with the finding that a patient is late in theater, causing a delay.

Why? Because there was a long wait for a trolley.

Why? A replacement trolley had to be found.

Why? The original trolley was not mechanically sound.

Why? It had not been regularly checked for wear.

Why? Because there is no equipment maintenance schedule (NHS, 2018).

The principle behind the method is that it reveals the hidden factors, those perhaps not immediately clear, that influence an outcome. In other words, it aims to help the analyst look beyond the proximal causes and identify the distal causes of an event. Although a crude heuristic, it has proved useful (or at least popular) in the identification of contributory factors that may not always seem immediately obvious. There are, of course, a number of methods that can support idea generation in a causal analysis context. For example, the mind map process (e.g., Millen et al., 1997) results in a web-like graphical representation of factors (in some ways similar to the Accimap); the storyboarding method (e.g., Truong et al., 2006) can give temporal meaning to the factors identified; and the Six Thinking Hats Technique (e.g., Vernon & Hocking, 2014) can facilitate inclusion of different perspectives on the analysis. Nevertheless, it is the Five Whys that is the most widely adopted root-cause analysis approach, particularly in healthcare where it is recommended by a variety of national and international organizations, for example, the UK’s National Health Service (NHS, 2018) and the World Health Organisation (WHO, 2011), owing largely to its simplicity. That said, the method has very significant limitations.

It is important here to make it clear that we discuss this method as something that could be helpful when combined with other approaches (e.g., Accimaps); due to some significant and deeply rooted problems, it is not one that should be used on its own. First, the underlying concept of “root-cause” is outdated and unhelpful. There almost never exists a single root cause of an accident, collision, or system failure. Focussing on one cause alone, no matter how distal or wide-ranging, will never support reliable driver system safety improvements. Second, although our preceding discussions have been about identifying distal causes, this should not be at the expense of addressing proximal causes, factors that also merit attention (Card, 2017). Responsibility for road safety outcomes is shared across all system actors (McIlroy et al., 2019; Salmon et al., 2016), hence road safety interventions should consider all levels of the system, not just the most abstracted. Third, it is unclear why the analyst should ask “why?” five times; sometimes further inquiry is necessary, others it is enough to stop after one or two rounds of questioning. Finally, the method itself encourages (or even forces) the analyst to explore just one accident pathway. A fundamental principle of the sociotechnical perspective of safety in complex systems is the existence of multiple linear and nonlinear event pathways, and that identification and consideration of the full complex web of interconnections are necessary for system improvement. This is clearly in contrast with the basic five whys approach. As such, we would like to make it very clear that we do not recommend the use of the five whys technique as a stand-alone tool.

That said, we would argue that the simplistic idea behind the “whys” approach (from herein we drop the “five”) can be useful as an aid to an analyst constructing an Accimap. Indeed, it could equally be argued that the Accimap can present aid to the five whys analyst in identifying the distal contributory factors to a system failure, insofar as it makes the analyst think of more than one pathway through the system. For the purposes of system safety and accident (or collision) analysis, taking the questioning principle of the whys approach, and using it in combination with the Accimap method to explore multiple potential pathways, is the approach that we have taken herein.

1.3 | ANALYZING A ROAD TRAFFIC COLLISION

1.3.1 | The analysis

To illustrate the potential for Accimaps and the whys to help assist in identifying the three orders of factors described above (i.e., immediate, proximal, and distal), and to visually represent the pathways and distance to the event of the contributory factors involved, we present the analysis of a fatal road traffic collision involving a motorcycle that occurred on a busy, commercial street. To minimize the chance for identification, we do not report the location or date of the collision. This particular collision was chosen primarily for practical reasons. First, the road area in which the collision occurred is, in relative terms, a site that experiences an elevated and concentrated number of traffic collisions compared to other streets in the city in which it occurred (identified in direct collaboration with the local police constabulary). Second, motorcyclists are the most over-represented road user in killed and seriously injured (KSI) statistics (per passenger km/mile; DfT, 2019a). Moreover, multi-vehicle collisions (mostly involving a car and a motorcycle) represent the cause of the majority of KSI motorcycle casualties, with most occurring when a motorcyclist is going straight ahead and a car driver turns into its path (as in the case of the incident under analysis here; e.g., DfT, 2016). Finally, one of the current authors is an experienced...
motorcyclist, hence has additional expertise and knowledge in that field, and strong motivation to address road safety for that user group.

To develop the Accimap, the first analysis step was to gather information from the online STATS19 database. This raw data, giving details of the people and vehicles involved, the time and location of the collision, and the nature of the collision and the resulting injuries, was supplemented with two reports published in a local newspaper, and with the authors’ own local knowledge of the area. Then, contact was made with the local HM Coroners’ Service offices. Permission to view the case files concerning the incident was sought from, and granted by the coroner for the area in which the collision took place. A member of the research team traveled to the coroner’s offices to view the collated reports. A single visit was sufficient to extract the required information to develop the initial Accimap. Ethical approval for this study was granted by the University of Southampton’s ethics board (ID: 49186). The following description represents a summary of the information contained within the various documents and reports reviewed.

1.3.2 | The collision

The incident occurred on a dry, sunny, weekday afternoon at approximately 17:30, one of the busiest times on the roads in the United Kingdom (where vehicles drive on the left-hand side of the road). An experienced, male motorcycle rider in his early 50s, riding a large-engine motorcycle (1199cc), turned onto a busy two-lane, two-direction street and began to accelerate up to his target speed. This street is the main thoroughfare into the city center from the northwest; it runs through a highly populated residential zone and has a large number of commercial premises (including shops, supermarkets, restaurants, and pubs) along its length. Meanwhile, a male driver in his late 20s had brought his car to a halt in the opposing lane approximately 100 m from the junction at which the motorcycle rider had just joined the street, and was waiting to turn right into a side road (across the lane of opposing traffic). The car driver began to turn into the side road, across the path of the motorcycle rider who was coming from the opposite direction. Although the car driver had encroached onto the opposing lane, he stopped his car before a collision occurred; however, the motorcyclist had already applied emergency braking that had resulted in the front wheel locking. This loss of control resulted in the motorcyclist being unable to stop in time to avoid the collision or to swerve around the car.

The resulting collision with the front near-side of the car was fatal, with the sustained injury (an atlanto-occipital dislocation) the result of the rapid deceleration of the trunk in relation to the head. In the pathologist’s report, this injury was noted as a common cause of motorcyclist fatality. Analysis of CCTV footage from a nearby laundry business indicated that the motorcyclist had been traveling approximately 46 mph (74 km/h) immediately before the collision, where the speed limit was 30 mph (~50 km/h). A toxicology report stated that the deceased’s blood tested positive for alcohol and amphetamine. The alcohol level was lower than the UK legal limit (at 14 mg/100 ml, the limit being 80 mg/100 ml). Amphetamine levels were stated to be in excess of what would be considered therapeutic levels, being consistent with recreational use. The rider had been wearing a helmet and protective leathers but had not been wearing high visibility clothing (not legally required in the United Kingdom), and his motorcycle did not have its headlights on (a requirement for motorcycles and mopeds sold or registered since 2016, but not a legal requirement for older vehicles; DfT, 2015).

1.3.3 | Identifying higher-order factors

To construct the Accimap, the lower two levels, namely "equipment and environment" and "physical processes and actor activities," could be populated using information contained within the coroner’s reports. These are the levels dealing with the equipment, environment, and immediate physical processes associated with the collision. These two levels were, therefore, completed first; however, to complete the higher levels, additional information was required. This information was gathered from publicly available online sources, including insurance companies, motorcycle organizations, road safety charities, national and international standards organizations (e.g., British Standards Institute [BSI], EU, International Organisation for Standardisation [ISO], etc.), and government policy documents (primarily from gov.uk, the UK government’s online portal). Recourse was also made to McIlroy et al.’s (2019) Actor Map of the UK road safety system. This provides a basis from which to consider the actors involved in a given collision or accident, insofar as it provides a comprehensive (though not exhaustive) list of the entities involved in road safety, structured using the same RMF levels as used in Accimaps (i.e., from equipment and environment up to international organizations).

The process of identifying higher-order factors was as follows. First, a predefined node in the lower levels, that is, those identified from the coroner’s reports, was chosen. The question why was then considered, with respect to the information surveyed and the experience of the analysts; why did this event, action, or decision point take place? The UK Actor Map (available in McIlroy et al., 2019) was consulted, with each Actor being considered in turn. As many or as few connected nodes, at any level of the diagram, could be identified; this was not limited to one (as in the original "whys" technique), nor was it limited to only the level immediately above. This approach not only supported the identification of the nodes but of the connections between those nodes. Once these ideas had been exhausted, each of the nodes that had been identified was then considered in the same way. This was continued until no further factors could be identified. The whole process was then repeated for the next lower-order factor in the Accimap. Sometimes these led to the same, already identified higher-order factors, for others there were no higher-order factors. This was not restricted; simply asking "why" until all ideas had been exhausted was the principal heuristic used in the analysis.
This activity continued until the two analysts (i.e., two of the current authors) agreed that the Accimap was complete.

A focus group, facilitated by the current authors, was then held to discuss and further identify the factors that could have contributed to the collision. This focus group had nine participants, all of whom were employed in academia. Table 1 details the participants' ages, their field of expertise, and their experience (in years) in that field (at the time of the focus group). Participants were recruited through their involvement in an on-going, multi-university, multi-disciplinary project on road safety. The participants were first introduced to the details of the collision as they appear in the STATS19 database and in the coroner’s report. During the focus group, recourse was made to the Street View feature of Google Maps to assist in the visualization of the incident, and the first iteration of the Accimap introduced. This Accimap formed the basis of the subsequent questioning process. This process was the same as that described above, that is, for every node or collision characteristic selected by a member of the focus group for consideration, the question “why did this event, action, or decision point take place?” was posed. No formal description of what constitutes a “contributory factor” was given beyond the notion of it being a factor that directly or indirectly contributed to the node under consideration, with ultimate decisions arrived at through consensus.

Focus group members were free to comment on any aspect of the draft Accimap or on the collision information generally, with little structure given to this initial step other than that the process started at factors lower down in the Accimap (or if to do with an aspect not included on the draft Accimap, related to the equipment, environment, or physical process involved). The activity progressed with all members comprising a single group, with all participants encouraged to add to the discussions. Again, no limit to the number of answers was imposed. This process continued until there was group consensus that the particular line of inquiry currently under discussion had reached its conclusion. This focus group lasted approximately half a day and served to validate the Accimap already constructed from the coroner’s reports and online information and to supplement it with additional, higher-order factors where appropriate.

### Table 1: Focus group participants

| Age | Field of expertise          | Experience (in years) |
|-----|-----------------------------|-----------------------|
| 60  | Public health               | 35                    |
| 27  | Communications              | 7                     |
| 38  | Road safety research        | 10                    |
| 58  | Transportation engineering  | 32                    |
| 25  | Transportation engineering  | 3                     |
| 61  | Transportation engineering  | 32                    |
| 38  | Transportation engineering  | 13                    |
| 44  | Transportation engineering  | 22                    |
| 44  | Transportation engineering  | 22                    |

### 1.3.4 Coding factors

As described above, in the resulting Accimap we distinguish between three orders of factors. "Immediate" factors draw directly on information contained within the coroner’s reports, media reports, and STATS19 database information, and only on that information. "Proximal" factors are those that are directly connected to immediate factors and that can be immediately inferred (based on analyst experience, domain knowledge, and relevant document review). "Distal" factors are those that go further beyond the recorded or published information specific to the collision, requiring some intuiting (or imagining) on the part of the analyst. Categorizing the immediate factors was done by all current authors collaboratively, with reference to the details of the case. For the remaining nodes in the Accimap, two of the current authors individually categorized each identified factor as either proximal or distal. This was done after the Accimap had been finalized (i.e., after the focus group). Agreement between the two authors was at 81%, and inter-rater reliability, measured using Cohen’s kappa ($\kappa$), was 0.60, indicating moderate agreement (e.g., Viera & Garrett, 2005). A third individual, experienced in the use of Accimaps and in human factors and traffic safety, but not directly involved in the current work, then acted as a third coder. They were introduced to the aims of the current work, shown the Accimap with proximal factors already coded, and provided with the descriptions of the three classes of contributory factors. Inter-rater reliability with the first author was $x = 0.58$ (moderate agreement), with 81% agreement; with the second author, reliability was $x = 0.71$ (substantial agreement), with 86% agreement. Differences between raters were discussed between the authors and the independent rater until agreement was reached.

The completed Accimap is presented in Figure 1. On the diagram, the three factors, immediate, proximal, and distal, are represented with the use of shading. Note that the Accimap represents only the events and decision points leading up to, and at the moment of the collision. Although possible, we have not in this instance expanded the Accimap to include the emergency response.

At the lowest level, environment and equipment, the physical objects, including the road, motorcycle, and car, that in some way influenced or were involved in the collision and its outcome are listed. For example, the rider was not wearing reflective protective equipment. At this level, two items were added following the "why" process of identifying factors: "weekly rush hour traffic" and "no traffic cameras at junction." Although not explicitly stated in the case files, the presence of weekday rush-hour traffic could be inferred based on the time of the collision (i.e., around 17:30), local knowledge, and the photos of the scene included in the files. The lack of traffic cameras was inferred from the fact that CCTV footage from a nearby laundry business’s cameras was used by the police analyst. In the next level up, the actions and decisions directly linked to the collision are displayed. These include the car driver deciding to turn right, waiting, then initiating his manoeuvre. All nodes at this level were identified as immediate factors. The middle four levels were mixed between proximal and distal factors, except "Regulators,
Associations,” where all were identified as distal. In the upper two levels, all factors were identified as distal. The frequency and distribution across the eight levels of the different types of factors identified is displayed in Table 2.

**TABLE 2** Frequency and distribution across Accimap levels of the three classes of contributory factors identified

| Category                                           | Immediate | Proximal | Distal | Total |
|----------------------------------------------------|-----------|----------|--------|-------|
| International committees                         |           |          | 6      | 6     |
| National committees                               |           |          | 6      | 6     |
| Government policy and budgeting                   |           |          | 3      | 5     | 8     |
| Regulators, associations                          |           |          | 6      | 6     |
| Local area government planning and budgeting, company management |           | 2        |       | 6     | 8     |
| Technical and operational management              |           |          | 5      | 4     | 9     |
| Physical processes and actor activities           | 11        |          |       |       | 11    |
| Environment and equipment                         | 10        | 2        |       | 12    |
| Total                                              | 21        | 12       | 33     | 66    |
why this is the case, a variety of additional higher-order factors were identified, including a lack of equivalent New Car Assessment Programme safety standards for motorcyclists, and the inability of relevant international organizations (e.g., the United Nations, WHO, the EU) to translate research and practice into national law and policy (noting that this may or may not beneficial, depending on the issue under consideration, and the person or organization doing the considering).

2 | DISCUSSION

All of the immediate factors in Figure 1 are at the lowest two levels of the Accimap, whereas the majority of proximal factors are at the lower and middle sections of the diagrams, and the distal factors are concentrated in the upper levels of the system hierarchy. The frequencies with which each type of factor is seen across the Accimap levels (see Table 2) reflects the tendency of current road traffic collision investigation (and wider road safety) efforts to focus on the end-user and immediate road environment and equipment levels, at the expense of considering higher-order factors (e.g., Hamim et al., 2020b; Larsson et al., 2010; Salmon, McClure, et al. 2012). This was largely to be expected; as one moves further away from the collision (organizationally speaking), more inference is required, hence the greater numbers of proximal factors at the middle Accimap levels, and distal factors at the higher levels. For example, the physical objects of amphetamines and alcohol were detected in the deceased’s blood (though alcohol levels were below the legal UK limit). This immediate factor is preceded, at the technical and operational management level, by a proximal factor that was not explicitly stated in the case files, but one that requires minimal intuiting, that is, that the police had not, before the collision, detected that the rider was under the influence of alcohol and amphetamines. Beyond this are the distal factors of insufficient traffic police staffing, the ineffectiveness of television drink and drug safety campaigns, and the motorcycle schools not fully preparing riders for the dangers of the road (in this case). In turn, these are connected to the higher distal factors of there being a lack of advice from vehicle insurers on advanced motorcycle training, a need to improve motorcycle testing and training procedures, and an overriding influence of budget cuts, financial pressure, and a minimal push for motorcycle safety at the highest levels of government.

As discussed in the introduction, these distal factors were identified through applying a modified version of the idea behind the “five whys” technique. It was modified inasmuch as there were no upper or lower limits to the number of “whys” asked (i.e., we dropped the “five”), and the questioning was not done linearly. To expand on the latter point, rather than move on to the next factor once one potential answer had been produced (as is commonly described in “five whys” discussions), the same node was considered repeatedly. This is crucial to the identification of multiple pathways through the Accimap, a central tenet of the sociotechnical systems approach to the accident (or collision, in this case) analysis and modeling (i.e., multi-causality; e.g., Grant et al., 2018). System failure rarely (if ever) arises from a single, linear pathway through a system; this is where the Accimap approach can benefit the whys approach. As Card (2017) argues in his critique of the five whys approach, following a single pathway will likely result in a solution that is incomplete, and does not consider the broader system. Crucially, “systems thinking requires both depth and breadth of analysis” (italics in original; Card, 2017, p. 672). Combining the whys approach with the Accimaps overcomes some of the limitations of both.

Although itself a potentially complex and challenging set of tasks, the recording of the physical, post-collision condition of the road and vehicles, and the interviewing of witnesses, is quite straightforward compared to the task of identifying distal casual factors that may or may not have influenced outcomes. This is because the latter requires a far greater degree of imagination, intuiting, or inference; they are not an immediate result of the investigation into the road environment, vehicles, casualties, or witnesses. Although one could interpret this necessary level of subjectivity as a criticism, we would argue that for collision analysis to achieve one of its primary aims, that is, to inform policy that reduces the likelihood of such incidents in the future, greater levels of inference and intuiting are necessary. The current contributory factor approach does not seem to be working well enough; fatality rates have been static in the United Kingdom since around 2010 (DfT, 2019a). It is in this aspect that the Accimap is most beneficial, as the Accimap is, in part, about idea generation; it is a supportive tool for brainstorming around causality (Waterson et al. 2007). It will always involve some creativity and, therefore, subjectivity; however, it provides a frame to work with, and a hierarchy to structure ideas in terms of the organization of the system. Moreover, it is not a prescriptive method, rather it allows for flexibility in its application. As Waterson et al. (2017) describe, the “freedom afforded by Accimaps allows the analyst to explore a range of options for analysis and encourages experimentation and exploration of explanations which draw on the systems approach and systems theory” (p. 493). Something the Accimap lacks, however, is a simple-to-follow heuristic to help the analyst populate the hierarchy. We argue that the “whys” approach fills this gap; with both techniques combined, the analyst has a structured method for exploring the multiple potential pathways of causality through the system. In doing so, the analyst is making sense of events, and the factors leading to those events, with the mapping of causal links involving a process of both revealing connections and hypothesizing connections.

Svedung and Rasmussen (2002) first introduced the Accimap as an aid to accident analysis; however, we have here discussed both analysis and investigation. Waterson et al. (2017) describe the differences between two in terms of an Accimap’s typical application; “Accimaps are primarily used for the purpose of accident analysis (e.g., understanding factors which caused the accident, suggesting countermeasures) and not investigation (e.g., finding a root cause or set of root causes)” (Waterson et al., 2017, p. 500). In practice, analysis and investigation often go hand in hand, with a coroner’s task a combination of the two; while they analyze that which has
been provided to them (e.g., from police and pathologists), they also investigate, making inquiries where necessary. Following (Waterson et al., 2017) definitions, our activities have included both analysis (i.e., of the coroner’s report and STATS19 data) and investigation (i.e., in the factor identification process) of the chosen case study. That said, we would argue that it is probably not useful to try and separate the concepts. For example, the “Five Whys” technique is described as a Root Cause Analysis method, despite being more about the investigation (if using Waterson and colleague’s distinction), and the Accimap is often referred to in terms of its support for contributory factor identification (hence, investigation; see e.g., Hamim et al., 2020a; Salmon et al., 2020). The confusion between the two concepts is highlighted in the following phrase from an article authored by, among others, Waterson; “the degree to which the accident analysis method successfully identifies the causes of an accident” (Goncalves Filho et al., 2019, our own emphasis). Although this topic likely merits greater attention than we can give it here, it is sufficient to argue the combination of Accimaps and the whys to be useful for both investigation and analysis, if such a dichotomy exists, as the benefit primarily comes in the structure it gives to creative thinking in the context of causal factor identification and consideration.

Providing structure to the coroner’s work may help address issues arising from there being multiple, autonomous coroners across the UK, something Pilkington et al. (2014) describe as a missed opportunity for public health. There is no national structure to the corner service, rather it is locally resourced and governed. This localization has led to inconsistencies in the services provided across coroner areas (Chief Coroner, 2018). Using something akin to the Accimap, in combination with a whys approach, would still accommodate the differences between individual coroners, their backgrounds, experiences, and ways of working, but would provide a structured framework to organize their reports, or indeed a publishable summary of their reports. This aggregation across all coroners’ reports could provide, through the freely accessible publication of the commonly structured outputs, a means to observe nationwide patterns in higher system factors contributing to road traffic collisions, something currently lacking.

In their empirical study of contributory factors, Rolison et al. (2018) showed them to be very heavily focussed on driver actions and errors, a similar result found by Montella (2011). Going further, Montella also found that despite transport experts’ ability to identify additional factors (over those reported by police), all were related to environment and road interactions; no considerations of higher system factors were made (Montella, 2011). This bias towards physical, immediate factors can be seen throughout Imprialou and Quddus’s (2017) review of crash data for road safety research, where the overwhelming majority of discussions revolve around the vehicles, the road users, and the immediate physical environment. To focus on that end is to do so at the expense of focussing on higher factors, ones that could have wider-reaching influence.

It is not that the perspective is erroneous, rather that it has become less useful. It is our argument that the immediate factors are likely to lead only to short-term and/or very localized safety improvements. For example, changing the road layout of a particular junction may well reduce collision rates at that specific site; however, it will do little to affect the wider road system. Moreover, given no incentives to use active or public transport, car use rates are likely to continue to rise, with the resulting increase in traffic likely to cause more on-road conflict. Addressing these distal factors is more likely to result in long-term benefits that affect not just those at a given location, but all those that use the system (or even other, related systems, e.g., in other countries). The proximal factors, being somewhere between immediate and distal factors, would likely have effects that are also in-between; for example, having car makers introduce protection for those colliding with the side of the vehicle (not just for the occupants) could provide medium-term benefits to a potentially wide array of road users. These distinctions would, however, need to be tested to be confirmed.

Currently, the UK’s STATS19 database, comprised of data collected by police officers, provides a relatively thorough treatment of the immediate, physical, and road user factors. We argue here that perhaps it is time to develop a secondary system, one where coroners can provide a summary of proximal and distal factors. Such a system could be incorporated with a contributory factor categorization scheme additional to the three categories used here (i.e., immediate, proximal, distal). Research expanding on that of Newnam and Goode (2015) and Newnam et al. (2017) could provide useful in this regard. Those authors developed a generic contributory factor system for road traffic collisions involving large goods vehicles. Those factors were specifically based on higher system factors; however, this is not yet practical for use across all road traffic incidents.

The task of identifying these distal factors, categorizing them, and summarizing them, would be far better suited to the coroner than the police officer. Among other things, a police officer’s role is the protection of property and maintenance of social control through enforcing laws and gathering evidence. Police training reflects this, and as such gives little (if any) attention to safety science or policy design (e.g., Montella, 2011). Moreover, training all traffic police officers in the Accimap method, and performing a full Accimap analysis of each of the three or four fatal collisions that (on average) occur every day on the UK’s roads is not possible given current levels of police resources. Indeed, Stanton, et al. (2019) suggested that full, in-depth analyses could be prioritized for major (involving multiple casualties) or indicative (ones that keep recurring) incidents. That said, the Accimap and whys approach could be integrated into the existing coroner investigation process. The outputs, publishable in a publicly searchable database, would be complementary to the STATS19 database. To go back to the point made at the very start of this article, this would represent “successful” data collection, insofar as it would be appropriate to its use as a basis from which to inform policy and intervention (see Juran & Godfrey, 1999), and would provide structure and organization to the collision analysis activity and its outputs (in the identification of the immediate, proximal, and distal factors).
One final point to make is that there may be things captured in the coroner’s reports that may or may not be relevant for inclusion in the Accimaps. For example, in the case study described above, the motorcyclist’s wife was reported to have been undergoing a long battle with cancer. This would have affected, in a significant way, the emotional and psychological state of the motorcyclist. This is not a decision or action, rather a pressure exerted, over an extended period of time, that may have contributed to the recreational use of amphetamines, to the use of excess speed, or to a higher level of distractedness, all factors that could have contributed to the loss of vehicle control. In the Accimap above we did not include this contributory pathway; however, one could argue that inclusion is merited. This points to the balance that must be struck between including the evermore distant and ill-defined influences of family, society, and culture, and those that are distal, yet directly relevant in terms of road safety research, and policy and intervention design.

The skill of the analyst is a factor in this respect; it is not possible to include all factors (the analysis would be unending and therefore meaningless), yet it is important to include those that help researchers and analysts understand causality, and could, in the future, lead to reductions in those types of road traffic collisions. As discussed above, however, this is no different from the current coroner investigation process, whereby all factors that might arguably have contributed to the death must be included (e.g., Dolan, 2016).

2.1 | LIMITATIONS AND FUTURE WORK

There is often no correct or incorrect choice concerning the inclusion (or omission) of certain higher-order factors, with decisions necessarily involving a level of subjectivity. As discussed above, once one goes beyond the immediate, physical evidence of the collision, a greater level of imagination and intuition is required to identify contributory factors. The immediate, proximal, and distal distinctions we make therefore not only represent the proximity to information contained in the STATS19 database and the coroner’s report, but also the level of confidence it is possible to have in a given factor. Although these two aspects, that is, the proximity to the recorded data and confidence in a factor, are not identical, they are very closely linked. Nevertheless, future work could make this distinction clearer, for example using the coding of nodes in conjunction with the use of dotted or dashed lines to indicate low confidence in connections between those nodes.

Relatedly, the Accimap presented above was the result of the analytical and creative thinking processes of a number of specific individuals, each of whom has their own expertise, experiences, opinions, and way of perceiving and interpreting the world. It is quite possible that an Accimap produced by a different set of individuals (using the same raw data) would show some differences to that which is presented here. This relates to a wider discussion on the reliability and validity of the Accimap method (whether supported by additional heuristics or not), an on-going debate that merits further study. That said, this does not necessarily impact upon the utility of the output for traffic safety; two different representations of the same road traffic collisions can both be useful. To quote Waterson et al. (2017), “In some respects questions centered on the reliability and validity of Accimaps may be missing the point” (p. 500).

This article provides a discussion of, or argument for, the use of systems thinking and Accimaps, in combination with a “why” heuristic, in the coronial process for the study of road traffic collisions; it does not test or apply the approach with the intended user group (i.e., coroners). This is the logical next step to the research. A number of practical questions, therefore, remain, for example, surrounding the impact such an approach would have on the time required to investigate a collision, or the way in which such an approach might be integrated into existing practices. A preliminary, qualitative approach to investigating these, and other issues, with coroner involvement, would be highly useful before embarking on wider testing of the Accimap and whys approach discussed here.

3 | CONCLUSION

This article has presented an argument for the combined use of the Accimap approach to accident (or collision) analysis and a modified version of the five whys technique for the guided analysis and structuring of the results of a fatal road traffic collision investigation process as undertaken by coroners in the United Kingdom. Starting from the immediate contributory factors, situated at the physical environment and road user levels of the system, multiple causal pathways can be explored through the proximal and distal factors that were influential in the failure of the system (i.e., the collision). Using this three-order categorization scheme, and the relatively easily interpreted graphical Accimap, a secondary, complimentary road traffic collision database (in addition to traditional databases populated by police officer-reported data) could be populated from coroner investigations and made public. This would help researchers, policymakers, and intervention designers understand the higher system factors at play, and ultimately offer more wide-reaching, systemic safety improvements to the road transport system.

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