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Published online: 14 Sep 2020.

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Progress and prospects for data-driven coordinated management and emergency response: the case of Ireland

Aoife Delaney [a] and Rob Kitchin [b]

ABSTRACT

Internationally, there is a drive to make coordinated management and emergency response (CMER) more data-driven and centralized through shared data infrastructures and control centres. While there are a few well-known case examples of data-driven CMER, in general it has been partially implemented. In this paper, we highlight the importance of historical institutional and spatial context and path dependencies in shaping the development of CMERs within and across jurisdictions. We examine the progress and prospects of data-driven CMER in Ireland, with respect to the general landscape of inter-agency cooperation and with reference to a single key agency: An Garda Síochána (AGS), the Irish police force. To do so, we draw on 36 in-depth interviews with key stakeholders and a critical discourse analysis of 15 key policy/guideline documents. Our analysis reveals the ways in which embedded institutional cultures, structures and working practices, which are relatively resistant to change, have thwarted data-sharing and data-driven analysis and decision-making. These factors act as barriers to the adoption of smart-city approaches more generally, not just in Ireland but globally.

KEYWORDS
coordinated management and emergency response (CMER); big data; smart cities; all-hazards approach

INTRODUCTION

Coordinated management and emergency response (CMER) to natural (e.g., earthquakes, tsunamis, hurricanes) and people-made (e.g., terrorism, pandemics) events involve a complex, multifaceted network of institutions working together to tackle unfolding circumstances. As well as managing operational concerns, CMER seeks to support tactical application through predictive modelling, scenario-building and simulations to create policy interventions designed to minimize occurrence and disruption, and devise mitigation tactics for different kinds of events, along with training programmes and practical exercises (MEM, 2006; O'Riordan, 1992). The leading framework used worldwide for modern CMER is the all-hazards approach (Gregory, 2015). This approach recognizes local contingencies and the need for tailored place-based responses (Canton, 2013; Marietta, 2012), but also advocates for a hierarchy of generic steps suitable for preparing for

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and responding to all emergencies regardless of the type of event (Adini et al., 2012; Ayyub et al., 2007; Rogers, 2011; Waugh, 2005). The generic steps work to pull relevant institutions together, designate leadership and responsibility depending on the event, and allocate roles and operational procedures. It enables the development of agency-specific responses that are contextualized and coordinated within broader local, regional and national plans. As such, the approach enables effective coordinated response that is efficient in terms of time, resources and cost, reduces duplication or misalignment of effort, and minimizes conflict and misunderstandings between response agencies (Gregory, 2015; Waugh, 2005). In particular, the all-hazard approach seeks to breach the institutionalized and siloed nature of some agencies by sharing knowledge, building trust and developing a common understanding of their roles and responsibilities through formal networking and inter-agency training before events.

While the all-hazards approach has its advantages, it is also critiqued from several perspectives. For some, the approach is too generic and universal, implementing a technocratic approach that lacks contextual sensitivity to event and place in its mitigation tactics (Godschalk, 2003). All-hazard response plans can also be overly tailored for specific kinds of common events, lacking contingencies for rarer occurrences (Waugh, 2005). The technocratic, instrumental nature suits most traditional response agencies, which are often strongly hierarchical and institutionalized with formal procedures and practices, but creates an approach that limits interaction with and involvement of local communities, voluntary bodies and other agencies (Drabek, 1985). There are often pressures at play both internally (e.g., entrenched organizational structures and ways of working; internal politics and competing interests; constrained resourcing and competing demands) and externally (e.g., securing budgets, political manoeuvring, media critique), which mean that institutions resist inter-agency collaboration and can be actively competing for investment and support. Moreover, local and national CMER policy might have limited input from response agencies, being formulated by policy-makers with weak operational experience, creating generic guidelines that are broad, ambiguous, and lack sufficient detail and measures (Waugh, 2005).

In recent years, the increasing use of digitally networked technologies and big data (continuously produced, voluminous data streams that are exhaustive to a system; Kitchin, 2014a) has further reinforced and deepened the technocratic nature of all-hazards CMER. Here, the real-time generation of data about an unfolding event, gathered by response agencies or third parties (e.g., weather networks, social media, utilities, transport providers, data brokers), or workers *in situ* through mobile phones or specialist equipment, can be used to plan and manage ongoing operations (Misra et al., 2020; Thomas et al., 2019). Data and analytics can be shared between agencies or pulled into a centralized system and/or control room to provide greater intelligence and coordination. Such control rooms can be mobile, deployed in the field, using wireless and satellite communications to transfer data and commands. Digitally mediated CMER pulls their development and use into the orbit of the smart city (Hollands, 2008; Kitchin, 2014b) or smart nation (Ho, 2017; Hoe, 2016), in which the governance and management of public services and infrastructures become data-driven endeavours designed to increase safety, security, efficiency, sustainability, productivity, competitiveness and quality of life (Kitchin, 2014b).

Here, data-driven CMER work extends and complements more traditional, routine agency work that has also become more digitally mediated (e.g., predictive policing, digital surveillance, traffic control, environmental sensor networks, performance management), often managed within control rooms. Indeed, such agency control rooms often double up into CMER spaces during an event. For example, for a local emergency within the bounds of Dublin City Council, the traffic control room has adjoining meeting rooms to create a shared hub for CMER. In Rio de Janeiro, Brazil, the Centro de Operacoes Prefeitura do Rio (COR) is a shared inter-agency control room for everyday management of the city, as well as acting as a CMER when required. It coordinates real-time data streams from 32 agencies and 12 private concessions (e.g., bus and electricity companies), including traffic and public transport, municipal and utility services, emergency and

security services, weather feeds, information generated by employees and the public via social media, as well as administrative and statistical data (Luque-Ayala & Marvin, 2016). However, each agency located in the COR is autonomous and continues to maintain its own control room, operative systems and response protocols, with the COR providing a site of coordination and horizontal integration (Luque-Ayala & Marvin, 2016). In the case of New York, the Office of Emergency Management (OEM) is housed in a purpose-built 65,000-square-foot facility in Brooklyn and it hosts a Watch Command Center that utilizes a Citywide Incident Management System (CIMS) (Smith, 2006). The building includes a suite of operational and training rooms, including workstations for 130 agencies (from city, state and federal bodies, plus non-profit entities and private sector partners), video conferencing, secure communications, several large video displays, and back-up power generation, as well as a Joint Information Center for media communications during an emergency. As such, it draws together and shares real-time data from across the city and in return directs responses.

While the move towards data-driven CMER is already underway globally, it is also clear that its adoption is highly variable across locales and its implementation often limited, piecemeal and ad hoc. As Kitchin et al. (2017) detail, there is a notable adoption gap in smart-city technologies, with agencies only partially investing or actively resisting new developments due to funding and capacity issues, internal institutional factors, incompatibility with legacy systems and a lack of mature, proven solutions. In addition, Kitchin and Moore-Cherry (2020) highlight the role of fragmented governance arrangements between agencies and jurisdictions. In cities composed of many local municipalities, there might be multiple instances of similar agencies. For example, Metropolitan Boston is made up of 101 autonomous towns and cities; there are 101 police and fire departments, along with 101 of every form of municipality department, with limited coordinated collaboration between them. The result is a highly fractured and uneven deployment of a data-driven smart city (Kitchin & Moore-Cherry, 2020).

In this paper, we examine the progress and prospects of data-driven CMER in Ireland with respect to the wider inter-agency landscape and with reference to a single key agency, An Garda Síochána (AGS), the national police force. Ireland is a relatively small country with a population of 4.9 million people, and much of its emergency management and policies are organized by a set of national bodies. Traditionally, organizations would have acted independently and there would have been little data-sharing. Data are a key component of the AGS's everyday work in terms of managing operations, conducting investigations and preparing cases, and the AGS is often central to addressing any emergency-related event in the country given its mandate with respect to safety and security. However, while data are a vital element of their work, the organization is far from being data driven. Moreover, it has historically operated independently, largely shunning inter-agency cooperation. We concentrate on one agency to provide an in-depth examination of the factors that limit an organization's ability to function effectively within a data-driven CMER (which are largely replicated across other Irish response agencies).

Our analysis is informed by an understanding of CMER as an assemblage of agencies, institutions, technologies, processes and policies that are shaped by a suite of internal and external factors contextualized by culture, histories and geographies. Assemblage theory is a live debate in geography (Anderson et al., 2012; Dittmer, 2014; Muller & Schurr, 2016). In contrast to the notion of an assemblage being a flat network of different actors and actants operating through distributed power, as posited by McFarlane (2011a, 2011b), or a formally structured, hierarchically configuration of entities with defined power dynamics, as detailed by Brenner et al. (2011), we understand an assemblage to be more fluid, being built on-the-fly within established and evolving procedures, and oscillating between flat and hierarchical positions depending on circumstance. The type of crisis and its scale, along with varying context, means that assemblages metamorphize under different conditions and expected outcomes, and are enabled or constrained by formal and informal factors such as governance and legal arrangements, policy, inter-agency trust and

compatible infrastructures (Dittmer, 2014). As a crisis emerges, the configuration and nature (flat or hierarchical) of a CMER assemblage oscillates and evolves as elements are repositioned, deterritorialized (move out and/or replaced/exchanged) and reterritorialized (elements move in and/or replaced/exchanged for others) to deal with different situations and priorities (Delaney, 2019). As a result, the structure and operations of CMER assemblage for a weather event can be constituted quite differently for a terrorist event, despite consisting of the same set of responding agencies.

Our analysis is rooted in a study of CMER in the Irish context that consisted of 36 in-depth interviews with key stakeholders, including the Office of Emergency Management, National Directorate of Fire and Emergency Management, AGS, National Ambulance Service, Dublin Fire Brigade, Civil Defence, Irish Defence Forces, Health Service Executive (HSE) and Red Cross. This was complemented by a critical discourse analysis (CDA) of 15 key policy/guideline documents, including: the *Framework for Major Emergency Management* (MEM, 2006); *A Guide to Flood Emergencies* (MEM, 2013); *A Guide to Severe Weather Emergencies* (MEM, 2010); *A Guide for PRA Local Competent Authorities* (MEM, 2015); and a *Multi-agency Protocol* (MEM, 2016). CDA is a branch of discourse analysis, developed in the 1980s, that views language as a social practice and examines 'power and inequality in language' and how language is used within certain social contexts and in the construction of societal, political and cultural ideologies (Blommaert & Bulcaen, 2000, p. 447; Gee, 2004). Each document was carefully read and coded multiple times, guided by a set of questions designed to explore critically the thinking, beliefs, aims, practices, policies, power relations and intended outcomes within the documents. At times, the case material is compared with the situation in Boston, which formed a comparator case study composed of 15 interviews and a review of 10 policy/guideline documents. As this introduction illustrates, CMER is a field littered with acronyms, which are all defined in Table 1 as a reference guide.

THE IRISH CMER LANDSCAPE

Irish Emergency Management policy was relatively undeveloped until the production of the 'Accident Plan' in 1974, which detailed procedures for declaring emergencies and coordinating procedures across the different emergency service organizations (McMullan, 2010). Subsequent new policies, guidelines and practices usually occurred in the aftermath of major crises, leading to the development of more structured emergency management plans. The Buttevant Rail Crash in 1980 led to a new Major Accident Plan and Guidelines (O'Riordan, 1992), and the Stardust Tragedy of 1981 led to all local authorities having to develop emergency plans. Heavy blizzards in 1982 led to the drafting of a Framework for Co-ordinated Planning for Major Emergencies, the first major inter-agency framework for Ireland, leading eventually to the Department of the Environment being assigned the lead agency for emergency management within the Irish State (McMullan, 2010; O'Riordan, 1992). This framework did not take a comprehensive hazard analysis approach, though it did lead to all agencies producing emergency plans. This was replaced by the Framework for Major Emergency Management (MEM) in 2006. Several events since then, such as large-scale flooding in 2009 and 2011, and terrorism events across the globe have led to revisions to its auxiliary guidance and protocols documents.

The Irish CMER consists of an assemblage of first-responder agencies, government departments, voluntary agencies and private enterprises working within the protocols and institutional arrangements of the MEM framework. The framework provides a general overview of the procedure and steps of action to be taken by each principal response agency (PRA) (i.e., local authority, HSE and AGS), utilizing the all-hazard approach, while also providing limited direction as to how external agencies, such as voluntary services, work alongside the PRAs (MEM, 2006). It sets out guidance on declaring a major emergency, inter-agency coordination, command and control, sharing and use of resources, and allocation of responsibility (MEM, 2006).

Table 1. Acronym's used and their definition.

Acronym	Definition
AGS	An Garda Síochána (Irish police force)
BRIC	Boston Regional Intelligence Centre
CCTV	Closed-circuit television
CDA	Critical discourse analysis
CIMS	Citywide Incident Management System
CMER	Coordinated management and emergency response
COO	Controller of operations
COR	Centro de Operacoes Prefeitura do Rio
COVID-19	Disease caused by the coronavirus SARS-CoV-2
CSO	Central Statistics Office
DHPLG	Department of Housing, Planning and Local Government
EOC	Emergency operation centre
ESB Networks	Electricity Supply Board Networks (national energy supplier)
GDPR	General Data Protection Regulation
GIS	Geographical information system
GSAS	Garda Síochána Analysis Service
HSE	Health Service Executive
I2	GSAS's self-designed data analytics tool
MEM	Major emergency management
OEM	Office of Emergency Management
PRA	Principal response agency
RIC	Royal Irish Constabulary (Irish police force pre-independence)
WebEOC	The United States online emergency operations centre and crisis management system

Formally, the Irish CMER assemblage is hierarchical with clear networks of power, with most everyday emergencies and local major emergencies being dealt with by first-responder agencies and, depending on the event, their bureaucratic parents (e.g., the National Ambulance Service (Child) and Health Service Executive (Parent)). The PRAs are the designated lead agencies at the local and regional scale, with each being pre-assigned certain events in which they take the lead. For instance, the local authorities take the lead for flooding, AGS take the lead for terrorism and the HSE for health-related incidents. The framework principally establishes a hierarchy and directs cooperation with respect to specific events, with each PRA responsible for developing and establishing their own protocol of procedures for dealing with a range of emergencies, and each agency retains full operational power and control over their own resources. Rather than breaking down silos, such an arrangement seems to reinforce them, and enables agencies to internalize and use the framework as they see fit given their own culture and priorities. As such, our respondents noted that the framework was designed to paint over inter-agency conflict rather than directly confront and nullify it. More problematically, agencies acknowledged some communication channels appear to be closed: for example, a member of the Civil Defence claimed that the Department of Housing, Planning and Local Government (DHPLG), in which the MEM is located, did 'not talk to them'.

Local emergencies can be escalated to a regional or a national scale depending on the geographical distribution and scale of the event. Theoretically, each scale has its own teams and groups, with every agency represented at each scale. In practice, however, there is a slippage

between scales with a more informal co-locating of agencies and departments in a flatter decentralized manner (Delaney, 2020). Moreover, there is confusion and contradiction in the CMER assemblage and its bureaucratic organization. For example, at the national level, The Office of Emergency Planning, the National Steering Group, Inter-Departmental Working Group on Major Emergencies, and Task Force for Emergency Planning all have similar status and performative roles, and several government departments have an emergency response remit (e.g., DHPLG; Justice and Equality; Defence; Health; and Taoiseach (Irish Prime Minister's office)).

Such slippage and confusion, along with agency autonomy with respect to plans and control and closed or inefficient communication, can lead to inefficiencies in facilitating inter-agency cooperation. Indeed, the relative position of agencies within the CMER hierarchy can cause splintering effects which can have an impact on major emergencies (emergency services representative). In addition, there might be jurisdictional issues around an event; for instance, it crosses the border of several AGS divisions or local authority boundaries. This is usually resolved by assigning a controller of operations (COO) based on the situation, skill and appropriate level, or the first rostered senior officer on site. Moreover, there are 32 local authorities, four AGS divisions, 92 HSE ambulance bases and nine community health regions (HSE, 2018; An Garda Síochána, 2019), meaning that regions of governance are misaligned, with inter-agency coordination working across different scales and geographies. This also has implications for the siting of coordination centres, of which there are four types – on-site coordination (in mobile units), local coordination off-site (in pre-assigned hotels or offices), crisis management teams, and national coordination centres – with different constituencies expected to be present at each. The COO and centre have important roles in decision-making, organizing resources, ensuring coordination, maintaining communications, activating information management systems and creating activity logs. Depending on the situation any escalation from local to regional to national scale can result in local centres working in tandem or being closed.

With respect to producing data-driven CMER, each agency is responsible for its own digital technologies, data infrastructure, data standards and protocols, and data-sharing policies. As Kitchin and Moore-Cherry (2020) note for Boston municipalities, this fragmented, autonomous approach can lead to a lack of interoperability between systems and the production of data ontologies that cannot be merged. Each agency might be producing and using data to guide their response to an event, but each can only be viewed and analysed in isolation. Without a common data architecture, coordinated data-driven emergency management will be at best partial. However, achieving such a common approach will be difficult with present institutional and jurisdictional arrangements that also hinder collaboration. Even if there is political will at a governmental level to pursue a coordinated strategy to address deficits, there are significant issues within agencies that will also need redress, which we now explore through an examination of AGS, a key Irish PRA.

CASE STUDY: AN GARDA SÍOCHÁNA

The evolution of An Garda Síochána (AGS) is marked by its colonial heritage and practices. Its creation was a direct result of Ireland's independence, replacing the colonial police force the Royal Irish Constabulary (RIC), a highly centralized force, in 1922. Much of its staff, structures and procedures, as well as the law to which it policed, remained in place. Over the course of nearly a century of operation, AGS has been a respected police force worldwide as a (mostly) unarmed force. They have been regularly lauded and praised by the Irish government and yet they have also been subject to public, political and media scrutiny regarding their practices of promotion, treatment of women, operations during the Troubles, dealings with the Catholic Church, ignorance of the conditions and practices of the Magdalene Laundries and other institutions, and the governance and culture of the force, to name but a few (Conway, 2014).

AGS is viewed as a somewhat insular institution that operates largely independently of other agencies and has been resistant to change management regarding culture and structures. The most recent change to the structure and organization of AGS was the Garda Act of 2005 that introduced neoliberal new public management practices that included the use of performance indicators, which have since infiltrated all aspects of the force (Conway, 2014). As part of this transition, the Garda Síochána Analysis Service (GSAS) was created in 2007, which included the hiring of professional civilian personnel. Before this, data analysis was conducted on an ad-hoc basis by Garda staff. GSAS has sought to professionalize internal data services and analyse data to inform operational and strategic decisions across the organization. Since its founding, GSAS has grown slowly due to 'the recession and the economic crisis', but has developed 'to about 45 people' (ID33). At the time of our interviews, it was planning to launch a recruitment campaign for another 25 staff. Yet, the scale of GSAS is small in comparison with the overall size of AGS and its operational scale. Staffing restrictions have no doubt been a barrier to the development of data infrastructures and data analytics within the organization, as well as limiting capacity for inter-agency cooperation, but there are three other significant barriers identified by our respondents that constrain involvement in data-driven CMER.

## Barrier 1: Data and control room infrastructure

To date, AGS priorities with respect to the creation of data infrastructures have been focused on the Pulse system that is used to manage its investigations, rather than on a broader operational data infrastructure that might be suitable for inter-agency CMER. Pulse data are highly sensitive, confidential, cannot be shared with third parties and operate as a 'closed wall system' (ID35). It is not integrated with other AGS computer systems, such as computer-aided dispatch. Both Pulse and computer-aided dispatch are narrowly designed as data input and retrieval systems and cannot be easily repurposed for secondary use. For example, it is difficult to aggregate data to create crime statistics or to produce data to guide operations. Both systems actively limit access to relevant officers and the volume and type of data that can be retrieved (about 50 records maximum) for data-protection purposes. The limited data that can be extracted use proprietary formats, which along with restricted indexical data limits data interoperability and matching with other systems. Further, there is a lack of clarity of the data lifecycle from creation to deletion, and its journey through its intersections, replications and mutations, that can provide context to inform how data are used. In order to interrogate the Pulse data, GSAS has had to build their own investigative tool called I2, though its analytics are limited.

Without a radical overhaul of their data infrastructure, AGS will remain a siloed agency in data cooperation terms with limited potential for real-time inter-agency sharing. This is evident in the extent to which AGS participates in CMER coordination centres/control rooms during emergency events. In such cases, information is shared via phone or around a table and is inputted on to whiteboards (Figure 1). In fact, all agencies in Ireland are following this analogue procedure, as described by ID05:

> Well, we use the same thing for managing a system, we use a system called Information Management and we use that so that people can break down large chunks of information and analyse it and make evidence-based decisions on that. It is a system on four boards that all agencies are trained on now and it is a very effective tool.

The interviewee continues: 'We tried it electronically, but it just didn't work.' As a consequence, in Ireland, there is no digital platform for the management of data or the sharing of information during an emergency. This is compounded by strong resistance to its introduction, as described by ID26: 'Our four-board system is really at the core of this [CMER] … [all] it needs is a black marker [pen] and you could run Ireland. And that is what we have done.' Here, there is
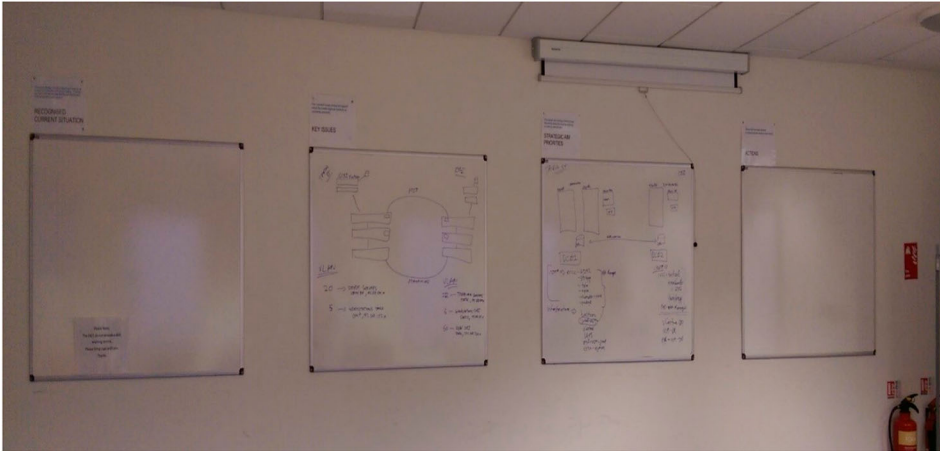
Figure 1. Four whiteboards in a local coordination centre.
Source: Authors.

a belief in not getting lost in the data, drawing out the high-level information and keeping it tangible, and maintaining strategic decision-making and action. The key function of the coordination centre/control room is collective discussion and negotiating a common message and response. The emphasis is on following established protocols not reacting on an ad-hoc basis to data flows. In other words, even if AGS were willing to collaborate on a shared data infrastructure, there is no present programme to which to contribute.

In contrast to the limited data infrastructure and analogue CMER sharing in Ireland, other jurisdictions are moving towards data-driven policing and CMER. In the case of Boston Police Department, they have their own data infrastructure for internal use, with some data being selectively made available to other agencies. In addition, the Boston Regional Intelligence Centre (BRIC) control room uses digital platforms connected to city cameras, sensors and other technologies to ensure the quick sharing of information and a more efficient response during an event. At the wider CMER level, WebEOC, an online emergency operations centre and crisis management system that supports the sharing of real-time information between agencies concerning resources and other response mechanisms, is used. WebEOC creates a seamless flow of information from senior officials in the control room to operational staff on the ground. All agencies in the Emergency Operation Center (EOC) can follow and contribute to inter-agency developments through the WebEOC. Data-sharing does not, however, denote data interoperability, though WebEOCs generally seek to match and integrate data from across agency systems where possible. However, the lack of common data standards and formats across agencies remains a significant barrier to conjoining data which would enable a more integrated analysis. While the shared data do not drive response in a linear, technocratic way, they do provide contextual information to inform collective decision-making. As interviewee IDG stated: 'If everyone is trying to use the same tools we can have the same operating picture.' In the Irish case, such a picture is only shared through the four whiteboards and discussion amongst those in the coordination centre.

Barrier 2: Data quality

Beyond the infrastructure for enabling agency collaboration, there are concerns regarding the quality of the data that might be shared if a collaborative infrastructure existed. With respect to AGS, for example, the data quality of crime statistics produced by I2 has been questioned (Garda Inspectorate, 2014) and internally acknowledged by our interviewees:

> Now, the quality issue is a big one. Once data was actually being entered into the system, I don't think people thought about the quality element of it at all. And I think the quality issues have really begun to emerge over the last few years to a greater extent because of what we do here. All of a sudden, we are now churning data at a rate of knots, we are not looking at 10s of records, we are looking at 100,000s of records.

In 2014, crime data analysis was suspended and placed under review by the Central Statistics Office (CSO) (n.d.). Since 2015, the data have been published with the guidance 'Statistics Under Reservation', with the CSO working with AGS to improve data recording and statistics production. The statistics were suspended again briefly in 2017 due to issues with homicide data (CSO, n.d.). Part of the reason behind this lack of quality is 'because of the way the data is structured or the way that the data is completed', which is compounded by 'the organisations' … poor data governance' (ID33). Crimes are recorded in relation to the police stations that handle them, rather than the location they are committed (with some stations specializing in some crimes), meaning that when mapped, the data provide a false impression of the distribution of crimes. There are also issues in the standardization of data entry, with some police officers recording the same incidents in slightly different ways, and timeliness of recording. In addition, there are suspicions of falsification of some data. For example, in a high-profile example, AGS revised the number of breathalyser tests performed between 2012 and 2016 down from 2 million to approximately 0.5 million (Gallagher, 2017). While part of the discrepancy between claims and reality was administrative error and careless data recording, it is also clear that there was deliberate inflation of the numbers to make it appear that more was being done to tackle road safety. This is further compounded by weak data governance, meaning it is not straightforward to ensure that officers follow protocols designed to improve data quality. There seems little appetite to improve data governance and the drive to improve data quality is largely coming from outside the organization. Not unsurprisingly, there are trust issues across other agencies with using AGS data.

Barrier 3: Resistance to change and data protection

As the discussion of barriers one and two intimates, there is resistance to change with respect to data-driven policing and CMER within AGS and across the CMER assemblage in Ireland. Rather than overhaul their data infrastructure to build a fit-for-purpose system and improve data quality, the AGS solution has been to build an additional, limited system (I2) to salvage what can be from the existing Pulse system and to improve data reporting while doing little with respect to data governance and recording. At the CMER level, the attitude seems to be that the four-board system works, that the key to efficient event coordination is following protocol, managing inter-agency interactions and maintaining a common approach, accompanied by a belief that technology will not improve those processes. Indeed, our experience was that there was a lack of interest or understanding of the benefit of a system such as WebEOC. Moreover, there is a general reluctance to share data which is rooted in the siloed and independent growth of CMER agencies and the absence of 'a culture of sharing data' (ID33), with data being 'locked down [and] inaccessible' (ID16). Similarly, ID35 notes:

> Some agencies feel that they have ownership, complete and total ownership of the dataset and releasing it or anything like that for collaboration feels like we are giving away the farm as it were. They no longer have control over this data.

In addition, bureaucratic and legal restrictions concerning data protection can hamper data-sharing. As ID35 stated:

Sometimes it is very hard to find complete datasets. … For example, the ESB Networks, it took six months of legal back and forth to get power line information just to put it on the map to stop the helicopters crashing into power lines. The big problem was [that] it was the HSE requesting it and they had to make sure in legal terms that the HSE would not use census data or other data to start comparing health conditions with location or proximity with power lines.

Data protection is a key concern in Ireland hindering the ability for CMER agencies to share data because 'within an Irish context, I think there is a greater concern about the whole issues around data and data protection and so you can't share, it has been impossible to share data at an individual level'. This is further influenced by the presence of a 'very firm data protection commissioner who probably enforces the rules quite strictly' (ID33).

While agencies are reluctant to engage in data-driven CMER, all recognize that they are collecting huge volumes of data that need to be protected by law, each preparing their own data-protection plans under the General Data Protection Regulation (GDPR). However, ID31 explains that regardless of the parameters set regarding the ethical use of data, the PRAs such as AGS should be able to adequately share data, even vulnerable and identifiable data, if it is for the common good, especially if data protection is already being breached during an event (e.g., via social media); an argument presently being put forward regarding patient confidentiality versus community protection in light of COVID-19 (Clarke, 2020). Thus, ID31 states that they 'would have absolutely no hesitation saying we should share that information' in a system that would allow data to be shared but the access tracked and audited. At present, such a relaxing of data protection rules are unlikely to occur and act as a convenient argument for why data-sharing should not proceed.

DISCUSSION

Our analysis highlights the partial and piecemeal approach towards a data-driven CMER in Ireland, at both a countrywide and an institutional scale, and the issues and barriers that have limited more sustained progress. What is clear is that Ireland appears to have been particularly resistant to adopting data-driven CMER. The reason for this slow adoption lies in the historical context and path dependencies of CMER development in the country, shaped by a siloed history of institutions post-independence, but also its relative poverty up to the 2000s, the relatively few large-scale disasters requiring management, and its postcolonial attitude to the use of data by states.

After independence, Ireland struggled to create a thriving economy. In 1987, it was the second poorest country in the European Union, with high unemployment, interest rates and emigration (Breathnach, 1998). Most parts of the public sector had been under-funded for decades and there had been limited investment in state apparatus for managing emergencies. The Celtic Tiger economy of the 1990s led to a large change in the country's fortunes and a significant investment in public infrastructure initiatives, including emergency services (Kitchin & Bartley, 2007). However, the financial crash of 2008 led to a severe fiscal crisis, strong austerity measures and a lack of investment at the point where data-driven CMER was becoming viable. Budget cuts across the public sector often reinforced boundaries between institutions, which sought to protect their own roles and assets. In addition, there has been little social and political pressure for extensive data-driven CMER infrastructure given that to date the country has experienced few natural or people-made events that have led to significant disruption or loss of life. The predominant use of CMER in recent years has been for storm and flood events that pose some threats but are relatively straightforward to coordinate. Given the lack of major terrorism events, Ireland lacks the dense security infrastructure of other countries.

As a postcolonial state with strong memories of imposed data and governance regimes by the British, there is a general concern in Ireland with respect to state surveillance, privacy and data misuse, and apathy to creating data-driven government and agencies. For example, there has been public resistance to the Public Services Card, which is a de-facto ID card, since it was first introduced in 2011. Surveillance technologies and data systems are only generally implemented if required operationally to deliver a service, and even then they might be configured to the lowest levels of intrusiveness and their use curtailed. For example, the closed-circuit television (CCTV) footage from the traffic management system in Dublin is not ANPR-enabled (automatic number plate recognition scanning) and is not recorded or put to secondary use by the local authority, although AGS do have access to it. Data protection, including data minimization that limits data use to the purpose for which it was generated, is strongly enforced. Moreover, the cornerstone of much CMER, geographical information systems (GIS), is under-developed and underused compared with other states due to the paucity of georeferenced data. Ireland was the last country in the Organisation for Economic Co-operation and Development (OECD) to introduce postcodes in July 2015 and its adoption has been patchy, meaning most administrative data sets lack spatial precision that makes it amenable to mapping. Consequently, there is little appetite within state institutions or amongst the public for data-driven governance technologies, plus little finance available to invest in such systems.

That said, there has been a weak push for stronger inter-agency and inter-jurisdictional coordination since the 1970s, and CMER has become progressively more organized across institutions and jurisdictions. This development is uneven in respect of both locales and agencies. For example, the inter-agency organization in Cork is more pronounced, with stronger levels of cooperation and coordination of operations. While some institutions are open and keen to collaborate, such as some local authorities and Met Éireann, others such as AGS participate in a more distanced and reserved manner. As other countries move towards stronger use of data, Internet of Things (IoT) enabled public infrastructures, and data analytics within agencies, and data-driven CMER that span agencies, pressure will undoubtedly be placed on the Irish system to adapt. Such adaptation, however, will be slow if it is optional rather than mandated by policy. Moreover, while data-driven CMER could aid in addressing the structural and institutional issues shaping CMER more generally in Ireland, it will not solve these issues. The use of a platform such as WebEOC would encourage/force agencies to begin to share real-time information and potentially could begin to break down institutional barriers. It would also speed up inter-agency information sharing and decision-making, and communication across operational staff on the ground and the public. However, Irish PRAs and other CMER agencies will need a structural, institutional and information technology (IT) overhaul before they can embrace the benefits of platforms such as WebEOC, inter-agency data-sharing and integrated control rooms. It also needs to tackle issues such as data quality. Part of this overhaul would require change management in attitudes to collaboration and the breaking down of siloed chains of command. As one of our interviewees stated, what is required is a change in:

> the culture of the organisation. You actually have to try and shift people's ways of thinking. When you start shifting peoples' ways of thinking that is when they will absorb and take on a data-driven approach. So that is where you have to spend a bit of time sitting, listening, understanding what their dilemmas, what their problems, what their issues are. And then feed information, tailor that information to their problems. (ID33)

At present, Ireland's strategy for developing a stronger use of data within CMER is encouraging adoption rather than demanding change; the hope is that 'as one agency shows the benefits, more will follow with time' (IDM).

While there has been a more concerted effort to create coordinated, data infrastructures and command centres elsewhere, it is important to note that the Irish case is far from unique. The kinds of coordinated EOM command centres in New York, Boston and Rio de Janeiro are relatively uncommon (though separate agency control rooms are more common). The siloed histories and path dependencies of agency structures and working practices, the intransigence of institutional cultures, the reactive policy responses to specific events, and diverse implementation barriers that affect Irish institutions shape the CMER landscape in many jurisdictions. Moreover, data quality and data interoperability issues are significant barriers to creating integrated data infrastructures, and are not easily resolved given institutional and political reluctance to cooperate (Kitchin & Moore-Cherry, 2020). As such, while the all-hazards approach is common across many countries – including Ireland – the structure and operation of CMER in every jurisdiction varies depending on its historical context and unfolding. For example, within the United States there are many cities with limited data-driven CMER, especially smaller sized cities rather than large metropolitan areas. Further, similar coordination issues across jurisdictions and scales (local, regional, state, federal) are evident in the fractured approaches to large-scale events such as 9/11 and the Boston Marathon bombings, and the Katrina and Sandy hurricanes (AAR, 2014; Bevc et al., 2009; Boyle, 2015; GAO, 2006; HHSCR, 2014; Powell et al., 2012). Likewise, across Europe, there is a variable level of coordinated, data-driven CMER, from large cities with a history of terrorism events – which have a denser network of real-time data generation across infrastructural systems and more developed plans and responses based on know-how and necessity – to smaller more remote locales which have relatively less capacity, infrastructure and experience.

In seeking to understand the adoption of data-driven CMER it is important, in our view, to recognize the historical and spatial context that has shaped the development and present configuration of coordinated management and emergency response within and across jurisdictions. Often the media and academic literature focus on lighthouse examples of best in class and good practice – those that are at the forefront of adopting and deploying new technologies and practices and implementing new institutional working arrangements. Or, they focus on absence and critical failures, where responses to emergencies have been partial and uncoordinated, leading to severe consequences such as large-scale property damage or deaths. More absent from the discussion is the middle ground or long-tail; those cases where there is a functioning CMER approach that has strengths and weaknesses, which produce suboptimal outcomes, but nonetheless produce adequate responses. Ireland, as does most other jurisdictions, fits into this category. It has a functioning set of inter-agency structures, policies and protocols that are deployed to tackle emergencies, but also has a set of institutional and structural weaknesses, and it is not well set to move to the adoption of data-driven CMER. The kind of contextual analysis we have undertaken enables us to understand the diverse ways that CMER is constituted and deployed in practice.

CONCLUSIONS

In recent years, there has been a move globally towards data-driven CMER, with the adoption of multi-agency control rooms, data-sharing protocols and facilities between institutions, and the use of data analytics to help guide operational decision-making. Such data-driven coordination often falls under the rubric of developing smart cities and communities, in which there is a general turn to digital technologies to aid the management and governance of public services and infrastructures. Some jurisdictions have invested heavily in building new EOC, equipped with a variety of digital systems and underpinned by new real-time data architectures, and reconfiguring associated institutional and structural arrangements to facilitate inter-agency cooperation. Most others have made more modest investments as they grapple with assessing how best to reorganize their CMER, which technologies and work practices to adopt, and tackle barriers across and within the CMER system that hinder progress. The result is that while the all-hazards approach remains the

predominant means to prepare for and respond to emergencies, how that approach is implemented is highly variable across jurisdictions.

In this paper, we have examined the progress and prospects of data-driven CMER in Ireland with respect to the general landscape of inter-agency CMER and with reference to a single key agency: AGS. Our central argument has been the need to frame CMERs as assemblages and to understand them in historical and spatial context. CMER consists of an evolving and fluid constellation of agencies, institutions, technologies, processes and policies that are translated in messy ways from planned configurations in policy and framework documents into complex institutional arrangements and working practices that mutate and de- and reterritorialize as events unfold. They can remain local or extend/shrink across scales, and power can be distributed or concentrated and vary in form across elements and scales. The Irish CMER is neither a flat network of actors and actants nor a rigid, formalized hierarchical structure, but rather oscillates in nature and form depending on circumstance and event. And as the Irish example highlights, the emergence of an effective assemblage can be thwarted by a variety of institutional and political barriers that seek to maintain silos and weaken collaboration. The result has been to limit the pursuit and adoption of data-driven systems.

The weak CMER assemblage and strong institutional barriers are rooted in the historical development and wider political economy of the Irish state. Ireland is a postcolonial nation, with the civil service, some parts of the public sector and the police service inherited from the British regime operating before independence in 1922. It was also a relatively poor state until the emergence of the Celtic Tiger economy of the 1990s, with relatively under-developed public services compared with Northern Europe, much of which has been delivered through separate agencies, semi-state bodies, the Church and charities (Kitchin & Bartley, 2007). Together these have created a siloed landscape of protectionist bodies seeking to defend their independence and resources, which are averse to surveillance and data-driven governance. The result has been a set of embedded institutional cultures, structures and working practices that have produced and perpetuated institutional barriers which have proved to be relatively resistant to change. Together, these factors and barriers have thwarted the development of a data-driven CMER. Progress will continue to be slow unless there is significant institutional/political *and* practical/technical change that ruptures existing path dependencies. On the one hand, this requires a top-down diktat, significant resourcing, change management, capacity-building and new governance arrangements, and, on the other, considerable investment in developing a suitable CMER data infrastructure and addressing issues such as data and system interoperability. Given continued austerity and resistance to change across institutions and scales, this is unlikely to change in the near future. Consequently, the benefits of integrating and sharing data and analytics will be unrealized, instead relying on the analogue four-boards and protocol approach.

Contrary to the celebrated and emblematic cases of Rio de Janeiro and New York, the Irish case reveals the difficulties and contingencies of developing data-driven CMER. Other countries are likewise grappling with implementing a data-driven approach within their own historical context and path dependencies. However, we know little about the adoption of data-driven CMER across jurisdictions, nor how the drive to make CMER institutions more data-driven is playing out within organizations. We, therefore, advocate for similar studies that map out the wider CMER landscape, chart the barriers that institutions face in becoming data-driven and in cooperating with others, and details resistance to change. This research would provide grounded, empirical evidence of the diverse ways in which CMERs are being transformed (or not) by data-driven technologies within context. This evidence would provide an understanding of how CMERs are evolving and highlight points of convergence and divergence between jurisdictions and potential lessons and paths forward for those seeking to progress their endeavours. Certainly, there is much for Ireland's CMER community to learn from other jurisdictions about utilizing data resources to supplement and guide protocols.

ACKNOWLEDGEMENTS

DISCLOSURE STATEMENT

FUNDING

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