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Data for Ambulance Dispatch

New & emerging forms of data to support the London Ambulance Service

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EXECUTIVE SUMMARY

How data can improve ambulance service delivery

Every year the London Ambulance Service (LAS) handles more than 2 million calls and sends a physical response to more than 1 million incidents. These are Londoners asking for help. Are policymakers doing everything they can to encourage LAS performance?

We live in a time of rapid technological development, which presents opportunities for improving ambulance services. The priorities, risks and challenges involved merit careful consideration. The Data Awareness for Sending Help (DASH) project set out to **establish policy recommendations on the use of new and emerging data sources and technologies for emergency ambulance dispatch.**

Ambulance services aim to respond to emergency medical situations quickly and effectively, providing care and saving lives. Operating in a dynamic and uncertain environment, ambulance services use computers to support 'dispatch'. Dispatch is the complex series of decisions staff take to understand needs and take appropriate action across the whole volume of calls received, from triage to allocation to implementation.

Six new data initiatives to improve dispatch

(see Section 4 of this report on page 36)

This report makes six practical suggestions for initiatives by the LAS and policymakers, listed below.

Altogether, this amounts to a recommendation that LAS develop a **strategic programme to concentrate attention and resourcing on the problem of dispatch improvement, using new data**. This can help alleviate technical and resourcing challenges and complement the Mayor's health equality and Smart London ambitions. Some of our recommendations (such as initiative 5) can be taken forward directly by LAS, while others (such as initiatives 1, 2 & 4) depend on partnership working with stakeholders such as Transport for London and mobile network providers.

Six new data initiatives recommended for LAS

1. Encourage **broader, pan-London connections around the integration of health and social care data, to improve evidence on what works.** *Patients deserve dispatch decisions, including conveyance as well as treatment decisions, which are evidence-based and safe.*

2. Partner with **Transport for London to allow ambulance services to navigate traffic more intelligently.** *Travellers benefit from near 'real-time' traffic data; why shouldn't patients?*

3. Engage with the **London Air Quality Network to help predict demand for ambulance services for those with breathing problems.** *Air quality models can enable improved care for patients with asthma and COPD.*

4. Use **mobile network providers' data and insight to support service effectiveness.** *Aggregate mobile phone location data is used for marketing; why not support ambulances by tracking crowded areas and anticipating need?*

5. Extend the **use of video communications technology to improve triage and remote treatment where appropriate.** *Patients should be able to communicate with LAS by video as well as audio if useful.*

6. Challenge researchers to propose specific ways to **facilitate access to and uses of weather data.** *Can researchers go further to help LAS maintain service levels whatever the weather?*

EXECUTIVE SUMMARY

Journey towards more 'data aware' dispatch

1. Promoting bottom-up innovation based on patient needs (not just performance targets)
2. Partnership working to draw on new data sources

	The world of big data	The world of ambulance services
1	Integrated care datasets	Better evaluative evidence to develop non-emergency care
2	Intelligent transport system data	Improve accurate anticipation of traffic delays
3	Air quality monitoring data	Help patients avoid breathing difficulty crises
4	Mobile phone location data	Improve anticipation of where incidents might happen
5	Video apps	Visual assessment as an option where care may be enhanced
6	Weather forecast data	More intelligent preparation for weather impacts

LAS dispatch already incorporates substantial technological innovation. This should get more attention and investment because of the real opportunities to benefit from more informed decision-making

(see Section 3 of this report on page 24)

The DASH project found significant technological innovation ongoing around the ICT systems used to support the LAS dispatch process. For example, a system called 'Geotracker' is now used to help control room staff make better-informed dispatch decisions including 'Active Area Cover' which is a function designed to ensure real-time ambulance coverage across London.

Dispatch tends to be conditioned by top-down policy (national performance targets) rather than bottom-up innovation. But recent changes to targets through the Ambulance Response Programme (ARP) may relieve some of this pressure, enabling services to consider new data which can be used to improve the quality of decision-making. More informed decision-making can support improvements, including to: the quality of care; its cost-effectiveness; and the equality of provision across areas.

Dispatch effectiveness used to be understood mainly in terms of 'when' (time targets). The issue of 'where' is now becoming increasingly important. The map opposite shows the distribution of ambulance incidents around London over 2016, showing how demand is distributed unevenly. In setting performance expectations (for example, 'non-conveyance' targets), it is important to consider potential consequences carefully – including the risk of exacerbating health inequality.

The bigger picture: data and technology for public services

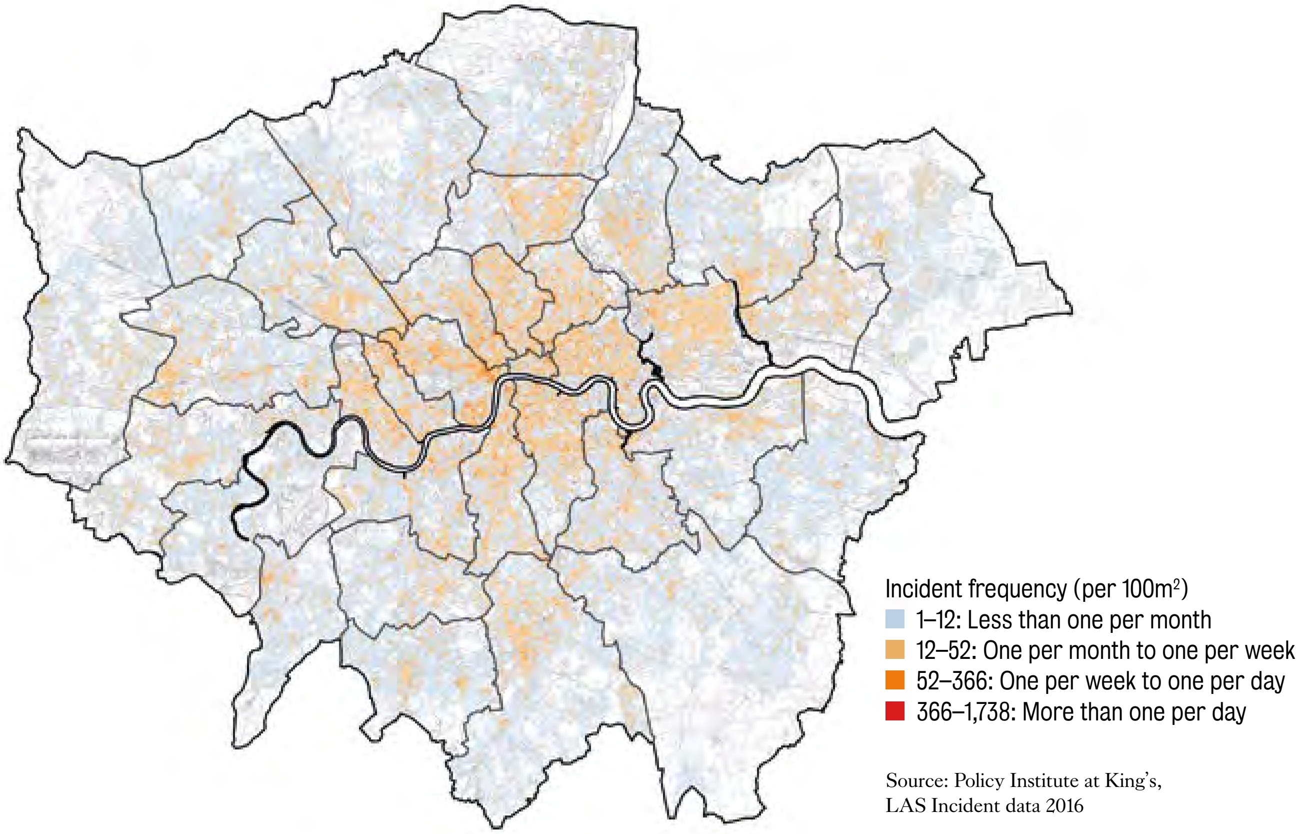
(see Section 1 of this report on page 8)

Making sure that new technologies benefit society is one of the greatest policy challenges of our times. The Mayor of London, Sadiq Khan, has pointed out that there has been a 'dereliction of duty on the part of politicians and policymakers to ensure that the rapid growth in technology is utilised and steered in a direction that benefits us all'.[15]

Digital change in health & care services has proved particularly challenging. But ambulance dispatch is a good example of how better use of data can have an immediate impact on public services because:

- The service already embraces technology (database systems and telephone networks).
- There is significant potential for gains from the 'data deluge' (real-time insight from various sources).
- The benefit provided is widely and readily appreciated (accessible care and saving lives).

Map of ambulance incident frequencies in London over 2016, showing borough boundaries



Source: Policy Institute at King's, LAS Incident data 2016

CONCLUSION: the need for policymaker engagement to exploit these opportunities

(see Section 6 of this report on page 66)

DASH highlights that operating an effective ambulance service needs more than just financial resources and human resources; it is vital to provide and maintain appropriate data and related infrastructure, reaching well beyond the organisational boundaries of LAS. Policies helping LAS to pursue more 'data aware' dispatch could improve effectiveness significantly. Despite the recent tensions between 'big tech' and government, such policies can also help affirm the beneficial effects of technological development by demonstrating positive public service applications. The clearest concentration of policy opportunity and responsibility in London is in local government, with the Mayor and the Greater London Authority.

Visit dash.kcl.ac.uk/reports for a copy of this Policy Report, the DASH policy summary and other project outputs.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PART A

Background

PART A: BACKGROUND

1. Introduction

1.1 'Big data': all that glitters is not gold

We live in a time of rapid technological development. Many are excited about the apparent promise of insights from 'big data' to deliver radical efficiencies and transformations.

> *'Advances in information and communication technologies, the increasing use of electronic devices and networks, and the digitalisation of production processes mean that vast quantities of data are generated daily by economic and social activities. This 'big data' can be transmitted, collected, aggregated and analysed to provide insights into processes and human behaviours. Big data analytics have the potential to identify efficiencies that can be made in a wide range of sectors...'*[1]

But the situation is more challenging than many appreciate. There is a tendency to overstate the completeness, accuracy and ease of the solutions which this information revolution may deliver.[2]

Data has no inherent value in itself; it only gains value as people process it into information and knowledge, thought and action. The big data phenomenon is having different effects in different circumstances, because it is not simply about scale (Volume, or 'bigness'). It also involves changes in:

- **Variety**. Unstructured and semi-structured data of various types are becoming more prominent.
- **Velocity**. Data is generated at a faster rate and analysed at higher speed.
- **Value**. Large-scale data often has 'low value density', but when analysed can yield very high values.
- **Veracity**. Much data is unreliable.[3]

Some have argued that big data is fundamentally disruptive to the 'social technology' of expert power and government itself.[4] It is certainly now clear that change based on 'big data' cannot, as some thought, simply cut past 'traditional organisational structures'.[5] Digital developments are not socially or economically neutral, and as such will generate controversy.[6]

1.2 Big data and public services: demonstrating how technology serves society

Modern visions of a 'progressive digital future' tend to acknowledge 'the needs of the citizen as well as the consumer, and of civic society as well as the security state'.[7]

The issues are relatively well-considered in theory. The Royal Society and the British Academy have jointly suggested that the growing volume of data and proliferation of its technological uses demands re-evaluation of our systems of governance: nothing less than a change to how we organise ourselves as a society. Applications of big data 'can make a great contribution to human flourishing but to realise these benefits, societies must navigate significant choices and dilemmas: they must consider who reaps the most benefit from capturing, analysing and acting on different types of data, and who bears the most risk'.[8] The main issues are said to be: privacy; ownership; skills; and inclusion. Security is also clearly a significant issue.

There are fewer signs of a concrete plan of action in government. Most attention is concentrated on issues of privacy and security, most notably with the European Union's new General Data Protection Regulation (GPDR) which explicitly sets out to protect citizens from 'privacy and data breaches'.[9] The further challenge is to move beyond a defensive stance and show initiative, demonstrating clearly how new forms of digital technology serve society and help in the delivery of public services.

This challenge is increasingly recognised in policy circles. The UK government's new Industrial Strategy, for example, sets 'grand challenges' for prosperity in the UK general economy, including the challenge of 'Artificial Intelligence and the data economy' which is described as 'transforming business models across many sectors as they deploy vast datasets to identify better ways of doing complex tasks'.[10] But public services have fallen far behind the private sector in terms of technological change.[11] As John Manzoni, Chief Executive of the UK Civil Service, said in February 2017:

> *'The impact of data analytics and big data in our lives – for example the way online retailers tailor their recommendations for the food, books and music we buy – is quite familiar. … Less has been said about the transformative power of this technology for the delivery of high-quality public services. And it's time that changed.'*[12]

The Digital Economy Act 2017 was meant to deliver public service improvement by permitting data sharing between agencies, but its initial applications were marginal (eg TV re-tuning) and there are few signs of uptake.[13] For many, especially drawing on the experience of North American municipal governments for inspiration, the initiative has anyway now passed from Whitehall to the UK's cities.[14] Speaking in Texas in March 2018, Sadiq Khan, the Mayor of London said:

> *'There's been a dereliction of duty on the part of politicians and policymakers to ensure that the rapid growth in technology is utilised and steered in a direction that benefits us all.… [We're working in London to utilise] data to transform the way public services are delivered, making them more accessible, efficient and responsive.'*[15]

1.3 Delivering digital change in health & care services

One of the biggest and most urgent challenges in the UK, especially given fiscal pressure and priorities amongst public attitudes, is digital change in the National Health Service (NHS).

> *'One of the greatest opportunities of the 21st century is the potential to safely harness the power of the technology revolution…to meet the challenges of improving health and providing better, safer, sustainable care for all.'* **National Information Board, 2014**[16]

Policymakers used to be 'wedded to techno-utopian dreams of big computer systems' for health & care data.[17] Fairly or not, the NHS in England has acquired a reputation for IT project failure based (for example) on issues with the National Programme for IT (2002-13)[18], the care.data programme (2013-16)[19] and, more recently, the Google DeepMind-Royal Free breach of data protection law.[20]

The Health and Social Care Information Centre was rebranded 'NHS Digital' in 2016 and is now implementing a fresh £4.2 billion system transformation effort.[21] Amongst the issues NHS Digital faces are the following:

1. **Fragmentation**. The Health & Social Care Act 2012 localised the procurement and oversight ('commissioning') of goods and services by Clinical Commissioning Groups (CCGs) and renewed local authorities' responsibility for public health.[22] So NHS Digital faces a delivery landscape which it can only influence, not control.[23]

2. **Resourcing**. Although digital goals are usually explained in terms of efficiency, transformations often require significant investment in skills and 'secondary uses' of data

(like performance review and improvement, research, commissioning and planning).[24] With most of the attention on the NHS delivery funding allocations, and on the significant cuts to adult social care, it is less well appreciated that the Department of Health non-NHS budget (including education and research) is dropping by over 20% between 2015 and 2021.[25]

3. **Regulation**. It is reasonable to expect that regulation will develop quickly in areas of innovation. The European Union General Data Protection Regulation (GPDR), which introduces stricter data processing standards including more explicit consents, becomes law in the UK on 25 May 2018.[26] But regulators' emphasis on direct public engagement (eg Caldicott 3, 2016) creates a compliance cost and a functional challenge that many health bodies are ill-equipped to face.[27]

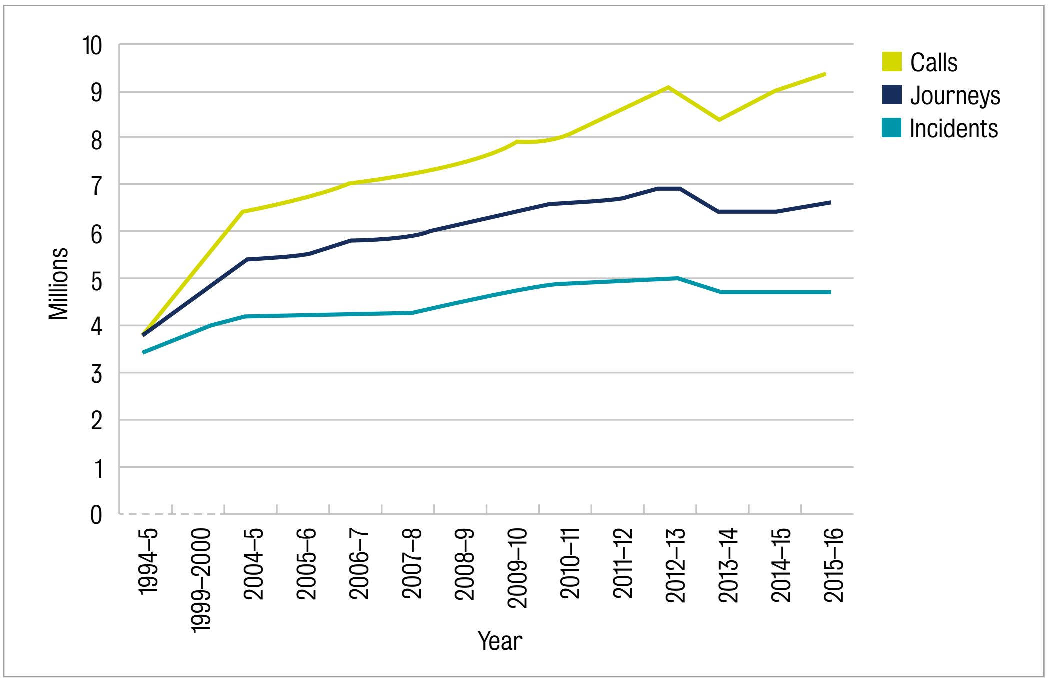
It remains to be seen whether 'health devolution' (gradual increases in local health determination in Greater Manchester, Cornwall and London) can improve the situation regionally by supporting system coordination, resourcing and public engagement.[28]

1.4 Ambulance services in the big data context

The NHS 'Five-Year Forward View' locates ambulance services within the 'Urgent & Emergency Care' (UEC) system, which also involves hospital Emergency Departments, the NHS 111 urgent care telehealth function, General Practitioners (especially out-of-hours provision in evenings and at weekends) and new 'Urgent Treatment Centres' (or 'Urgent Care Centres'). The UEC element of NHS reforms has proceeded from the 2013 Review by NHS Medical Director Professor Sir Bruce Keogh.[29]

Demand for ambulance services in England has risen dramatically over recent years (see **Figure 1.4.A**). A 2017 report by the National Audit Office (NAO) points that this rise in demand has moved at about twice the pace of funding increases.

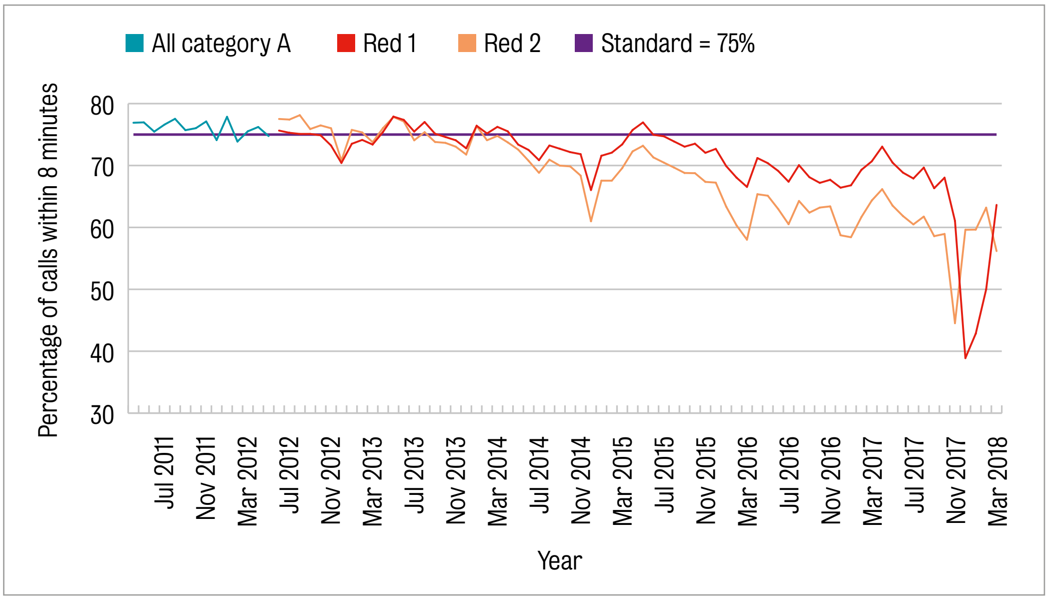
FIGURE 1.4.A: DEMAND FOR EMERGENCY AMBULANCE SERVICES, 1994-5–2015-6[32]



'Increased funding for urgent and emergency activity has not matched rising demand.... Between 2011-12 and 2015-16, income for ambulance trusts' urgent and emergency care activity increased by 16% from £1.53 billion to £1.78 billion. Over this period, activity (ambulance calls and NHS 111 transfers) rose by 30%.' **NAO, 2017**[30]

Performance appears to have suffered under these conditions. NHS England administers the Ambulance Quality Indicators (AQI) which are designed to track ambulance service performance.[31] The headline AQI system indicator shows a disintegration in performance against highest-priority (Category A) response time measures since 2013 (see **Figure 1.4.B**).

FIGURE 1.4.B: NHS ENGLAND ALL AMBULANCE SERVICES – PERFORMANCE AGAINST 8-MINUTE CATEGORY A TARGET[33]



The relationship of demand, funding and performance at the London Ambulance Service (LAS) is discussed in more detail below (see **Section 3.1.1**). This Report also returns to look at the national picture in a more considered way: **Section 3.2.2** explains how NHS England undertook a significant national reform in 2017 called the Ambulance Response Programme (ARP), designed to address services' performance issues.[34]

PART A: BACKGROUND

Given the apparently far-reaching consequences of the big data, there are good reasons to look beyond these customary ways of looking at information about and around ambulances. Ambulance services offer good potential insight into how big data can improve public services (as well as how public services can inspire big data developments), for three reasons:

1. **Ambulance services are fundamentally enabled by Information and Communications Technology (ICT).**
   Above all, modern ambulance services use Global Positioning System (GPS)-enabled 'Computer Aided Dispatch' (CAD) relational database systems to organise their operation from a central control room.[35] The London system crash on 1 January 2017 was a sharp reminder both of how reliant ambulance services now are on CAD systems and of the need to maintain both system resilience and backup processes.[36]

   The other vital ICT system for ambulances is telephone networks. The UK was the first country to introduce a 999 emergency telephone line, in 1936.[38] In recent years, mobile phone use has helped people call ambulances more quickly in life-threatening situations, saving lives.[39]

THEN AND NOW: FOR DECADES, AMBULANCE SERVICES HAVE RELIED ON CONTROL ROOM CAD SYSTEMS[37]

2. **From a public service perspective, the nature of ambulance dispatch makes big data unusually relevant.**
   Like many public services, ambulance services face a 'data deluge' in terms of the volume and variety of new data that they might potentially use. But ambulance operations also have unusual qualities from a technical point of view compared to other public services. The 'real time' nature and urgency of their work makes the 'velocity' aspect of big data relevant. And the often under-appreciated conditions of uncertainty under which ambulance staff work raise sharp questions of 'value' and 'veracity' too.

3. **Ambulance services deliver clear, demonstrable public benefit.**
   The intended purpose of data use is vital in determining whether people will support it or not.[40] Ambulance services are highly responsive to demand; staff are at work 24 hours a day, 7 days a week; they are patient-focused and save lives every day; large numbers of people have direct or proximate experience of their services; and they are highly visible in public spaces. They therefore provide good opportunities for clear presentation of how big data can enable public services.

2. DASH project design & activities

This section sets out information about the DASH project, starting with general information (**Section 2.1**) and then moving on to describe the approach used to explore prospects, challenges and courses of action in the data landscape to develop project findings (**Section 2.2**).

2.1 About the DASH project

2.1.1 Research question

The Data Awareness for Sending Help (DASH) project was a 'policy demonstrator' project which explored the potential impact of integrating new and emerging data sources and technology on emergency response and wider policy.

This Policy Report addresses the project's overarching policy goal which was to **establish policy recommendations on the use of new and emerging data sources and technologies for emergency ambulance dispatch.**

2.1.2 Partners and structure

DASH builds on the existing research collaboration between King's College London and the London Ambulance Service (LAS). The King's Department of Informatics led the project, supported by the Policy Institute at King's. DASH is funded by the Economic & Social Research Council grant ref. ES/P011160/1 (April 2017-May 2018).

The project was structured around three work packages: (1) identification and analysis of new data from a policy perspective; (2) analysis of new data from a technology perspective; and (3) examination of London Ambulance Service as a case study.

This Report focuses on the results of the first and third work packages, comprising the policy element of the project. It has been developed in parallel with the DASH Technical Report which sets out the results of the second work package.

2.1.3 Methods

The policy element of DASH has been implemented as a wide-ranging mixed methods study, including literature review, framework analysis, stakeholder & process mapping, open policy development, interviews and observation. The project used a flexible, impact-oriented approach which emphasised the iteration of practical research insights in a co-productive manner.

2.1.4 Data

DASH primary data collection consisted of 15 semi-structured interviews with LAS staff and over 60 unstructured interviews with a variety of stakeholders, as well as: observation time in the LAS Emergency Operations Control (EOC) room at Waterloo and on a Fast Response Unit vehicle shift; and project stakeholder workshops. The project also undertook secondary data analysis on LAS London incident and response datasets over calendar year 2016 and other publicly available administrative data, as well as drawing on a broad range of literature.

2.1.5 Scope and limitations

As mentioned above, the DASH project structure involved focus on a Case Study examining the potential of new data and technologies to support emergency ambulance response at LAS. The project is exploratory and does not represent a comprehensive treatment, inevitably ignoring wider LAS or general issues. This is also a fast-moving subject and several developments during the project period changed the phenomena under investigation (notably the Ambulance Response Programme and roll-out of tablet computers to LAS ambulance staff – see **Section 3** below).

2.1.6 This Policy Report

This Policy Report is a project output designed to propose initiatives to interested policymaker audiences, as well as to promote insight amongst more generalist policymakers and members of the public. Its objective is both to raise awareness of the issues and to provoke action by putting forward some views as to what might usefully be done. Any comments or suggestions relating to this Report are welcome and should be directed to the project Principal Investigator, Dr Elizabeth Sklar, Dept of Informatics, King's College London (email: elizabeth.sklar@kcl.ac.uk) and this report's lead author Archie Drake, Policy Institute at King's (email: archie.drake@kcl.ac.uk). An electronic copy and the project policy summary are available on the project website: https://dash.kcl.ac.uk/reports/.

2.2 How the DASH project explored the landscape of data for dispatch

This section describes the approach DASH used to explore prospects, challenges and courses of action in the data landscape in order to develop specific project findings (see **Section 4** below).

2.2.1 Identifying prospects

The project's use of the qualifier *'new and emerging'* to describe certain types of data was adapted from the ESRC programme which funded the work. During the project, the definition broadened to encompass consideration of: (a) data sources which are *new* because London Ambulance Service (LAS) is not currently consulting or collecting these data; (b) data sources which are *new* because LAS is currently collecting these data but not consulting them for making day-to-day dispatch decisions; and (c) data-centric technologies which are *new* because LAS is not currently employing them for making day-to-day dispatch decisions.

The team ultimately identified prospects by looking at the degree of existing integration into dispatch systems, building new uses of data from existing practices. Data types were placed into the schema of dispatch system integration shown right in **Figure 2.2.1**.

The project settled on the following six data types as the prospects to be explored in detail:

1. **Integrated health & social care datasets** in the wider system (including information about patients outside the traditional UEC domain).
2. **Transport data** (especially exploiting London's 'Intelligent Transport System' (ITS)).
3. **Data on air quality** (including data generated and held by the London Air Quality Network).
4. **Data indicating population location** over time (especially from mobile phone networks).
5. **Data from video communications technology** not currently used in dispatch.
6. **Weather conditions and forecast data** not currently used in dispatch.

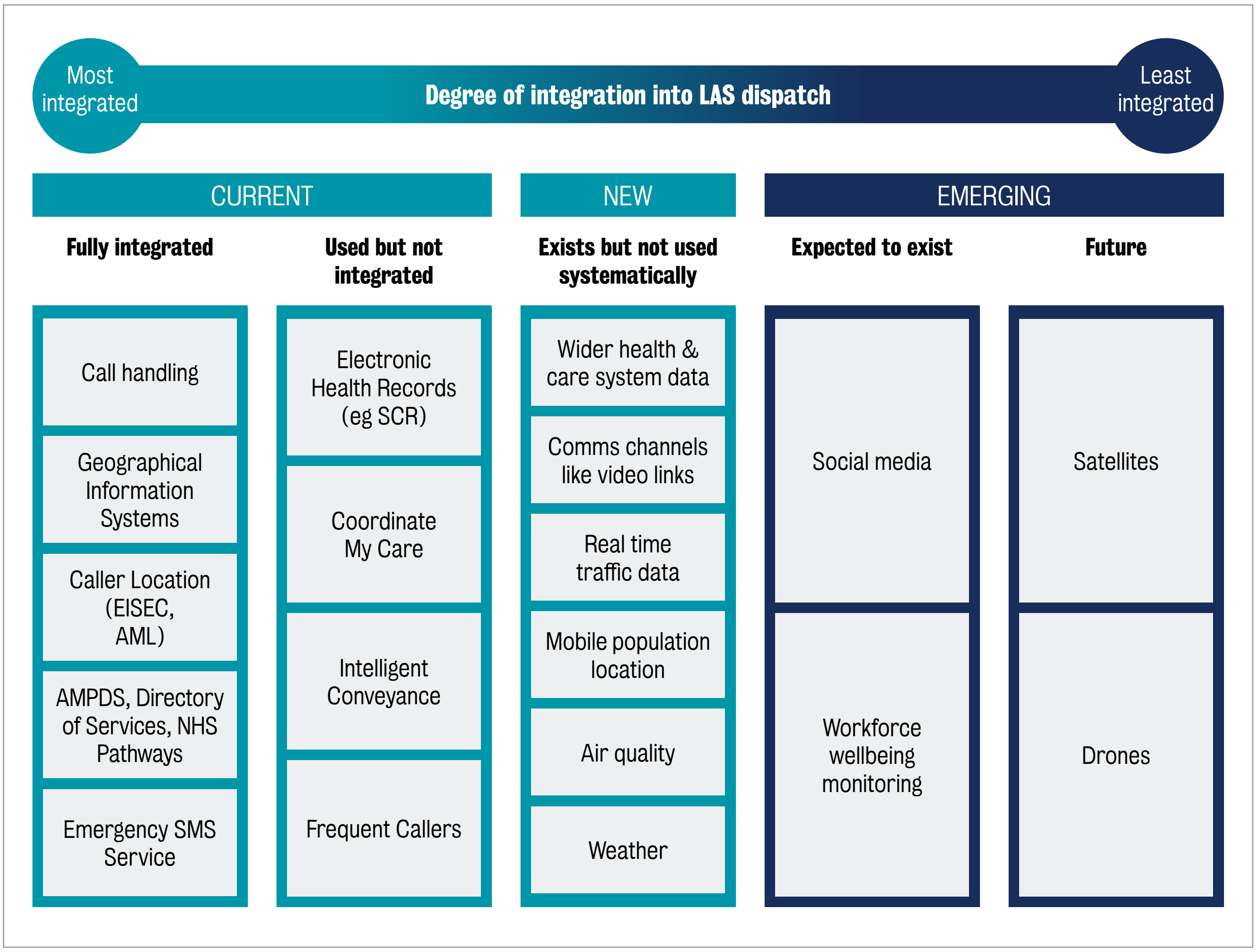


FIGURE 2.2.1: NEW AND EMERGING DATA SOURCES FOR LAS DISPATCH: CURRENT DEGREE OF INTEGRATION INTO THE DISPATCH PROCESS

2.2.2 Assessing challenges

Like other areas with technological potential, emergency service dispatch provokes commentary about future promise, ranging from the excitable to thoughtful; but the results tend to remain somehow just beyond reach (in this case, the label 'Next Generation 999' recurs).[41] The DASH project set out to examine challenges to the realisation of technological potential in detail, with the objective of developing practical recommendations.

The relevant technical challenges, extending out to organisational and governance perspectives, are relatively well-charted. The University of Exeter-led Medical & Environmental Data Mash-up Infrastructure (MEDMI) project is an example of a project which has investigated the issues of data linkage for ambulance dispatch extensively, focusing on the linkage of environmental data with ambulance dispatch data.[42]

The DASH project used a broad analytical framework to map and explore an abundance of wider practical challenges for LAS innovation in relation to new and emerging data, not just from a technical perspective (T) and considering organisational developments (O), but also acknowledging political, economic, social, legal and ethical issues (resulting in an overall 'T-PESLEO' structure). Most challenges related only, or differentially, to certain data sources or applications. The table below sets out the main challenges identified in relation to the six data types described above.

FIGURE 2.2.2: DASH T-PESLEO FRAMEWORK ANALYSIS OF CHALLENGES TO USE OF NEW DATA IN LAS DISPATCH

	Challenges	Data types					
		Integrated health and social care data	Communications technology (video calls)	Transport	Mobile population location	Air quality	Weather
TECHNICAL	Computational complexity (timely processing, heuristics)	Minor		Major barrier	Major barrier	Major barrier	Major barrier
TECHNICAL	Limited progress of digital standards (e.g. 'open data' principles)	Moderate	Minor	Minor	Moderate	Moderate	Moderate
TECHNICAL	Spatial, temporal and other causative complications	Major barrier			Major barrier	Major barrier	Major barrier
TECHNICAL	Misalignment between service concerns and research models	Major barrier	Major barrier	Moderate	Minor		
TECHNICAL	System resilience and security imperatives take priority	Major barrier	Major barrier	Major barrier	Major barrier	Major barrier	Major barrier
POLITICAL	Health policy generally: highly politicised and contested	Major barrier	Major barrier				
POLITICAL	Sub-national governance arrangements: fragmentation	Major barrier	Major barrier	Major barrier	Minor		Moderate
POLITICAL	Brexit/labour market threat: preoccupation	Major barrier					
POLITICAL	Public sector data 'trust deficit'	Major barrier	Moderate		Major barrier		
POLITICAL	Government leaves innovation and regulation to others	Moderate	Moderate		Major barrier		Moderate
POLITICAL	Mayoral health & digital policies under development	Moderate	Moderate	Moderate	Moderate	Moderate	
ECONOMIC	Private/commercialised control of data goods with quasi-public characteristics	Moderate	Moderate	Minor	Major barrier		Major barrier
ECONOMIC	Analytical processing carries costs, especially in terms of human resources	Major barrier	Major barrier	Major barrier	Major barrier	Major barrier	Major barrier
ECONOMIC	Evaluative focus on user choice (not constraint); unclear how supply stimulates demand	Major barrier	Moderate				
ECONOMIC	Nature of data goods inhibit clear identification of control, value and costs	Major barrier		Minor	Minor		Moderate
ECONOMIC	Lack of frameworks to handle events falling between 'routine' and 'disaster' categories	Minor			Major barrier		Major barrier
SOCIAL	Limited social scientific understanding of demand in context	Major barrier	Moderate		Major barrier		Minor
SOCIAL	Low public awareness of challenges and data potential/constraints	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
SOCIAL	Rising public expectations of public services, especially 'on demand'	Moderate	Moderate				
SOCIAL	Equity objectives de-prioritised relative to efficiency in public discourse	Moderate		Moderate	Moderate	Moderate	
LEGAL	Data protection and other information governance regulatory burden	Major barrier	Major barrier		Moderate		
LEGAL	Public data powers (data sharing, public health) relatively weak	Moderate	Minor	Moderate	Major barrier		Moderate
LEGAL	Complex and uncertain legal framework for public sector data sharing	Moderate		Moderate	Minor		
LEGAL	Uncertain accountability for computer-supported decision-making	Major barrier	Minor	Moderate		Minor	Minor
ETHICAL	Privacy issues: do service improvements justify population surveillance?	Major barrier	Moderate	Minor	Major barrier		
ETHICAL	Consent issues: should individuals' consent be sought to certain data uses?	Major barrier	Major barrier	Moderate	Moderate	Minor	
ETHICAL	Duty to undertake risk assessment and design for maximum assurance	Major barrier	Major barrier	Major barrier	Major barrier	Major barrier	Major barrier
ETHICAL	Ethics of individual location data processing especially unclear			Moderate	Moderate	Moderate	
ETHICAL	Lack of public debate on digitally-enabled public health surveillance	Major barrier			Major barrier		
ORGANISATIONAL	Resource squeeze (demand rising faster than supply)	Major barrier	Major barrier	Major barrier	Major barrier	Major barrier	Major barrier
ORGANISATIONAL	Lack of clear strategic focus and guidance to citizens about appropriate NHS access	Major barrier	Major barrier			Moderate	
ORGANISATIONAL	Data exploitation may require specialist analytical skills not available within services	Minor	Major barrier	Major barrier	Major barrier	Major barrier	Major barrier
ORGANISATIONAL	Usage bridges domains in various dimensions (professions, class, generations)	Major barrier	Major barrier	Major barrier	Major barrier	Major barrier	Major barrier
ORGANISATIONAL	Transformation fatigue / technostress[43] / staff demoralised and suspicious	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Major barrier Moderate Minor N/A white

2.2.3 Developing courses of action

There are extensive fields of study and lifetimes of work across this and the other challenges identified under the DASH project. The objective was not to consider them in isolation, but to apply a 'policy entrepreneur' approach aiming to bring potential interdisciplinary solutions onto the policy agenda.[44]

> *'The most effective initiatives to address specific contexts of data non-use will be those that: firstly, understand the pertinent sources, types and reasons for data non-use in a given domain in order to meet the challenges and create appropriate incentives and repercussions; and secondly, are cognisant of the multiple aspects to this complex issue in other domains to keep benefits and limitations in perspective, to move steadily towards socially responsible reuse of data becoming the norm to save lives and resources.'* **Jones et al, The other side of the coin: Harm due to the non-use of health-related data (2017)**[45]

DASH accordingly set out to test how new and emerging data for LAS dispatch could be beneficial despite challenges through iterative development and testing of proposals (see **Figure 2.2.3**).

DASH's exploratory approach enabled factors to be accounted for as their relevance became clear. For example, over time it became apparent that dispatch is likely to be affected by data from the developing collection of mobile devices and sensors commonly known as the 'Internet of Things' (including the prospect of improved connectivity using 5G mobile systems). However the 'number of connected "things" in the Internet of Things is not meeting the predictions made a few years back', which tended to temper expectations that relevant data can be exploited quickly or without significant difficulty.[46] Specifically, there has been some controversy about new Emergency Services Network (see box below) which influenced DASH away from speculation about the immediate future of dispatch as a more distributed information system.

Infrastructure for ambulance communications: the Emergency Services Network (ESN)

The new Emergency Services Network (ESN) is intended to enable technological advances for emergency services like ambulances. Emergency service communications in the UK currently run on a terrestrial trunked radio (TETRA) standard provided by a company called Airwave which is owned by Motorola.[47] However the government has been working since 2015 to transfer the ESN onto a mobile communications network basis, i.e. the same network technology used by mobile phone companies.[48]

The main ESN network contract has been awarded to the mobile phone provider EE, which is owned by BT.[49] EE is busying itself with the extensions of the 4G network required to give the ESN necessary coverage.[50] Motorola will continue to provide 'user services'.

Although the new mobile network standard for ESN holds significant promise of additional capacity (broadband data speeds as well as voice communications), the implementation process has been affected by controversy and delay. A parliamentary inquiry which concluded in early 2017 concentrated on the government's admission that the new network is 'high risk' and still faces significant technical hurdles in implementation.[51]

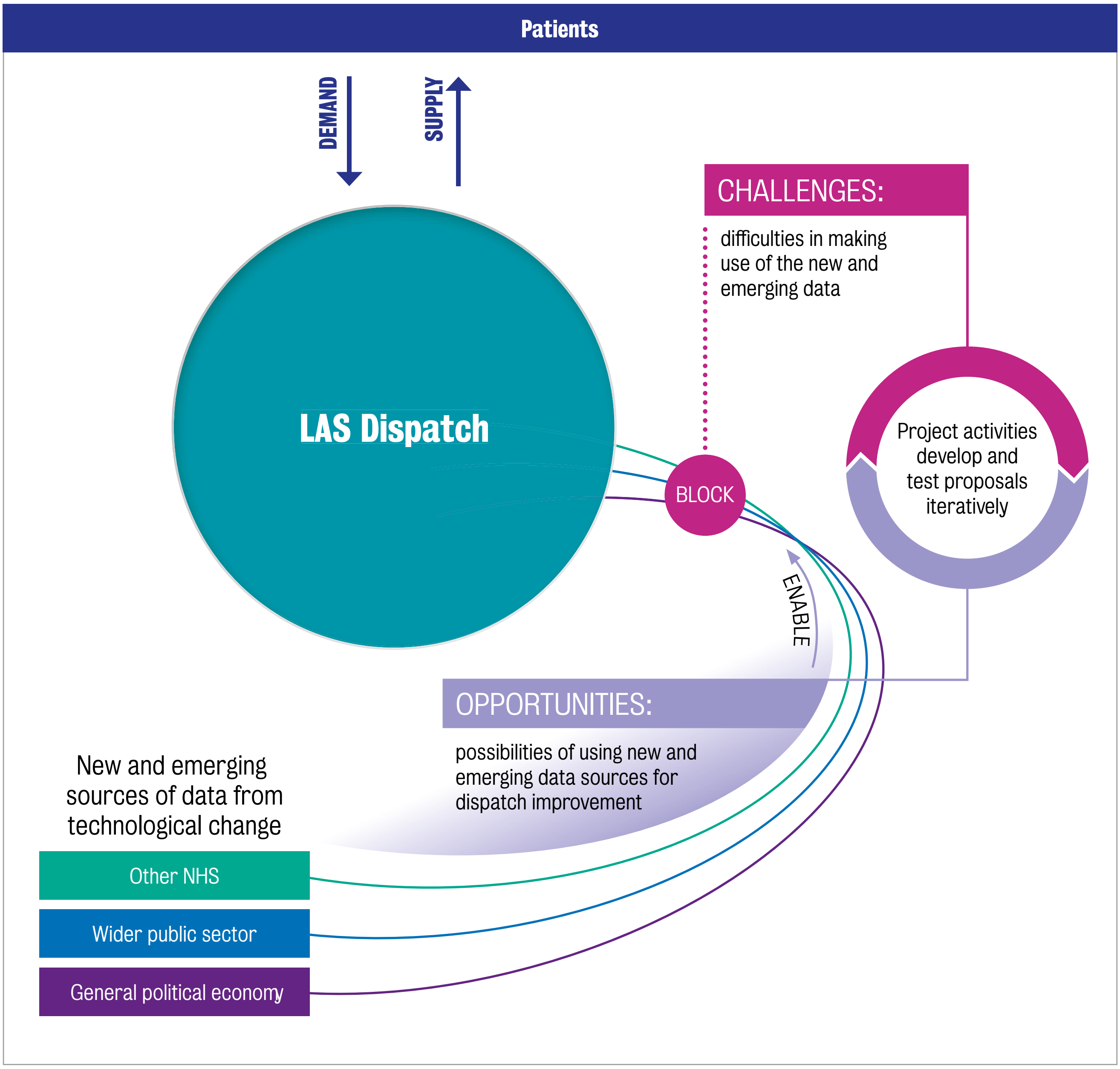


FIGURE 2.2.3:
SCHEMA SHOWING DASH APPROACH FOR DEVELOPING COURSES OF ACTION

Another example was observation that LAS has relatively high effective resilience requirements for dispatch systems; in other words, LAS needs to make absolutely sure that the system works well all of the time. The nature of ambulance dispatch requires managers to ask not just what is possible, but also what happens when things go wrong. This tended to influence DASH away from radical system redesign and towards gradual improvements.

> *'a lot of it is down to business continuity… our CAD system, that the control rooms rely on for handling emergency calls and despatching them out to ambulance crews, what happens if that fails?'*
>
> *'the… focus is on the CAD environment… [managers] don't like changing the system, it might bring in instability.'* **DASH interview participants**

Over the course of the DASH project, various new data prospects which had seemed promising at first were set aside. Some, such as data from drones or satellites, were considered interesting as possible future subjects for dispatch but left aside because people tended to doubt the scope for workable applications in the near future. Others, such as social media data or workforce wellbeing monitoring data, were considered relevant to dispatch but also left aside because of considerations which put them beyond priority implementation in practice.[52]

Social media data was considered to have too much irrelevant or meaningless data mixed in with useful signals (too 'noisy') to add real time value to LAS dispatch; limited geotagging and bias inherent in using data from any one platform also presented obstacles. This is far from saying that social media is irrelevant to LAS. On the contrary, there is good potential scope to improve LAS public awareness-raising and communications through through research on this subject; and understanding social media usage has become vital for effective management of major incidents.[53] But DASH revealed only limited LAS interest in developing uses of social media data at these strategic and tactical levels. Workforce wellbeing monitoring was equally regarded as an area of high potential, but not addressed due to limited project means to engage workforce sufficiently broadly (as well as pushback from employees due to perceived loss of personal privacy).

DASH's approach suggested suggested three broad types of improvement to LAS dispatch, which are explained here as background to their use as terms in **Section 4**:

- **Marginal** improvement represents general efficiency gain in the current dispatch process. For example, the 'Advanced Mobile Location' (AML) system saves call handlers time in determining the location of callers, enabling ambulances to reach patients more quickly. The big opportunity for marginal improvement is spatial awareness and equitable service delivery: supporting efforts to establish and maintain reliable 'coverage' (good consistent service across an area). Better coverage in dispatch is an increasingly important improvement consideration for LAS (see **Section 3.1.1** below).

  '… the system does not consider coverage.'

  '… the system does try to send right kind of response, but in doing so damages coverage of the system as a whole.' **DASH project interview participants**

- **Segment** improvement relates mainly to a certain group or certain groups of service users. For example, the Frequent Callers system is a current segment innovation, putting in place personalised care plans for people who call LAS recurrently. The big opportunity here is improved care pathways for less-urgent LAS patient segments (especially through improved evidence on outcomes as well as on-scene information – see **Section 4.1.1** below for more detail).

  'They think, "I'll look at this patient. I'll ask a few questions." The patient wants to go to hospital. It's not unreasonable. You're thinking they probably don't need to, but you don't know your local resources.' **DASH project interview participant**

- **Transformative** improvement includes more challenging dispatch initiatives involving a major innovation to the way in which LAS operates dispatch. The control room's Clinical Hub (CHUB) role in increased LAS 'Hear and Treat' is a current example of a transformative innovation.

  'Especially now, where we're looking at the whole Generation Z, the Millennials, who communicate in a completely different way. Then, we're forcing them to make a phone call.' **DASH interview participant**

PART B

Findings

PART B: FINDINGS

3. General findings: LAS dispatch should get more attention and investment

This section outlines different policy perspectives on LAS dispatch, understood within an evolving data landscape. It first describes **current dispatch as an information process within LAS (Section 3.1)**, highlighting innovative developments in the use of ICT. Secondly it describes some **significant recent changes in dispatch-related policy from outside LAS (Section 3.2)**, highlighting policy adjustments to priorities and parameters.

Altogether, these observations suggest that technological innovation in LAS dispatch should get more attention and investment because of the real opportunities (considered in **Section 4**) to benefit from more informed decision-making. LAS dispatch already incorporates substantial innovation. Some dispatch-related policy changes are giving more scope to consider new data, but system performance targets as opposed to data about outcomes or efficiency are still the dominant policy influence.

The perspectives in this section are intended to augment conventional approaches to dispatch from operational and health system research viewpoints. The idea is to suggest an overall description of dispatch which helps spread understanding of and engagement with the relevant issues beyond ambulance professional and related technical fields, supporting efforts to mobilise support around initiatives to improve dispatch.

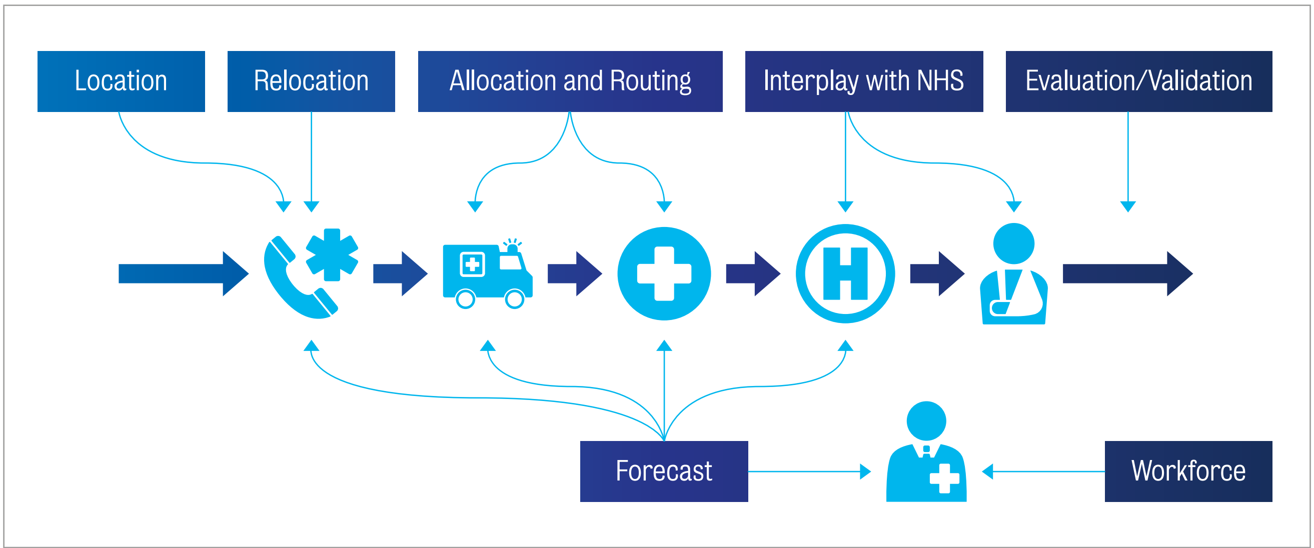


FIGURE 3.0: THE 'FULL RANGE' OF ISSUES INVOLVED IN AMBULANCE DISPATCH (ADAPTED FROM ARINGHIERI ET AL, 2017)[54]

The general, systems-oriented policy treatment advanced in this section is suggested by trends in the relevant bodies of research. Operations research on dispatch has tended to focus on modelling 'location': ensuring that vehicles are in the right place at the right time. But a 2017 review questions whether this emphasis is 'consistent with the main aims' of ambulance services and explains how the field is now broadening to consider the 'full range' of ambulance dispatch issues, supported by analytical forecasting (see **Figure 3.0**).[54] For example, researchers are beginning to pay more attention to the question of where to send ambulances after they finish treating a patient ('relocation'); and ambulance services are increasingly examined as one element of a varied landscape of health and care services rather than in isolation ('interplay with NHS').

Health systems research studies are also starting to view ambulance dispatch as a complex process linking to wider health systems, although they tend to emphasise the role of clinical functions. A 2016 National Institute for Health Research (NIHR) Dissemination Centre Themed Review on research for ambulance services emphasised the importance of understanding: (i) demand in the context of system interdependence; (ii) effective ambulance staff decision-making to improve patient experiences; and (iii) what improvements can be made to clinical interventions. The Review concludes that there are 'exciting opportunities for developing research capacity and culture in ambulance services'; but also that they have 'an important part to play in contributing to an evidence-based health service and improving patient care when it is most needed'.[55]

3.1 LAS dispatch as an information process: data innovation

3.1.1 Description of the dispatch process as the way LAS delivers its services over time and space

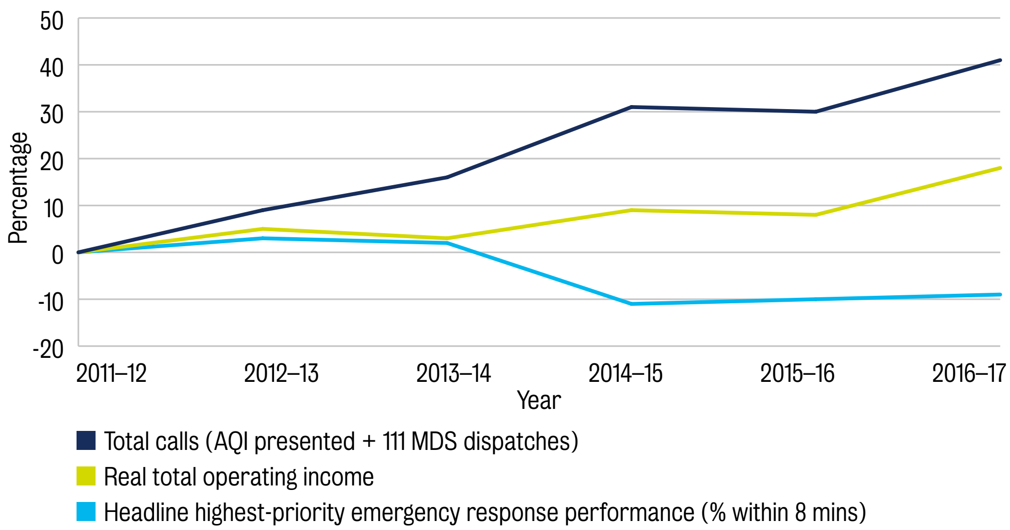
Ambulance service dispatch follows a demand and supply format. Demand arrives as calls from the public or other system actors (such as other parts of the NHS, or the police) following an 'incident', which could be anything from a routine individual health complaint to a major disaster. Supply involves ambulance service resources of various types including paramedics and ambulance vehicles.

'Dispatch' is the whole complex system of decisions that an ambulance service operates to organise this supply in response to demand. It is worth reiterating that the DASH team adopted a broad definition of the term which extends beyond the narrower sense of vehicle allocation only (see **Section 3** introduction immediately above).[56] Dispatch improvements constitute progress towards the overall goal of a more effective ambulance service (improved patient outcomes at equivalent levels of resourcing).

The dispatch process is under increasing pressure because demand is growing faster than supply. LAS resourcing has increased over recent years (from about £280m annually to about £355m over 2011-12 to 2016-17 in nominal terms, a real increase of about 18%); but it has not risen nearly as fast as demand (from nearly 1.5m to nearly 2.1m calls annually over the same period which is an increase of over 40%).[57] Headline system indicator performance has declined over this period.

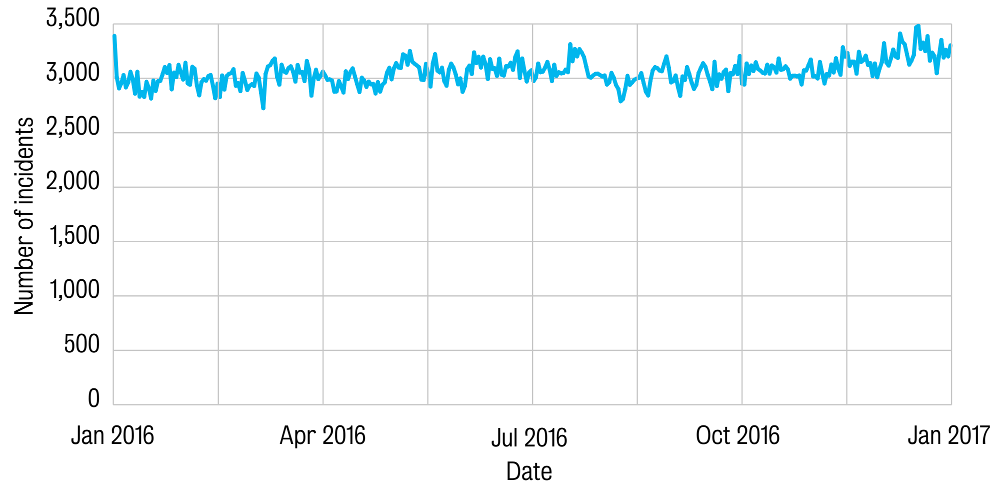
The chart below maps these developments crudely onto a single graph. Although it is important not to jump to conclusions based on simplistic indications of performance, as discussed below, the impression is of dispatch as a process under strain.

FIGURE 3.1.1.A:
COMPARISON OF LAS DEMAND, FUNDING AND PERFORMANCE TRENDS FROM 2011-12

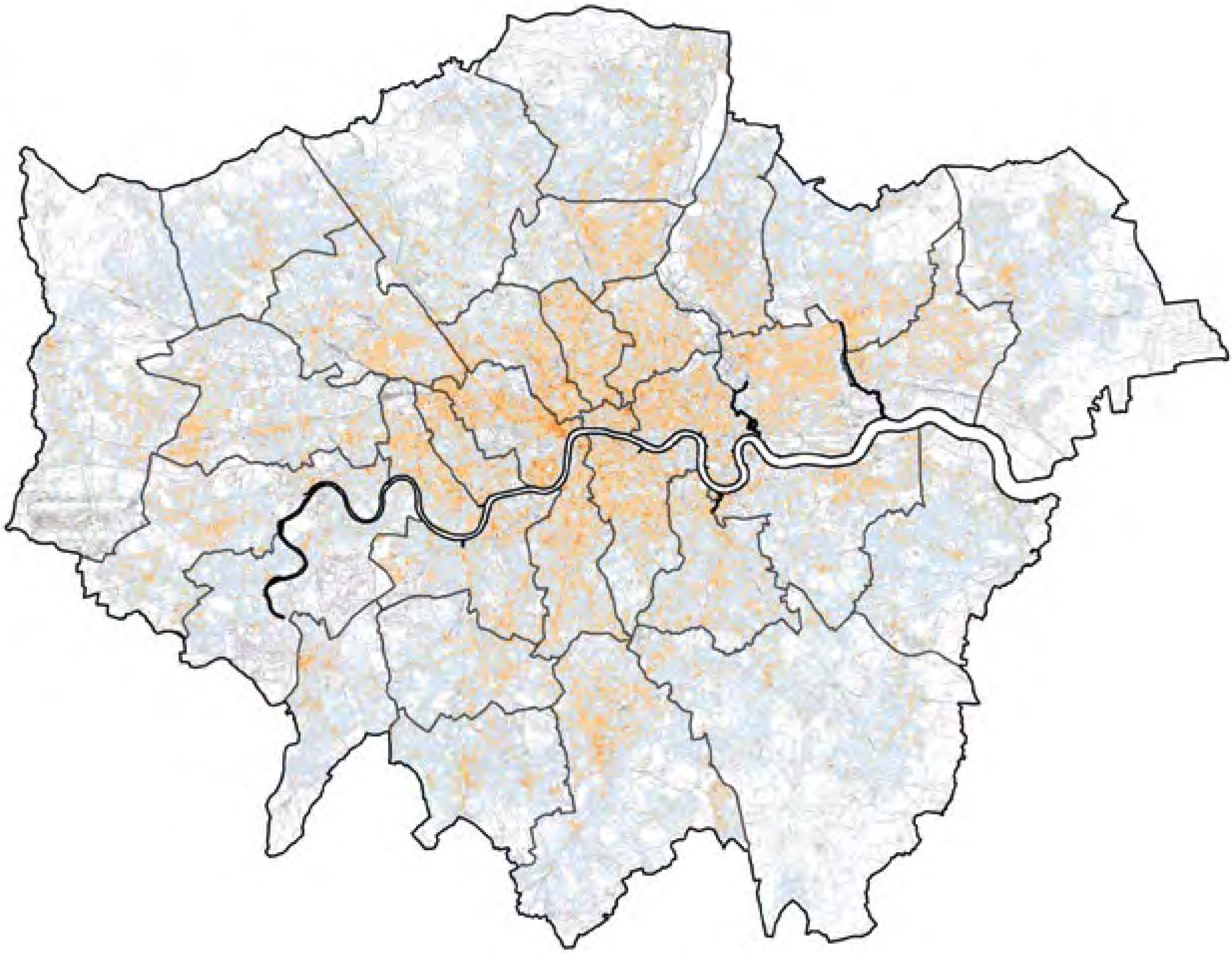


In the words of a 2004 NHS report, the essence of dispatch is: right skill, right time, right place.[58] In terms of time, the process operates continuously: 24 hours a day, 7 days a week. The chart below tracks London's overall daily ambulance demand 'heartbeat' over 2016, showing how many incidents received a physical response from LAS. This demand pulse looks fairly regular, and contains predictable spikes such as those evident around Christmas and over New Year's Eve. But variations in demand are hard to anticipate accurately, and forecasts retain a significant element of uncertainty. Unanticipated demand can lead to severe pressure on dispatch and undermine the quality of service.

FIGURE 3.1.1.B:
DAILY INCIDENT FREQUENCY, LAS 2016



Source: Policy Institute at King's, LAS Incident data 2016



Incident frequency (per 100m²)

- 1–12: Less than one per month
- 12–52: One per month to one per week
- 52–366: One per week to one per day
- 366–1,738: More than one per day

Source: Policy Institute at King's, LAS Incident data 2016

FIGURE 3.1.1.C: MAP OF AMBULANCE INCIDENT FREQUENCIES IN LONDON OVER 2016, SHOWING BOROUGH BOUNDARIES

In terms of space, the process operates over the whole area of London. The map above gives an impression of the spatial distribution of ambulance incidents in 2016. It shows the frequency of incidents which received a physical response over the year: a total of over 1.1m incidents (for scale, the total population of the city was about 8.8m).

It is interesting to note the apparent potential correlation of ambulance demand with population density, deprivation and health inequality in the city. The additional maps on the facing page give an impression of these factors. Moving from the map of LAS demand over 2016 (map A – top left), they show:

- Residential population density in 2011 (map B – top right)[59].
- Number of years spent in ill health for males (map C – bottom left), a map released by the Mayor in 2017 alongside the draft London Health Inequalities Strategy to illustrate the 'wide [health] inequality within the capital'.[60]
- Index of Multiple Deprivation rankings in London for 2015 (map D – bottom right)[61].

Although spatial analysis was outside the scope of the project, certain patterns appear similar, especially expanses of relatively concentrated population density and deprivation stretching out towards the East and North East from the centre, and there are also intriguing differences in distribution. Some research touching on these connections, and the implications for dispatch, is discussed below in **Section 3.2.1**.

Viewed as an information process, LAS dispatch works as a series of decisions taken by staff with extensive use of ICT to process data into information. There are a wide variety of organisational policies and procedures involved.[62] Relevant staff include Emergency Medical Dispatchers (EMD), who work in an Emergency Operations Centre (EOC), and various types of paramedic and ambulance technicians working in vehicles or on-scene at incidents.

What follows is an approximate summary of the dispatch process, based on observational visits by members of the DASH team to the Waterloo EOC on 8 September 2017 and a shift in a LAS Fast Response Unit vehicle on 22 May 2017.[63]

In simplified terms, there are three main **operational** stages to the dispatch information process:

1. **Triage:** Gathering information about incidents and classifying them. Calls which seem to indicate immediate threat to life are regarded as the highest priority emergencies and those that are not life-threatening as merely urgent. Classification depends on essential information about the medical 'Nature of Call' (NoC) and the incident location. Overall, this is known as 'disposition'.[64]

   Because triage is mainly undertaken by telephone, the bulk of triage work is performed by EMD 'Call Handlers'. Incoming calls are logged into a call handling software system (ProQA[65]) which uses decision-support 'cards', organised in a hierarchical tree structure, to script Call Handler participation in the conversation and to format their recording of information from the call. Call Handlers play a vital role in providing reassurance to callers and applying 'common sense' judgement as to how calls are classified (described as 'card surfing').[66]

2. **Allocation:** Assigning resources to incidents. The main vehicle types are Fast Response Unit (FRU) cars and Ambulance Emergency Unit (AEU) vans, but there are arrays of other resource types including for example motorcycle and bicycle units and specialised types like the Air Ambulance which handles serious trauma cases.[67]

   Triaged calls are automatically passed into the main LAS Computer Aided Dispatch (CAD) system CommandPoint[68], which is operated by teams of EMD 'allocators'. The CAD system provides the central allocation database for allocators to make decisions using Geographic Information System (GIS) functionality, tracking each ambulance using GPS. The CAD system is then used by EOC allocators to monitor and support implementation.

FIGURE 3.1.1.D: AMBULANCE DEMAND COMPARED WITH POPULATION DENSITY, DEPRIVATION AND HEALTH INEQUALITY[69]

A: MAP OF AMBULANCE INCIDENT FREQUENCIES IN LONDON OVER 2016, SHOWING BOROUGH BOUNDARIES

Incident frequency (per 100m²)
- 1–12: Less than one per month
- 12–52: One per month to one per week
- 52–366: One per week to one per day
- 366 – 1,738: More than one per day

Source: Policy Institute at King's, LAS Incident data 2016

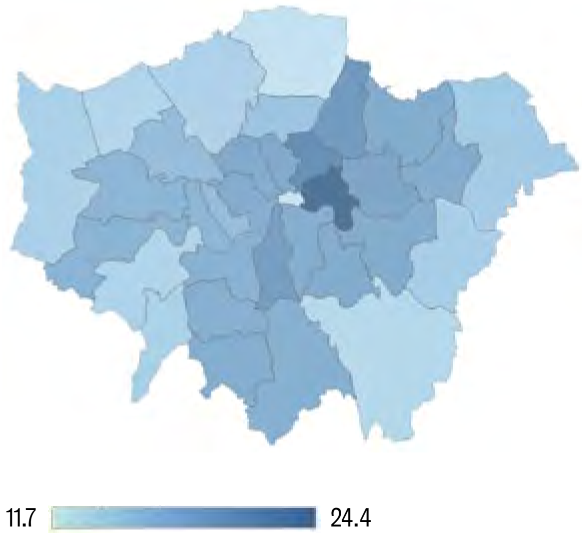
B. MAP OF LONDON'S POPULATION DENSITY, 2011 ('DASYMETRIC' MAP USING RESIDENTIAL LAND ONLY)

Net residential density (persons per hectare)
- 19 – 70
- 70 – 90
- 90 – 120
- 120 – 285

Data from
- ONS Census 2011 data on population
- ONS statistical boundaries
- European Environment Agency land use data

Map by James Gleeson jamesjgleeson.wordpress.[70]

C. NUMBER OF YEARS SPENT IN ILL HEALTH



Number of years spent in ill health

Source: GLA Intelligence

D. INDEX OF MULTIPLE DEPRIVATION 2015, LONDON

Of LSOAs in England
- In 5% most deprived (52)
- In 5-10% most deprived (222)
- In 10-20% most deprived (815)
- In 20–50% most deprived (1,964)
- In 50% most deprived (1,782)

Source: Department for Communities and Local Government, Indices of Deprivation 2015 © Crown Copyright and database right 2015. Ordnance Survey 100032215GLA

3. **Implementation:** Deploying paramedics and ambulance technicians to incidents. In the case of ambulance vehicles, blue lights and sirens may be used to travel more quickly to the scene of an incident. Treatment may be delivered according to on-scene assessment. Patients may be transported ('conveyed') to a health facility, usually an Emergency Department (ED).[71]

   CAD instructions are passed to 'Mobile Data Terminals' (MDT) in the ambulance vehicle itself, comprising the location of the incident to which an ambulance is assigned and some basic information about the incident (triage priority level, basic patient information and a description of the 'Chief Complaint'). Ambulance staff use the MDTs to log their status (responding, on scene, conveying, return to availability) and radio communications with allocators to discuss incident details. There is a LAS 'mobile app' for on-scene decision support using decision tree 'cards' for certain incident types such as trauma or falls. LAS' own Patient Report Forms (PRF) for on-scene recording remain paper-based for now, requiring crews to complete a form on A3-size paper.

These core stages of dispatch and their main ICT systems can be shown as follows:

FIGURE 3.1.1.E:
MAIN OPERATIONAL STAGES OF THE DISPATCH PROCESS

The dispatch process is actively supported at **tactical** and **strategic** levels in a variety of ways. These are the main channels for: (1) planning, implementing and evaluating systems for data usage, including ICT system transformations; and (2) interaction with research communities over system improvements based on data.[72]

The idea of equity, or fairness, of access to emergency services is an important part of the dispatch decision process.[54] Ideally ambulance services expect to maintain consistent good service provision, or 'coverage', across their whole geographical area over time. Base stations of emergency service vehicles are strategically positioned in anticipation of demand to minimise average or worst-case response times. Operationally, inequity may arise as vehicles are dispatched away from their idle locations and as demand varies over time. Inequitable coverage may be partly addressed by re-positioning idle vehicles in anticipation of demand but must also be considered when a dispatch decision is made. Uncertainty about demand locations, travel times, hospital handover times, and other factors make this a complex and dynamic problem. Real-time data combined with predictive models based on historical data can help reduce these uncertainties and ensure equitable coverage.

3.1.2 Significant current ICT innovation in LAS dispatch

The degree of uncertainty under which LAS staff work in the dispatch process is remarkable.[73] Decisions under conditions of higher uncertainty involve more risk. LAS can decrease uncertainty, and therefore risk, by improving the information available in the dispatch process using new sources of data. A thoughtful study in 2017 looked at measures which 'represent service provider and public perspectives' and found that the broad concept of 'accuracy of dispatch decisions' was most highly ranked by participants as a desirable quality and performance measure.[74]

The DASH project found that there is **significant current technological innovation around the ICT systems used to support the dispatch process**. LAS is actively engaged across a wide variety of initiatives to exploit technological opportunity and integrate new data into dispatch.

Examples relating mainly to **triage** have tended to reflect advances in telecommunications technology:

- The 'EmergencySMS' system to support access for deaf, hard of hearing and speech-impaired people exploits text messaging on mobiles;
- The 'RealRider' and 'eCall' systems for automatic transmission of data about road traffic incidents draws on the move towards telemetry data in road vehicles;[75] and
- Plans to replace the current 'Enhanced Information System for Emergency Calls' (EISEC) with the improved 'Advanced Mobile Location' (AML) system for improved rapid automated location data on individual incidents reported using mobile phones, exploiting advances in GPS tracking of mobile devices.[76]

Technological innovation around **allocation** has depended mainly on LAS' own capacity for innovative systems development:

- A system called 'Geotracker' has been developed within LAS in partnership with Birkbeck, University of London, the Ordnance Survey and others to augment dispatch allocation decisions.[77]
- An EOC 'Active Area Cover' desk works to balance resources between sectors, using features built into the Geotracker system to promote coverage (see **Section 3.1.1**).
- The LAS 'Frequent Callers' system supports the development of specialised responses for people who call 999 very often.[78]
- LAS also works with GoodSAM, an app designed to mobilise a voluntary network of registered responders to priority life-threatening incidents especially cardiac arrests.[79]

Implementation innovations have tended to relate to progress with system and patient digitisation in the NHS:

- In late 2017, LAS implemented a further layer of computerised support to ambulance crew decision-making in the form of tablet computers with the potential to access Electronic Patient Records (EPR) from NHS systems;
- LAS has developed an EOC function called 'Intelligent Conveyancing' to monitor ED department workloads which may cause handover delays. Intelligent Conveyancing aims to provide advice to ambulance staff regarding where to convey patients by looking up information about various ED, such as which facilities are closest, which have specialised treatment equipment and personnel and which have shorter wait times.
- LAS also played a pivotal role in the development of 'Coordinate My Care', a collaborative effort between services aiming to support clinically-led, patient-centred system for joined-up elective end-of-life care.[80]

3.2 Recent changes in dispatch-related policy: changing priorities and parameters (but targets still dominate)

These ICT innovations in LAS dispatch are good examples of 'diverse, hard-won, local and adaptive solutions', implemented within LAS and drawing in telecoms, operations and clinical professional expertise.[81] But the way the dispatch information process draws in data and operates generally is conditioned mainly by top-down policy rather than bottom-up innovation. This section discusses the key recent changes in policy constraints.

The main top-down policy levers are the AQI performance indicators (see **Section 1.4**) and commissioning arrangements. There are two AQI-related developments to consider:

- pursuit of 'non-conveyance' targets, where indicators are used to incentivise ambulances not to convey patients to Emergency Departments (ED); and
- the Ambulance Response Programme (ARP), a major reform to ambulance targets in England which was implemented in 2017.

Overall their effect for LAS has been: to increase appetite for new data which can be used to improve the quality of decision-making, especially clinical decision-making; and to raise questions of equity alongside efficiency goals. Dispatch is increasingly understood in spatial terms rather than purely in terms of time targets. Ambulance services are expected to minimise geographical disparities in performance as well as meeting certain aggregate standards.

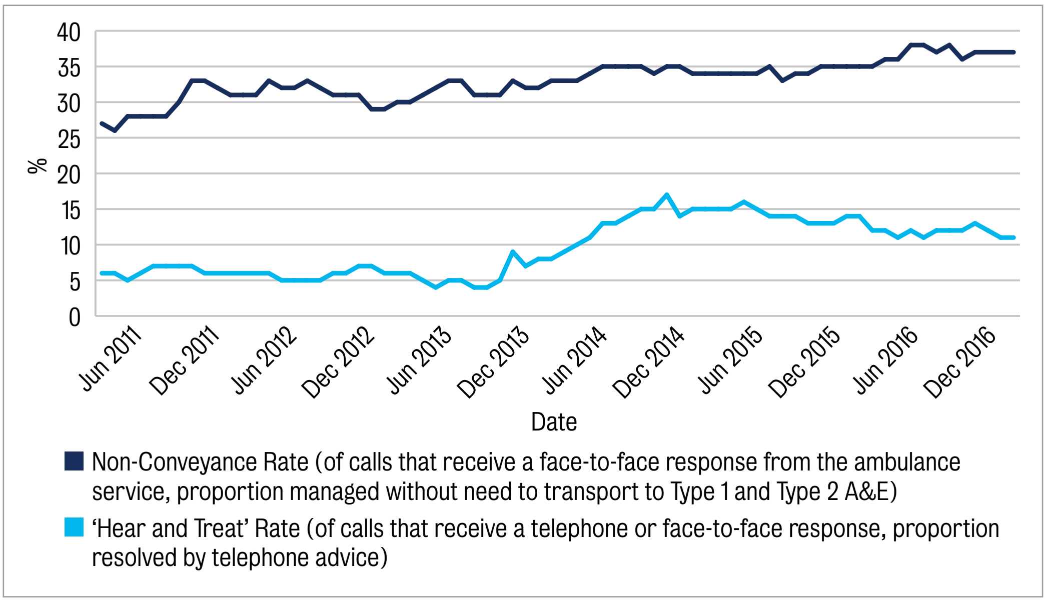
3.2.1 Non-conveyance targets and the rise of 'Hear and Treat'

The single most important ICT development in LAS dispatch in recent years is the 'Clinical Hub' (CHUB) which is designed to deploy advanced clinical skills in support of call handling and crews. Its key contribution has been to expand telephone advice to callers ('Hear and Treat'), usually in less severe (lower-acuity) incidents, decreasing the workload for the conventional dispatch allocation stage.

'Hear and treat' has become more prominent in dispatch because of NHS policymakers' concern with ambulance services' role in rising pressures on ED.[82] An AQI target has been established to reduce the ambulance 'conveyance rate', the tendency to transport patients to ED facilities. This is partly motivated by the prioritisation of ED cost pressures in NHS reform; partly by frustration with the 'vicious cycle of detriment'[83] caused by the notorious problem of handover delays from ambulances to ED[84]; and partly by observation that ED can involve poor experiences and outcomes for certain types of patient such as elderly people (who can get stuck in hospital for too long) or people with mental health problems (where ED is used as a 'place of safety' in the absence of alternatives).[85]

The AQI data suggests that LAS has made gradual gains on non-conveyance, and that it delivered a successful push towards 'Hear and Treat' over 2013-14 (see **Figure 3.2.1**).

FIGURE 3.2.1:
AQI AMBULANCE SYSTEMS DATA: NON-CONVEYANCE, 'HEAR AND TREAT'[86]



Continuing prioritisation of non-conveyance by policymakers continues as a strong influence on dispatch process development. The current focus is specifically data-related (see box) and explains why LAS has recently moved to introduce tablet devices for ambulance staff, as explained above.

How the NHS sees data as an 'enabler' of non-conveyance in dispatch

The NHS 'Commissioning for Quality and Innovation' (CQUIN) framework for 2017-19 includes an indicator for 'ambulance conveyance' aimed at 'reduction in the proportion of ambulance 999 calls that result in transportation to a type 1 or type 2 A&E Department'.[87] The idea is that 'better data sharing across the system', focused on individual-level health records, can help reduce conveyance rates. In Year 1 (2017-18), ambulance services are not expected to deliver results, but to fix 'enablers' to address the information scarcity problem:

1. Drawing in data about patients from the NHS Personal Demographics Service, Summary Care Record and Directory of Services systems.[88]
2. Putting in place the governance, guidance and skills necessary to make the data useful, by means of a 'system of support' for clinicians and a relevant 'workforce plan'.

In Year 2 (2018-19), ambulance services will be expected to deliver concrete reductions in conveyance rates, to levels determined by local negotiation informed by the results of the University of Sheffield CURE's 'Variation in Ambulance Non-conveyance' (VAN) Project which is exploring what drives dispatch performance relating to conveyance in practice.[89] The VAN 'First Look Summary' indicates 'opportunity for more standardisation of processes between ambulance services to reduce unwarranted variation in non-conveyance'.[90]

The drive away from physical conveyance in ambulance dispatch may pose risks to patient safety if it places emphasis on system diversion ahead of clinical decision-making. The importance of exploiting data to support non-conveyance with evidence grounded in relevant data is discussed further below in **Section 4.1.1**.

Risks to safety are especially serious because the effect could seriously exacerbate London's health inequalities. Ambulance demand tends to be higher in areas with high population density, especially under conditions associated with health stresses, and in areas affected by 'issues such as access to, and confidence in, primary care'.[91] So diverting people away, effectively hardening a definition of 'avoidable' ambulance usage, may exacerbate already-severe health inequalities by creating a feedback loop for disadvantaged groups in the context of severe pressure on general practice, adult social care and mental health care funding.[92] The LAS 'tethering pilot' initiative in 2017 could be interpreted as an example of the resulting pressures on dispatch. This restricted 'double crewed ambulances' (DCA) from moving outside the North Central sector boundaries as a response to persistently low high-priority incident response time performance in North Central London from 2016.[93]

3.2.2 The Ambulance Response Programme (ARP) and time to consider new data

Until 2017, the focus on time targets encouraged a focus on dispatch which tended to marginalise considerations of new uses of data and uses of new data. The ARP set out to address dispatch performance issues in England. It concentrated on the perverse and inefficient effects of over-applied time targets in the face of rising demand: the over-use of immediate dispatch decisions and the allocation of multiple resources to a single incident.[94]

'Ambulance trusts have organised themselves to meet response-time targets, at the expense of providing the most appropriate response for patients.' **House of Commons Public Accounts Committee**[95]

These have certainly been problems which have affected LAS.[96] The way in which time targets were applied pre-ARP meant that LAS and its staff tended to consider data with the potential to extend anticipation of demand as low priority compared with the immediate challenge of coping with demand.

'London Ambulance crews are utilised for over 85 per cent of their time... This constant pressure contributes significantly to our staff turnover rates with our staff leaving for a less pressurised environment. It also means that it is difficult for us to meet spikes in activity.' **LAS Five-Year Strategy to 2020**[97]

'... we're way too busy to be able to almost have the luxury of putting staff in particular strategic places ... we are so busy going from one job to the other that very rarely are we in a blessed position where we've got a crew member that we can put somewhere [to anticipate demand].'

'[dispatch performance] unravels, because we don't control it from the start. It's almost letting the horse bolt and then we're trying to get it to racing on the track. Whereas, if we just walked it to the track and let it go, it would be a different result.' **DASH interview participants**

The ARP has created space for LAS to consider new data differently, not by eliminating time as a measure of dispatch performance but by establishing that its application should depend on more thorough clinical decision-making.

Understanding the ARP

The ARP was split into three phases and evaluated by the University of Sheffield Centre for Urgent and Emergency Care Research (CURE).[98] It has reformed national dispatch triage categories from two (emergency and urgent) to four, each with a standard approach to allocation:

1. *Life threatening* – eg cardiac arrests, serious allergic reactions. Emphasis on the quickest response possible (including quick identification). This category, and therefore the number of calls subject to 8-minute response, has been substantially scaled down.
2. *Emergency* – eg burns, epilepsy and strokes. Emphasis on sending the most appropriate vehicle first time.
3. *Urgent* – eg late stages of labour, non-severe burns and diabetes. Treatment at home may be appropriate.
4. *Less Urgent* – eg diarrhoea and vomiting, urine infections. Telephone advice and/or referral to another service may be most appropriate.

The ARP also introduced more time for less urgent calls to decide the most appropriate response more accurately at triage (so-called 'Dispatch on Disposition').

Finally, it re-calibrated the 8-minute response time system indicator for highest-priority calls[99] in line with evidence on 'response time standard[s] as a measure of the impact and quality of ambulance service care' to break mistaken public perceptions of service failure and to mitigate the risk that:

'continued emphasis on 8-minute response times potentially reinforces the expectation that all 999 calls will, and should, get a rapid response and fuels a perception that the majority of 999 calls are for life-threatening conditions, when in reality these only comprise less than 10% of calls and cardiac arrest only 0.6%.' [100]

In summary, LAS dispatch is a field in which policy frameworks currently drive behaviour (including data innovation) more than technological possibility. But technological possibility needs to become more specific and practical to increase its relative influence. When considering new types of data, ambulance services need to assess costs as well as benefits and develop confidence that improvements in decision-making justify investment in data processing.

Policymakers might usefully reflect on the scope to develop policy – like the ARP – which tends to enable effective, outcomes-oriented innovation rather than crowding it out. Policies can enable service innovation both by supporting exploration of benefits and by seeking to minimise the costs of data processing. Non-conveyance policy also poses specific health inequality risks which deserve closer consideration in terms of needing to balance efficiency objectives with equity. The risks arise not only in terms of health treatment and access but in other dimensions including technological exclusion and the 'digital divide'.

4. Specific findings: how new data might improve dispatch

This section sets out the main findings of the DASH project on new sources of data for LAS dispatch. The first part discusses **six new data initiatives to improve LAS dispatch (Section 4.1). The second part presents the findings in overview and addresses the question of priorities (Section 4.2).**

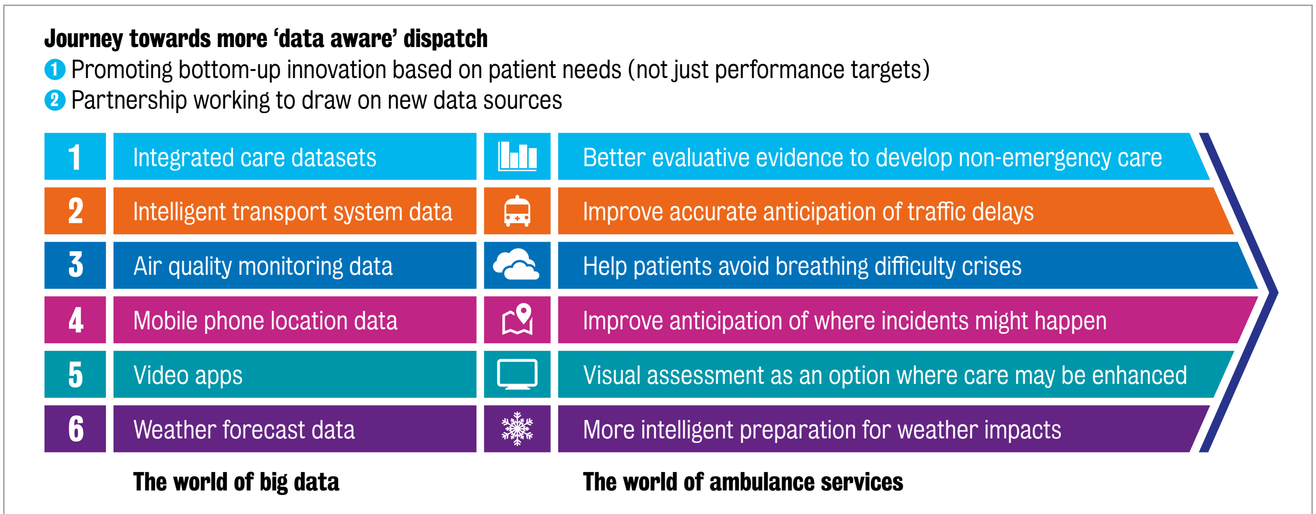
4.1 Six new data initiatives to improve dispatch

This section sets out key DASH project observations and recommendations on using new and emerging data to improve dispatch. The approach used to develop these observations and recommendations was described above at **Section 2.2**. By way of reminder, the six data types considered most relevant were identified in **Section 2.2.1** above as follows:

DASH data types for detailed consideration

1. **Integrated health & social care datasets** in the wider system (including information about patients outside the traditional UEC domain).
2. **Transport data** (especially exploiting London's 'Intelligent Transport System' (ITS)).
3. **Data on air quality** (including data generated and held by the London Air Quality Network).
4. **Data indicating population location** over time (especially from mobile phone networks).
5. **Data from video communications technology** not currently used in dispatch.
6. **Weather conditions and forecast data** not currently used in dispatch.

The illustration below gives an overview of the six new initiatives DASH recommends for LAS based on these data types.



Integrated care datasets

4.1.1 Encourage connections around the integration of health and social care data

Recent developments in the London health & social care data landscape are significant for LAS dispatch. As health and social care integration progresses, data on outcomes in social care settings as well as from non-emergency health systems like GP surgeries are being assembled under the same controllers. Leading examples of integrated care systems with data initiatives include: Tower Hamlets Together; South London Integrated Care; and NW London Whole Systems Integrated Care.[101] The DASH finding on this account is that a broad effort is required for LAS dispatch improvements, not just data 'linkage' in the technical sense. LAS has a leadership role to play in encouraging high-quality, patient-oriented progress across London as a whole.

Integrated health and social care data creates opportunities to extend the evidence base supporting ambulance dispatch. LAS can use data about what happens to people after they attend an incident to determine how their interventions promote the best possible outcomes for patients. 'Usually, [ambulance] systems collect a large amount of data, but this does not include data on what happens before and after the involvement of an [ambulance] vehicle'.[102] Data on patient outcomes is particularly valuable for improvement because it enables LAS to evaluate their decisions and processes and so improve the effectiveness of dispatch decision-making.

LAS is actively engaged in trying to draw in new data for outcomes evaluation, for example through the recent Pre-Hospital Emergency Department Data Sharing (PHED) project.[103] PHED set out 'to link ambulance data to hospital data to better understand what happens to patients after ambulance staff leave them at the hospital's emergency department, to show that greater information sharing can lead to significant patient benefits, without compromising confidentiality'.[104] The changing data landscape is creating opportunities for LAS to extend this approach to non-emergency incident segments in which patients were not conveyed to ED.

The most direct dispatch improvements from such uses of this data are likely to be at the implementation stage of the process. The variety of decisions, and responsibility involved in them, is growing over time; for example, the most experienced paramedics are being given powers to prescribe.[106] Ambulance staff are expected to make a range of on-scene decisions about how to help patients including decisions about whether and how to 'transition' patients to other services.[105] Patients deserve dispatch decisions, including conveyance decisions, which are evidence-based and safe.

The single most significant decision, given current NHS reforms, is one most paramedics face every day: whether to take people to hospital. As discussed above (see **Section 3.2.1**), LAS and other ambulances services are under pressure to increase 'non-conveyance' transitions that do not involve a trip to ED. The latest evidence suggests that progress against this target is affected by 'perceptions of the risk associated with non-conveyance within ambulance service management'.[89]

Commissioners recognise that access to data to inform ambulance staff decisions is a vital 'enabler' of non-conveyance, and there is some research to suggest that ambulance staff now being able to access patient records will improve the quality of care.[107] However the dangers of data overload on operational staff may be as great as data deficiency. As things stand, attention to providing data direct to staff is not matched with vigorous initiative to extend the evidence base demonstrating the safety and effectiveness of non-conveyance pathways. LAS staff difficulty in knowing whether non-conveyance is safe and effective can lead to unnecessary trips to ED. As discussed in **Section 3.2.1**, there is a risk that system non-conveyance targets push services to innovate in ways that are not proven to be safe or effective.

Elderly people who have experienced a fall are the leading example in terms of implementation. These patients form an increasingly important group from a system perspective, comprising 7.7% of overall demand in 2013/14 according to an LAS clinical audit in 2015.[108] LAS was one of three ambulance services to participate in a major randomised control trial ('SAFER 2') to develop a 'new clinical protocol which allowed paramedics to assess older people who had fallen and, if appropriate, refer them to community-based falls services'.[109] Another example is diabetic patients: the new LAS Integrated Hypoglycaemic Pathway for diabetic patients was developed over 2014-16 in partnership with the South London Health Innovation Network.[110] Recent research on dementia also indicates significant scope to develop higher-quality pathways with less tendency to conveyance.[111] As well as fresh ways to improve services for these patient segments, using integrated health & care data to improve understanding of outcomes might shed new light on decisions affecting other types of patients, such as: mental health patients; patients with breathing conditions (see below); patients with alcohol and substance abuse problems; and homeless patients.

There are also opportunities for triage improvements, but these are more contingent on factors outside LAS control. It is difficult to comment on plans for 'Hear and Treat' extensions in the EOC CHUB because much depends on implementation of the NHS 111 Clinical Assessment Service, as well as persistent concern about the accessibility of primary care and local authority telecare provision that is not 'fitted' to wider services.[112] However there may be potential to extend the Frequent Callers system using community responders or stakeholder engagement approaches, for example, building on local examples such as the Supporting You At Home pilot with the Royal Voluntary Society which concentrates on falls prevention and the alleviation of social isolation.[113]

It is important to recognise the variety and severity of the challenges involved in pursuing these potential LAS dispatch improvements. The necessary demonstrations of ethical responsibility depend on clearer understanding of practical possibility. There are positive indications that digital health technical development communities are making progress towards common standards for integrating health data.[114] But LAS' experience on the PHED project (see above) indicates that data linkage is difficult and time-consuming, even within the emergency care system where professionals are developing a shared dataset standard for emergency care.[115] Linkage in less acute incident types is likely to raise even tougher questions about the quality of data because of the general data quality bias towards sicker patients.[116]

In some circumstances, 'linking' datasets (in the sense of collating patient data at the individual level) may not even be possible because of what a recent paper on asthma calls the lack of 'scientific consensus... on the underlying definitions and algorithms'.[117] Arguably there has been insufficient attention to the need for conceptual integration to support the data effort. One thoughtful study on big data for dementia research likens the challenges to an iceberg, in that the more evident technical issues are underpinned by much larger problems which extend right down the level of 'mindset'.[118] There is a strong case for broader data 'connections' around ambulance dispatch, for example improving the dialogue between professional domains such as healthcare, public health and social services.

Forums for data integration conversations are becoming more active, notably the Healthy London Partnership (HLP)'s London Health and Care Information Exchange (LHCIE) governance framework initiative and the DigitalHealth.London catapult.[119] But London still has nothing as coordinated as Manchester's Connected Health Cities for the North of England[120] to convene actors, engage the public and work directly with data in a responsible way across London to generate evidence which is more firmly rooted in new data potential.

The opportunity here is as much about LAS supporting other services and researchers to develop insights from dispatch data as it is about LAS' own efforts to improve dispatch. One example of this thinking raised in DASH discussions was the potential value of making system urgent & emergency care system wait time information (similar to that used in LAS EOC Intelligent Conveyance function – see **Section 3.1.2** above) available to the public.[121]

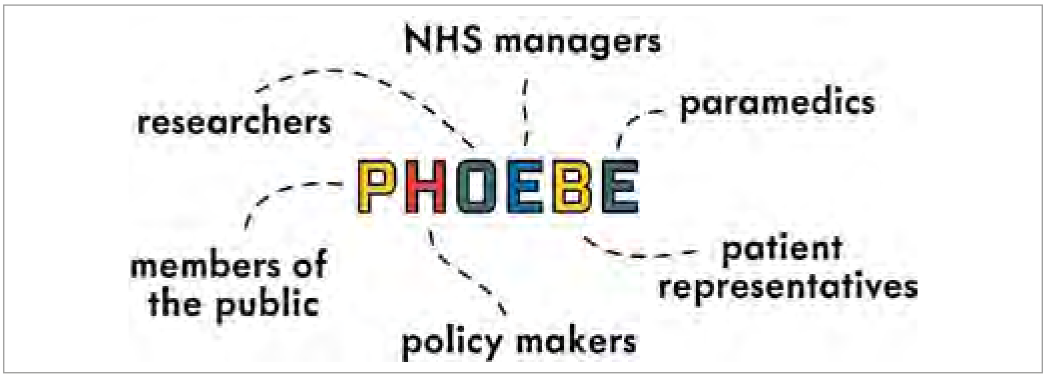
> *'Ambulance clinicians are routinely in situations and in patient's homes where they can identify health care prevention issues such as lack of heating, social care needs, mental health needs and the recognition of vulnerable adults. This information needs to be shared with other health and social care partners and more referral pathways developed.'* **National Ambulance Service Medical Directors (NASMeD): Future Clinical Priorities, 2014**[122]

LAS is uniquely placed to make a constructive contribution because the whole-of-London nature of dispatch means that it works to promote joined-up working across the city. For example, care home residents tend to be admitted as emergencies even when the indications are that outcomes for patients (including end of life experiences) would be equivalent or better in a residential setting.[123] One of LAS' key contributions to the 'Coordinate My Care' system for elective end-of-life care, which is a key feature of the LHCIE, was to promote a common standard for London-wide application in the development of a solution.[124]

This is not a matter of altruism for LAS. Post-ARP demands on dispatch present requirements for clinical evidence that have defied ambulance services around the world for more than a decade and which far outstrip LAS clinical audit resourcing.[125] The combined scale and severity of pressures exerted on LAS by public demand, system performance expectations and technological development call for a solution which exploits and promotes wider system strengths to improve care for patients.

Proper public engagement on data issues can also add to the channels available to LAS for the current, post-ARP 'opportunity to begin to have a much more open discussion with the public, and with policy makers, about ... challenges'.[126] The ongoing University of Sheffield Pre-hospital Outcomes for Evidence Based Evaluation (PhOEBE) project is showing the way forward for ambulance services by exploring models for outcomes-based evaluation which include the public and patient representatives, as well as policymakers.[127] The figure below shows how the project envisages the need for broad collaboration around service evaluation, emphasising innovations around data and evidence as a shared challenge rather than an exclusively technical enterprise.

FIGURE 4.1.1: PHOEBE PROJECT AS A MODEL OF COLLABORATION OVER DATA USAGE[128]



Recommendation: **LAS should encourage London data and policy research actors to develop broader, pan-London connections around the integration of health and social care data, to improve evidence on what works (especially in the context of non-conveyance targets).**

Intelligent transport system data

4.1.2 Partner with Transport for London to navigate traffic intelligently

Over recent years, people in London who have become accustomed to using transport applications like Google Maps, Citymapper or Waze to plan and monitor their routine travel might reasonably expect that the same or better technology is employed by emergency services to get an ambulance to them quickly.

> *'how come I can pick up my telephone here and, at a touch of a couple of buttons, I can bring up a map that shows me in big red lines which are the busiest roads, big orange lines which are the next busiest roads and then green lines, which roads are running freely, but I can't get that on the CAD system?'* **DASH interview participant**

Even with blue lights and sirens, and even taking into account LAS' use of bicycle and motorbike units, ambulances can find it difficult to get through London's congested streets to emergency incidents.[129] The map right shows 'straight-line' response speeds by LAS vehicles over 2016, indicating that these difficulties were relatively pronounced in inner North-West London.

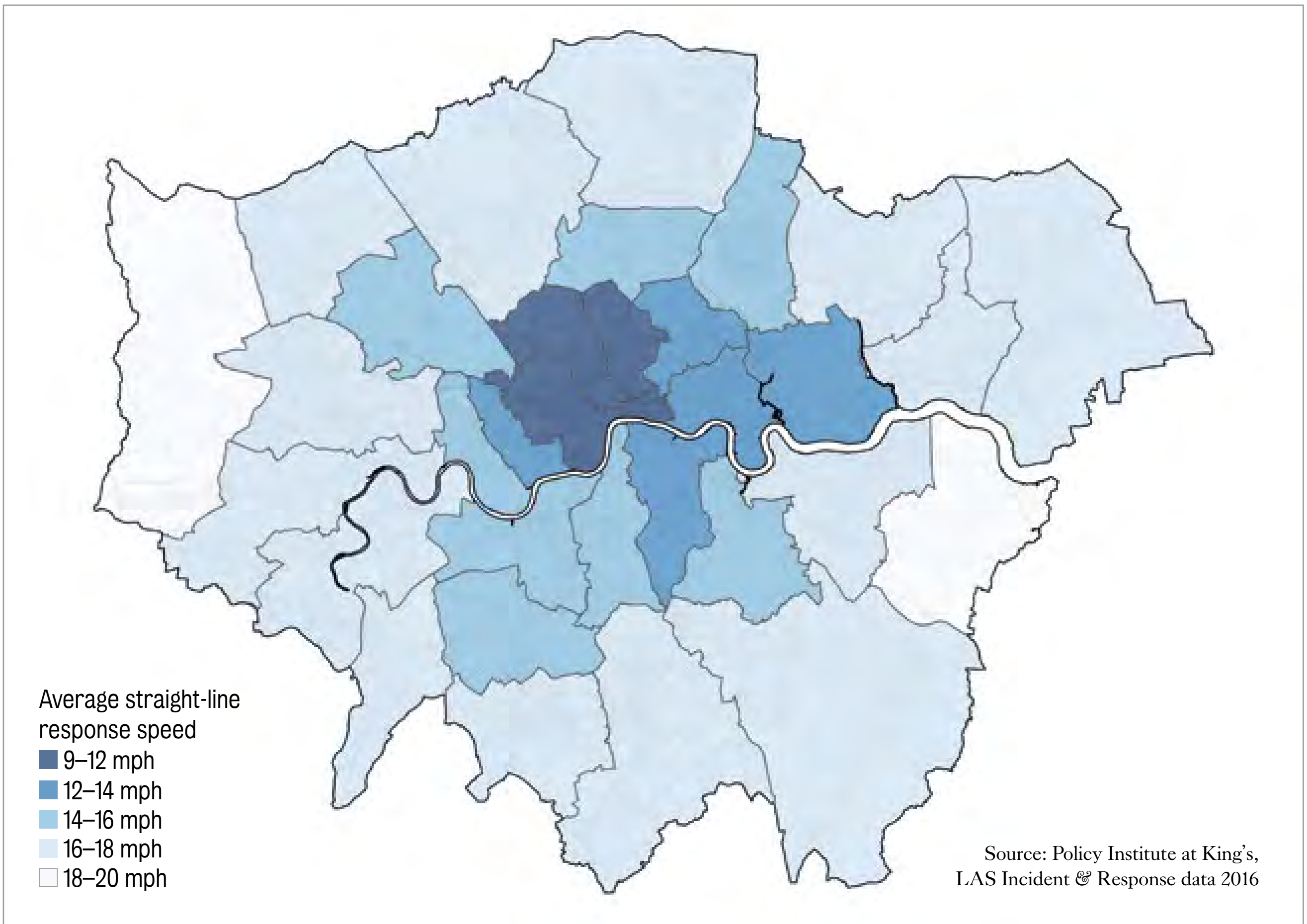


FIGURE 4.1.2.A: MAP OF AVERAGE STRAIGHT-LINE AMBULANCE RESPONSE SPEEDS OVER 2016, INCIDENTS GROUPED BY BOROUGH

London is considered a world leader in intelligent transportation and mobility.[130] There are a wide variety of new types and sources of data in the modern 'Transport Data Revolution'.[131] Traditional administrative data consists of notices about road closures and works; this has been superseded by 'live' dynamic traffic data, crowdsourced in real time from GPS-determined locations of devices in smartphones and vehicles.

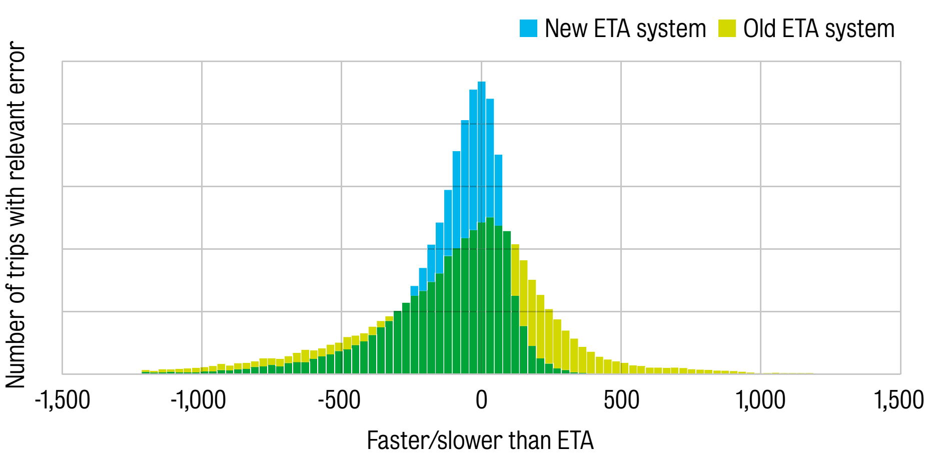
Transport for London (TfL) 'uses a variety of technologies to monitor and control traffic' in its TfL's Surface Transport and Traffic Operations Centre, including 'intelligent signal management' to adjust traffic light changes dynamically according to traffic conditions.[132] It has access to 'real-time, anonymous, proprietary incident and slow-down information directly from the source: drivers themselves' through partnership with Waze under its Connected Citizens Programme.[128] TfL is also committed to open data principles, making a 'unified API' available for data access and engaging vigorously with the 'developer community' in business to build a user base through which to realise the economic value of its data.[133]

There are three opportunities for LAS to improve its use of dynamic traffic data in dispatch decision-making. The first is for the routing engine of the CAD system, which generates estimates of how long it will take a selection of nearest available ambulances to reach an incident and recommends the one that will take the least time to reach it. The second is route recommendation and guidance by the LAS on-vehicle Mobile Data Terminals (MDTs) to support drivers in finding the fastest route.[135] Thirdly, there are potential uses of the TfL dynamic traffic light control system (as part of the London 'Intelligent Transportation System' – ITS).

Of these opportunities, the routing engine opportunity was found to show the most promise for dispatch system development and was the focal point for technical research under the DASH project. A recent LAS project to consider the potential for MDT data improvement has generated plans which LAS is reportedly implementing.[136] Dynamic signal management might potentially support LAS dispatch in limited circumstances but depends on wider TfL design considerations for the system.[137]

At present, static route cost estimation or historical response speed information is used to estimate ambulance vehicle response times which leads to avoidable uncertainty in the EOC as to whether an ambulance will arrive within the time estimated. Greater certainty that ambulances will arrive at the estimated time would make dispatch overall more efficient and reduce the propensity for large unanticipated delays to affect patient outcomes. **Figure 4.1.2.B** shows example results from a system innovation within a private company with a comparable fleet allocation challenge (Uber). Although the applications are very different, the underlying principle is the same: more accurate route cost estimations support efficient running of the system.

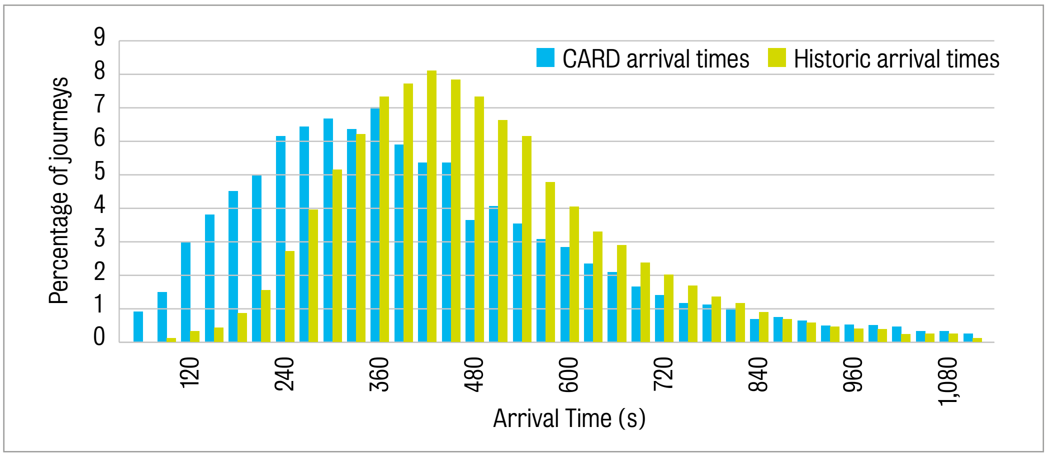
FIGURE 4.1.2.B:
ADAPTED FROM UBER ENGINEERING WORK TO REDUCE ROUTE ESTIMATION ERROR IN ALLOCATION DECISION-MAKING[138]



The systematic differences between the Estimated Time of Arrival (ETA) vs. the Actual Time of Arrival (ATA) across a sample of over a hundred thousand trips. The error distribution of the new ETA system... has a taller, tighter distribution than the old ETA system... This means there are smaller errors occurring in a fewer number of occasions.

Closer attention to this first traffic data opportunity represents an opportunity to improve dispatch location and relocation models, which consider optimal positioning of vehicles and other resources before and after an incident. Consideration of these implications enables estimates of the overall marginal benefit of improved use of traffic data. A 2013 paper from Birkbeck University suggested, based on LAS data from 2012, that using more accurate routing estimates that are sensitive to time variations in traffic could enable the majority of highest-priority (most serious, time-sensitive) incidents to be reached in 254 seconds rather than the actual 360 seconds (i.e. 29% faster).[139]

FIGURE 4.1.2.C: HIGHEST PRIORITY ARRIVAL TIMES COMPARED: HISTORIC (2012) VS. BIRKBECK'S 'CARD' VARIABLE-TRAFFIC MODEL



As discussed above, there are significant technical challenges for the real-time incorporation of dynamic data into dispatch given the degree of computational complexity involved.

> *'...routing would be much more accurate. [It would be] very, very useful. They just need real data! At the moment [it] is inaccurate and how can they trust that?... [But it] needs to be incorporated in a way that people don't have to think about – smooth integration so that it doesn't slow down the system; if there is a delay of a few seconds because the routing is more complex to calculate, that won't work.'* **DASH interview participant**

However DASH initial results indicate significant potential efficiency gains from using an auction-based algorithm to refine the current 'closest idle vehicle' allocation model. 'Closest idle' is demonstrably not always the best approach.[140] The box below sets out some of the work done under the technical side of the DASH project to explore alternatives.

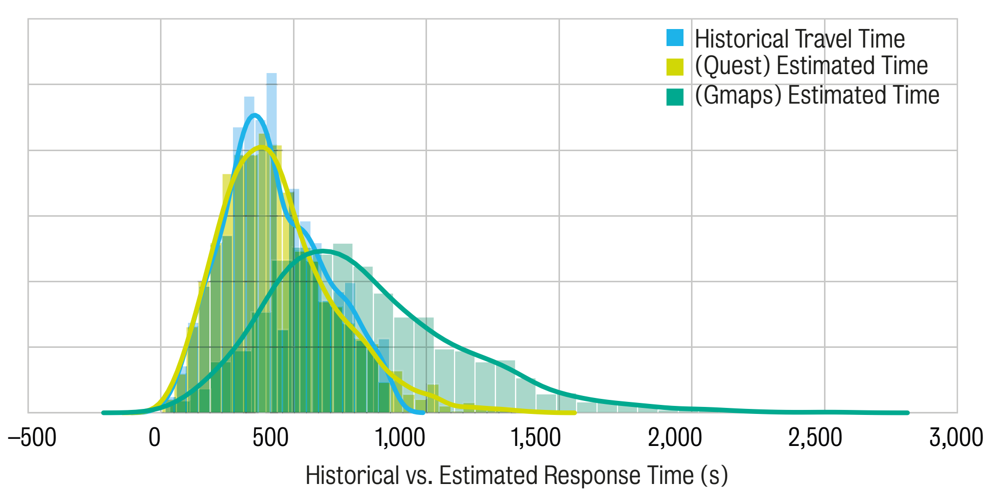
Multi-Agent Vehicle Routing and computer aided dispatch

The Vehicle Routing Problem[141] seeks to find optimal routes for a set of vehicles to travel from their current locations to a set of 'demand points' or incidents locations in an emergency services setting. The dynamic version of the problem, in which incidents do not appear according to a known schedule, poses challenges for traditional solutions such as mixed integer programming.[142] Market-based approaches such as auctions frame vehicle routing as a multi-agent systems problem, in which software agents independently compute the costs of travelling to incidents on behalf of vehicles in the forms of 'bids', and these bids are aggregated to compute an overall solution. Auction-based vehicle routing has been shown to produce near optimal solutions with the advantage of scaling well[143] and can adapt to the dynamic appearance of incidents.[144]

Experiments were conducted to compare average travel times of first-responding vehicles chosen by an auction-based routing algorithm with those observed in a sample of historical response times. The Quest Routing Engine[145] (Quest) was used to compute routes and estimate travel times between vehicle and incident locations. Quest's estimated travel times, which are derived from historical road speeds of emergency service vehicles,[141] were compared to estimates produced by the Google Maps Directions API[146] (*GMaps*) and to historical travel times. Quest travel time estimates show good agreement with historical travel times, while GMaps tends to overestimate, likely because its routing engine and traffic model are not tuned for emergency service vehicles.

A data set provided by the LAS recorded, for each incident that occurred in 2016, the location and call time of the incident, the locations of vehicles at the times they were dispatched to the incident, and the vehicles' travel times to the incident location. From this data set, 100 Category A incidents that occurred during January 2016 in the Haringey Clinical Commissioning Group were sampled. For each sample incident, the travel time, as estimated by Quest, of the historically-assigned first-responding vehicle from its location at dispatch time to the incident location was compared to that of a (possibly different) vehicle selected by an auction algorithm (see **Figure 4.1.2.D**).

FIGURE 4.1.2.D: DISTRIBUTION OF HISTORICAL TRAVEL TIMES COMPARED WITH ESTIMATES PRODUCED BY THE QUEST ROUTING ENGINE AND GOOGLE DIRECTIONS API FOR 2,000 VEHICLE JOURNEYS



Multi-Agent Vehicle Routing and computer aided dispatch (cont.)

In each auction, vehicles in the surrounding area not already assigned to any incident (idle vehicles) were identified in the data set and their locations at the call time of the incident were estimated. An auctioneer software agent ‘announced’ the incident location to agents representing idle vehicles, which computed and submitted bids to the auctioneer representing their estimated travel times to the incident location. The auctioneer then aggregated the bids received and assigned the lowest-bidding vehicle to the incident. While this simple auction mechanism essentially replicates the ‘closest idle vehicle’ model, bid computation may be extended to incorporate other factors, as discussed below. With this simplified model, auction-based vehicle assignment resulted in an average first-responder travel time of 205 seconds (σ=100) compared to an average of 396 seconds (σ=217) for first-responding vehicles historically assigned to incidents in this sample (see **Figures 4.1.2.E and 4.1.2.F**).

These results are based on several assumptions. The identities and locations of idle vehicles were not present in the data set provided by the LAS and needed to be estimated. Incidents were assumed to be independent: the effect of assigning a vehicle to an incident, possibly moving it away from responding to subsequent incidents in its idle area of coverage, were not modelled. Nevertheless, the auction-based model is attractive because the bid each vehicle agent computes can be extended to consider factors other than estimated distance or travel time, factors such as the cost of removing a vehicle from an area of service (decreasing the ‘equity’ of coverage53), crew fatigue, the ability of a vehicle to convey a patient, or the presence of specialist equipment or skills of personnel on board the vehicle. A key factor remains the ability of a routing engine to accurately estimate travel times, possibly enhanced by real-time traffic data. These factors that comprise a vehicle’s suitability to respond to an incident can be clearly presented to a human dispatcher who makes an ultimate assignment decision.

FIGURE 4.1.2.E: DISTRIBUTION OF TRAVEL TIMES OF HISTORICAL FIRST-RESPONDING VEHICLES COMPARED WITH THOSE SELECTED BY AN AUCTION MECHANISM

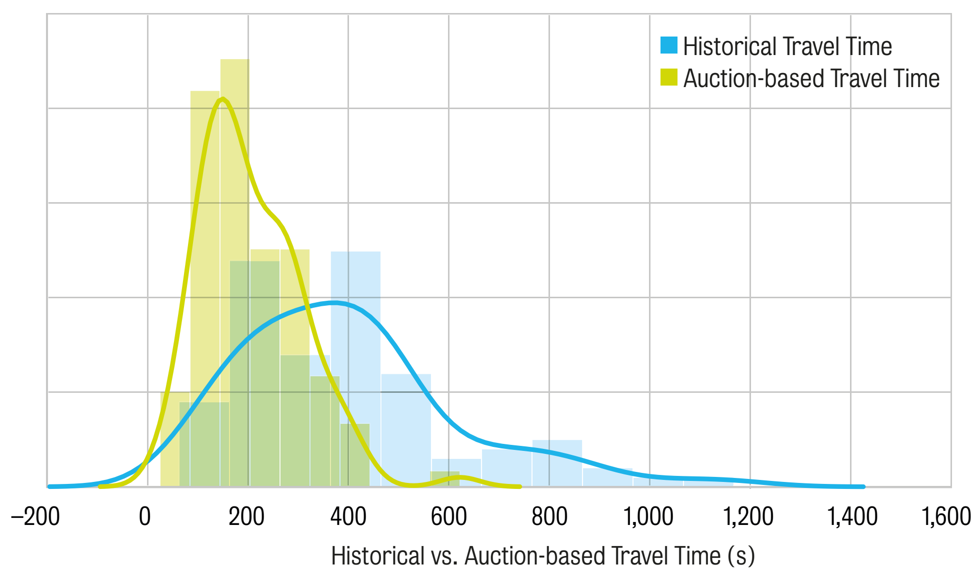
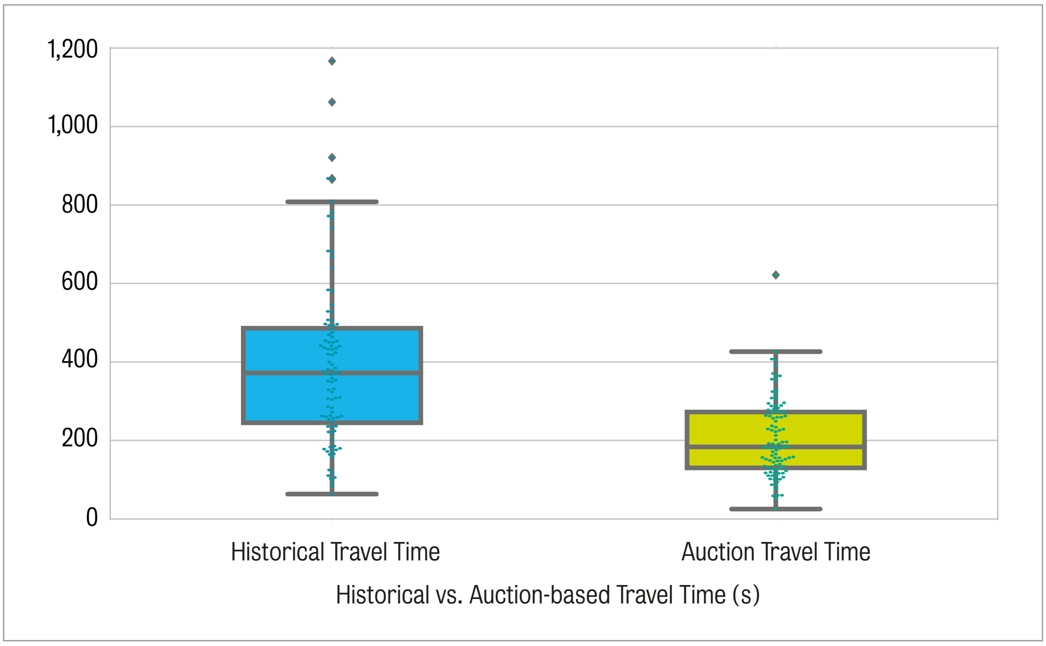


FIGURE 4.1.2.F: THE SAME VALUES SHOWING MEDIAN AND QUARTILE DISTRIBUTIONS



Although LAS has both significant expertise devoted to implementing related dispatch algorithm improvements (especially given ARP) and demonstrated EOC functional interest in area coverage (including use of the Geotracker system) it is not currently able to mobilise specialised traffic analysts like TfL or multi-agent algorithmic design developers to underpin a change initiative to draw on modern traffic data.

Difficulties in cross-sector working and limited city influence over basic services are amongst the recognised barriers to effective policy for the promotion of smart city benefits.[147] Although LAS and TfL increasingly work together on areas of mutual interest (such as the AED network on TfL sites and rapid response to health issues on the transport network with the potential to cause delays), it is not immediately apparent why transport in London, as a devolved function, should proactively engage to provide data for emergency health services, which forms part of the NHS and is therefore ultimately administered on a national basis. Building bridges between communities of practice in transport and health requires leadership, as the Mayor's Action Plan for Improving the Health of Londoners acknowledges.[148]

> *"...I don't want to get too political on it, but … we're not part of London [in the public sector structure]. Although we're the London Ambulance Service, we are London Ambulance Service of the NHS. We don't sit … anywhere [in London policy]."* **DASH interview participant**

These issues can be resolved through extension of London policy around ambulances as a priority user of London's roads and around leadership on intelligent mobility data-sharing as a key element of smart city progress.[149] The Mayor and the Greater London Authority (GLA) are well-placed to sponsor LAS partnership with TfL to demonstrate how London's networks of expertise can help mobilise cutting-edge traffic data in support of dispatch effectiveness.

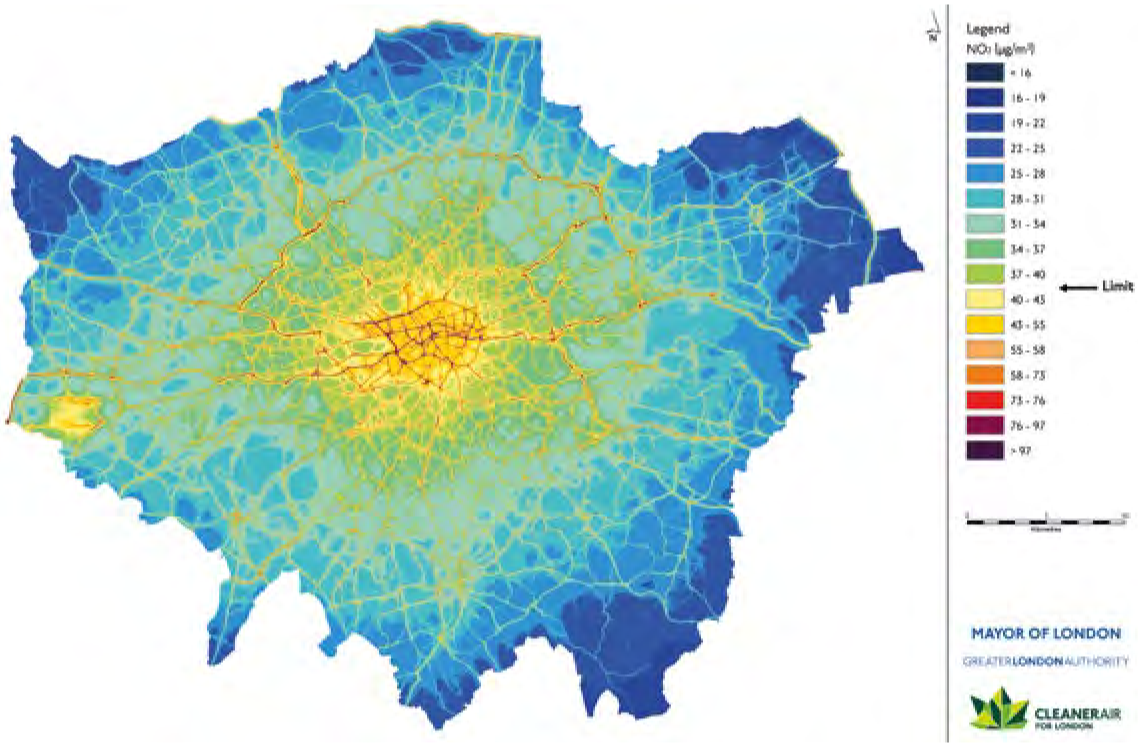
Recommendation: **LAS and TfL should initiate a joint programme of work aimed at delivering dispatch improvements drawing on TfL data, specifically concentrated on exploiting TfL live traffic data to improve the accuracy of LAS dispatch decision-making and therefore the quality and efficiency of LAS services.**

4.1.3 Engage with the London Air Quality Network to help predict demand

There is a strong and growing body of evidence that air pollution has a significant impact on health, especially in urban areas with high traffic.[150] A report from the Royal College of Physicians in 2016 highlighted how these health impacts begin to operate in childhood and even prenatally, as well as the role air pollution plays in the 'vicious circle' of health inequality.[151]

People in London with breathing conditions, such as asthma or chronic obstructive pulmonary disorder (COPD) are particularly vulnerable to heightened air pollution; and when they experience difficulty in breathing they often call an ambulance. The prominence of 'breathing problems' in LAS' demand (around 10% of incidents in 2016[152]) makes this a priority for dispatch improvement, notably finding ways to improve outcomes through non-emergency as well as emergency pathways (see **Section 4.1.1**) for patients with chronic breathing conditions. Asthma is a special priority because of the clear potential to improve the way the system manages patients with the condition.[153]

The new data relevant to this effort is air quality monitoring and modelling from networks of sensors. London has a world-leading position on air pollution data, reflected in the London Air Quality Network (LAQN).[154] The LAQN, which is administered by the King's Environmental Research Group, has played a pivotal role in supporting the Mayor and other city actors' development of environmental policy.[155] The map below gives an impression of the fine spatial detail available in the highest-specification LAQN models (the latest available year is 2013).



This map is used with acknowledgement to The Greater London Authority and Transport for London, who fund, develop and maintain the London Atmospheric Emissions Inventory. For more information please visit data.london.gov.uk https://www.londonair.org.uk/london/asp/annualmaps.asp

FIGURE 4.1.3: MODELLED ANNUAL MEAN NO2 AIR POLLUTION, BASED ON MEASUREMENTS MADE DURING 2013

Improved strategic intelligence for evidence-based improvement of LAS dispatch using air pollution data is a complex and technically challenging business. There are a range of different types of pollution involved, including Nitrogen Dioxide, Ozone, Sulphur Dioxide and various sorts of particulate matter. Sources, dispersion and exposure risks vary widely, notably according to atmospheric conditions, although pollution from traffic in and around roads is a major feature which makes TfL a key stakeholder for air quality modelling.[156] Although the field has concentrated mainly on static modelling for specific locations or areas over relatively long periods, specialists are now starting to move towards dynamic models which consider people's mobility over time and are therefore more directly relevant to LAS dispatch (including the new London Hybrid Exposure Model).[157]

Options are opening for LAS dispatch innovation as a result. Until now the focus has been on monitoring air pollution forecasts for extreme episodes as part of resource planning and public communications, based on work highlighting spikes in emergency admissions and ambulance call-outs under these conditions (especially after March-April 2014).[158] There may be an opportunity to apply insights from more detailed models to dynamic ambulance coverage approaches of the type discussed in **Section 4.1.2**, especially given growing knowledge about the longer-term and non-respiratory disease effects of air pollution on health (notably relating to cardiac conditions).[159] There is also potential to extend air quality analysis to include pollen and hayfever as well as air pollution.[160]

As with other chronic conditions (see **Section 4.1.1**), the main focus here is not on physical responses by ambulances but on a dispatch approach adapted to the wider clinical emphasis on holistic system prevention and management.[161] There is hype around self-management support apps, such as MyCOPD which support patients with COPD; but many apps are low-quality, and holistic 'medical intelligence' interventions based on service audits have stronger evidence on effectiveness.[162] Given its role in the wider health and care system, and its own direct concern about the incidence and spatial distribution of breathing-related crises requiring an ambulance, LAS is well-placed to improve evaluative standards around interventions.

LAS dispatch is also implicated in air quality as a producer of pollution through its fleet of vehicles. The status, and cost, of LAS' efforts to comply with London Ultra-Low Emission Zone implementation from 2019 is uncertain and could usefully be clarified as an example of public services leading by example.

There are no significant non-technical challenges for LAS in this area beyond the problem of resourcing. LAS can relatively easily collaborate with the LAQN to frame and resource specific initiatives relating to air pollution and improved dispatch around breathing conditions. DASH project work suggests two main points to consider:

1. Prompting actors to develop and pilot a patient support app for asthma sufferers in London which draws on LAQN 'nowcast' and forecast data[163] and patient location information, and which is properly designed and evaluated to maximise outcome improvement.
2. Public communications on plans to minimise pollution by LAS' fleet.

Recommendation: **LAS should develop a collaboration with LAQN to improve the analytical exploitation of air quality data for improvements in service provision to patients with breathing conditions.**

Mobile phone location data

4.1.4 Use mobile network providers' data and insight

As discussed above, the LAS dispatch process is supported at the tactical level by anticipatory forecasting functions and by frameworks for adjustment if demand outstrips planned supply.[72] New uses of data can help formalise the informal systems EOC currently use to monitor potential demand around the city in real time.

> *'We [currently] tend to rely on sight and sound stuff. So, if we start getting our resources on the ground saying, "There are a lot of people at Stratford,"... or, "Have you got something going on in Oxford Street, because there are a lot of people about today?"'*
>
> *'...we look at historical data, it gives an idea on what's going to happen. But, we don't yet put over the top of that real-time data... to see is it within the expected limits'...?'* **DASH interview participants**

LAS' analytical methods for ambulance demand prediction are sophisticated and forecasters engage with the constant challenge of keeping up with development in best-available modern dynamic adjustment standards.[164] One constraint is real-time population location data: '[the] data [typically used in predicting demand is] historical demand... [But] the most relevant data is how the city's population moves hourly, which is typically not available.'[165] In theory, using this data would enable transformation to a 'dynamic load-responsive ambulance deployment' approach to LAS dispatch (in other words, coverage adjusted to detailed knowledge about spatiotemporal demand for ambulances across London).[166] 'Combining spatial analysis and data mining' for ambulance demand prediction is at the cutting edge of ambulance research.[167]

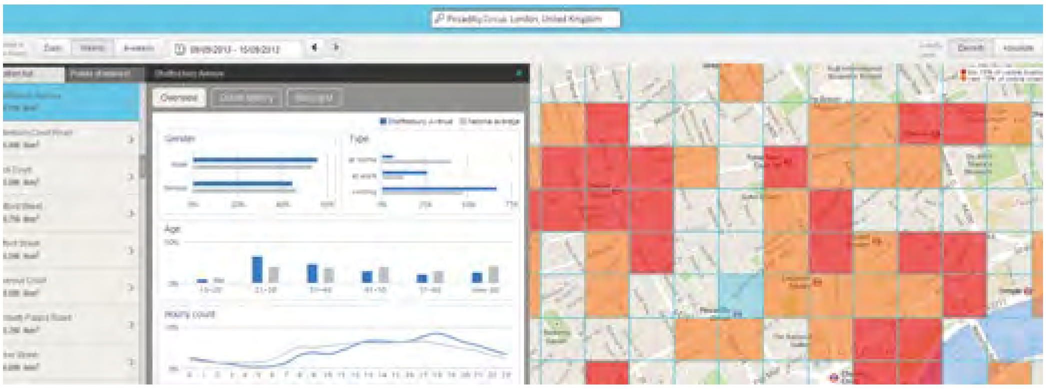
> *'... people don't think of the system this way. But with things like ... [the] increasing importance [of] Active Area Cover we may see increasing belief in data and trust in the system required to achieve usefulness from things like this.'* **DASH interview participant**

Questions of practical actionability create a problem for LAS not typically considered in the technical literature. Current prediction based on historical patterns is usually remarkably accurate[168], and can be used to organise dispatch on a reasonable time-horizon (shift pattern allocation etc). It is not always clear what can be done at short notice except to use existing approaches to cope with the unexpected extra pressures. The short-term benefits will likely be limited to a class of unanticipated events in which London's typical spatiotemporal mobility rhythms are interrupted for relatively extended periods (eg unplanned transport disruptions or natural disasters).

This remains an open question largely because the best available source of relevant real-time population mobility data currently lies beyond LAS' reach. 'Incorporating greater temporal specificity has already been established as having the potential to deliver massively more accurate assessments of population exposure to hazard, demand for services, and emergency preparedness...'.[169] But the best available data is population location data held by mobile network providers, which have different priorities.

A conference paper from 2014 based partially on Telefonica's 'Smartsteps' dataset shows the potential, although it looked at crime rather than health needs. The paper observed that mobile population location data 'provides significantly finer temporal and spatial resolution' than census and other administrative data: for 'each Smartsteps cell and for each hour, the dataset contains an estimation of how many people are in the cell, the percentage of these people who are at home, at work or just visiting the cell and their gender and age splits in ... brackets' (see **Figure 4.1.4**). Using this data for crime prediction 'significantly improves prediction accuracy (6%)'.[170]

FIGURE 4.1.4: SAMPLE VISUALISATION OF THE HIGH-LEVEL INFORMATION PROVIDED BY THE SMARTSTEPS PLATFORM[170]



This is an approach with significant technical challenges which have good potential for engagement with and resourcing through the research community.

> *'the technical barriers are related to performing privacy-sensitive reasoning with noisy and sparse data. … Mobile phone network data will ultimately provide both micro – and macroscopic views of cities and help understand citizens' behaviors and patterns.'* **Calabrese et al (2013)**[171]

Provided that the public are informed about intended use, including risks, and opportunities provided for objection and debate, there are grounds to proceed with 'macroscopic' perspectives with strong public health benefit potential. The risks include dispatch bias away from population groups less likely to use mobile phones (which is also a growing concern).[172] Privacy risks are relevant as well, although the data in question can be obtained from aggregated cell tower statistics reflecting load on masts and other sensors rather than from individual Call Detail Records.[173] Although the GPDR is now introducing higher standards (see **Section 1**), consent issues would depend on the extent of demographic information considered.[174]

This data is already being used extensively for commercial purposes. Although there is a movement to exploit mobile phone data for 'social good', it is currently focused on opportunities in developing countries.[175] As a result the greatest current challenge in London is economic: the network providers are exploring the value of the data for applications such as location-based marketing and normally expect to be paid for access. This effectively impedes any investigation into whether mobile population location data might be used by LAS or other ambulance services to improve dispatch and benefit patients.

> *'[They'd say:] I'll tell you what you want to know, as long as you can pay for it.'* **DASH interview participant**

There is a strong tradition of communications network regulation to support the work of the emergency services, including not only free access to callers on a priority basis but also the provision of caller location.[176] Recent initiatives have come mostly from industry and from European regulation (AML and eCall – see above).[177] The UK Department for Digital, Culture, Media & Sport (DCMS) operates a '999 Liaison Committee' which acts as the interface between the government, Ofcom as the regulator, emergency services (including LAS) and industry (including the British Association of Public Safety Communications Officers BAPCO).

Recommendation: **LAS should approach EE (as ESN provider) or another mobile network provider, via the DCMS 999 Liaison Committee, to request that they contribute sample aggregated mobile network population location data for proof of concept validation research.**

Video apps

4.1.5 Extend the use of video communications technology

People are increasingly familiar with applications which have video communications functionality, like Skype and Facetime, and able to use them on mobile devices. An Ofcom study in 2016 found that smartphone-based Voice over Internet Protocol (VoIP) applications for voice and video have a lower reach and frequency than other modes of telecommunication, such as email or instant messaging.[178] Nonetheless video communication is now a common phenomenon.

There is clear merit to considering the potential implications for LAS dispatch. As discussed above in **Sections 1.4** and **3.2.1**, dispatch is fundamentally reliant on communications technology: mainly audio telephone calls with patients at the triage stage of the dispatch process; but also increasingly at the implementation stage with the development of 'Hear and Treat' through the EOC CHUB. Historically speaking, fundamental transformations to ambulance dispatch have come through the uptake of underlying communications technology like the telephone itself. This continues to drive dispatch innovation, for example improvements to incident positioning (see **Section 3.1.2** above). It may be that video communications with callers to LAS or with patients may offer ways to provide more effective care.

> *'... for young mums at home, especially if they've got two children, the last thing I want to do is to go to an ED or to a GP surgery with two screaming kids ... and that's what you're going to have to do – so, 'Actually, I'll call an ambulance.' Well, actually, if there's an interim model that means, yes, you dial an alternative number or you dial 111 or 999 but you end up having a video consultation, then, absolutely, I think there would be a need for it, yes.'* **DASH interview participant**

There are various challenges for LAS use of video. Beyond limited existing use for event awareness[179], video has no clear place in the existing dispatch process. Consideration of its use for patient consultations needs to be considered from the perspective of wider clinical communities' evaluation of its advantages and limitations. Although it relates to a different context, the ongoing 'VOCAL' study is looking at how 'video consultations .... offer potential advantages to patients (who are spared the cost and inconvenience of travel) and the healthcare system (eg, they may be more cost-effective), but [also] fears ... that they may be clinically risky and/or less acceptable to patients or staff, [... as well as] significant technical, logistical and regulatory challenges'.[180]

LAS is obliged to start from first principles on video for dispatch because there is currently no applicable evidence available from other UK ambulance services on which to base an initiative. There have been reports that other services are trialling video functionality.[181] The Scottish Ambulance Service (SAS) reportedly uses video communications to serve remote communities, suggesting a stronger use case where geography obstructs the use of more conventional approaches to dispatch.[182] Under these circumstances, LAS would be well-advised to proceed 'slowly and incrementally' in accordance with VOCAL guidance.[183] Because of its combination of clinical expertise and familiarity with telemedical service delivery in the dispatch context ('Hear and Treat'), DASH interview participants tended to suggest the control room Clinical Hub (CHUB) as a suitable starting point from which to investigate utility.

> *'[The] best way would be through CHUB. Proof of concept. Get people comfortable. Learn lessons. Ethics and governance arrangements. Then pilot in call taking [later].'*
> **DASH interview participant**

Following a DASH project interview with a senior member of LAS operational staff, LAS are reported to be developing an exploratory pilot project for video link use in EOC dispatch decisions which would allow LAS dispatchers to request video linkage to a caller subject to their consent. There is potential to augment its work using qualitative data gathered under the DASH project including indications of support for uptake concentrated on relatively narrow application within the CHUB and Air Ambulance EOC functions (i.e. for 'Hear and Treat' support and major trauma triage). DASH work also suggests that proactive communications to the public about the pilot can help address the risk of negative media reporting. There are complex ethical and legal issues of access, consent and data protection to address here. Perhaps most significantly, any use of video communications in dispatch needs to address the risk of excluding patient populations without access to a smartphone or sufficient familiarity or skills.[184]

> *'We've often said in the control room, "Oh, man, if we just had a camera now…" You feel like saying, "I've got my phone. Look, mate, can you just video call?" You can't. You can't do that.'*
>
> *'… you've … got the usual nuances of having a phone – maybe, having a pay as you go, you haven't got that data allowance, perhaps, for whatever reason.'*
>
> *'… with things like consent, if you're there on the ground, … that footage of you, injured, unable to respond, if someone is suddenly videoing you, how do you store that data?'*
>
> *'… what [GoodSAM] … do is, they say, "I'm going to send you a text. When you open that text, I'm going to have control of your camera." And I think that's a lovely idea.'* **DASH interview participants**

DASH conversations tended to support the observations of a recent study which 'identified a number of unexpected potential barriers to successful transition from telephone to the video system. Most prominent were technical and training issues, and personal safety concerns about transitioning from telephone to video media. Addressing identified issues prior to implementation of a new video telehealth system is likely to improve effectiveness and uptake.' The study found that, 'while much has been written about the safety of patients in regard to video telehealth, there is little research on provider safety. When training providers in video-based communication, "video presence" should be one of the skills to consider'.[185]

LAS might also consider deployment of video consultations in the wider health system in the context of dispatch demand management. For example the launch of the GP at Hand service in London, based on the concept of rapid availability of remote GP consultation, has as-yet unclear implications for LAS.[186] As a CCG Clinical Review produced in response to objections observed, GP at Hand is new and there is insufficient evaluative evidence to determine what exactly its impact is and will be.[187] GP at Hand working at scale in London might diminish ambulance demand.[188] On the other hand, the Review observes that GP at Hand patients 'who need rapid face to face assessment may need to travel up to 45 minutes to see a health professional …[which] may… Increase the likelihood that they use closer, but less appropriate providers, particularly ED or other urgent and emergency care services …'

Recommendation: **LAS should continue with the proposed video link pilot project, drawing on DASH project insights if useful. LAS may also consider broadening work to consider the value of video consultation in the wider health system in the context of demand management forecasting.**

4.1.6 Challenge researchers to propose specific ways to extend uses of weather data

The scope for dispatch improvement based on weather data at strategic and tactical levels is less clear than for air quality, largely because LAS already makes extensive use of weather data. The main way in which climate data links to LAS dispatch is winter planning. Given the severity of annual 'winter pressures' on the NHS, it is positive that Public Health England (PHE) is 'making the case' for long-term strategic planning for cold weather.[191] But LAS is at the cutting edge, undertaking an annual winter planning exercise which integrates weather forecasts from the Met Office. Preparations are made through staff planning and fleet adjustments (winter tyres etc), as well as public information initiatives.[192] There are also more routine ways in which LAS uses weather data, for example taking forecasts into account in regular resource and special event planning and monitoring weather forecasts from the Met Office by email on weekly basis including alerts for severe weather such as storms.

A series of articles by John Thornes and others use air temperature data to establish the relevance of weather and climate conditions for ambulance dispatch, a relationship observed repeatedly in other countries but less well-studied in the UK.[193] In 2013, some observations on data from LAS observed a tendency for performance against indicators to deteriorate in cold (below 2 degrees Celsius) and warm (above 20 degrees Celsius) weather.[194] These findings were confirmed in 2014 with reference to data from Birmingham[195] and extended in 2017 using London data.[196] This research suggests two main climate impacts on dispatch: demand-side effects from weather-related health prevalence impacts such as fractures in cold weather and dizziness or fainting at warmer temperatures; and supply-side effects not only because of difficult road conditions (eg icy roads, poor visibility), but also because staff illness or travel disruptions can leave LAS short-handed.

> *'if we see a period of adverse weather coming up where it's going to be heavy snowfall, then it's a case of communicating that out to our operational colleagues to make sure their vehicles are equipped and ready. A lot of it comes down to business continuity and resilience, making sure that we're still able to get staff into site to carry on their work, somehow.'* **DASH interview participant**

Summer heatwaves (eg 2003, 2006, 2013, 2017) and unseasonable weather (eg 'heatwaves' in Autumn 2011 and Spring 2012) are less regular than winter pressures and receive less systematic attention in LAS, although the regular forecasting process for scaling resourcing adjustments and public information initiatives operates year-round. In the absence of clearer indications of what more LAS can do in practical terms to improve the use of weather information in dispatch to help patients, higher priority will be accorded to other data sources.

> *'I always thought it would be nice if weather forecasts could be incorporated more. What I'm not sure is how you would use it.'* **DASH interview participant**

The challenges involved in obtaining greater actionable insights from weather data are relatively well rehearsed in research, notably by the University of Exeter-led Medical & Environmental Data Mash-up Infrastructure (MEDMI) project.[197] The technical uncertainties for LAS remain considerable. Although air temperature correlations with aggregate demand are acknowledged and clinical functions are aware of developing knowledge about the causative relationships (for example, of weather on STEMI risks[198]), there is no evidence that spatial variations in weather across London are relevant to resource distribution planning or that LAS should be tracking other health-related weather metrics such as humidity. Forecasts are also not regarded as totally reliable.[199]

"You could plan, and then things change. The awareness is good, but things change within a week. For example, we were planning for 34-degree heat and it didn't happen. We don't want to change our plan too early.' **DASH interview participant**

DASH conversations indicated interest amongst several LAS functions in addressing these technical challenges, frustrated by three wider challenges: a lack of analytical capacity within LAS to explore the technical issues; discouraging experience of engagement with a diverse stakeholder landscape; and the economic barrier of being unable to justify financial allocations for uncertain returns. The Met Office is LAS' natural starting point for engagement. Three Met Office functions are relevant: health forecasting[200], which are delivered under a regular grant from the Department of Health & Social Care (DHSC); civil contingencies advisors[201], who 'help emergency responders assess the risk in their particular area from predicted or ongoing severe weather allowing preparations to be put in place to mitigate the impacts'; and the 'Big Data Drive'[202], under the Met Office 'is developing alternative solutions to meet the diverse needs of our users' because 'increasing volumes of data are providing a challenge to traditional delivery methods'.

'[We] have contacted Met Office before around… cold weather [and] snow [for example], but have found that they charge a lot for analysis.' **DASH interview participant**

This is discouraging but there is scope for LAS to reinforce its approach to weather data within specialist governance structures used for disaster preparation (Emergency Preparedness, Resilience and Response – EPRR). The figure below shows an overall conceptual model for emergency health planning which is remarkable in its similarity to the overall LAS dispatch process.[203] Given evidence about the differential impact of extreme events on patient segments like older people, there is also scope for LAS to improve evaluation of the effectiveness of its weather-related public communications.[204]

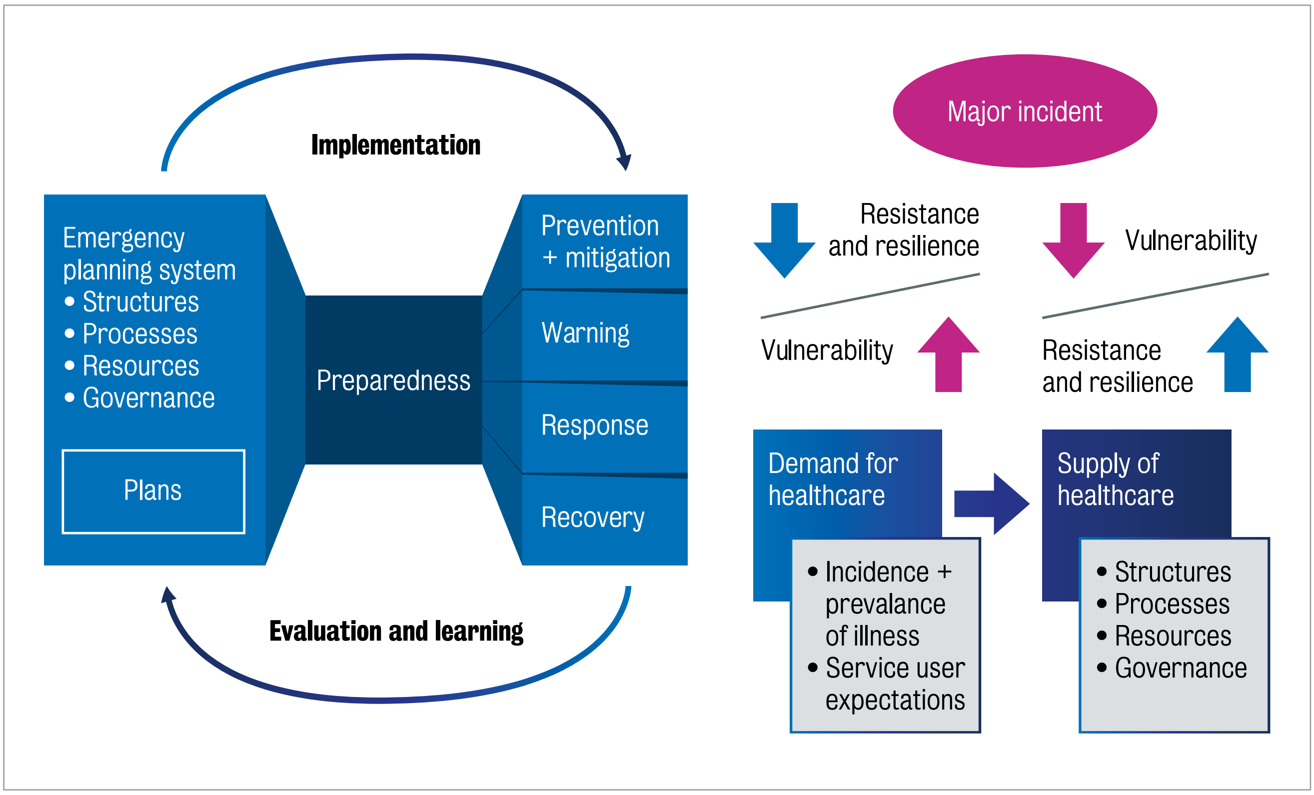


FIGURE 4.1.6: CONCEPTUAL MODEL OF HEALTH EMERGENCY PLANNING, SHOWING ROLE OF PREVENTION AND MITIGATION AND WARNING (ADAPTED FROM NIHR 2012)[205]

Recommendation: LAS should consider challenging researchers to generate further impactful research on weather and dispatch, including specific recommendations for further process improvements including to weather-related communications initiatives.

4.2 Overview of data to improve LAS dispatch

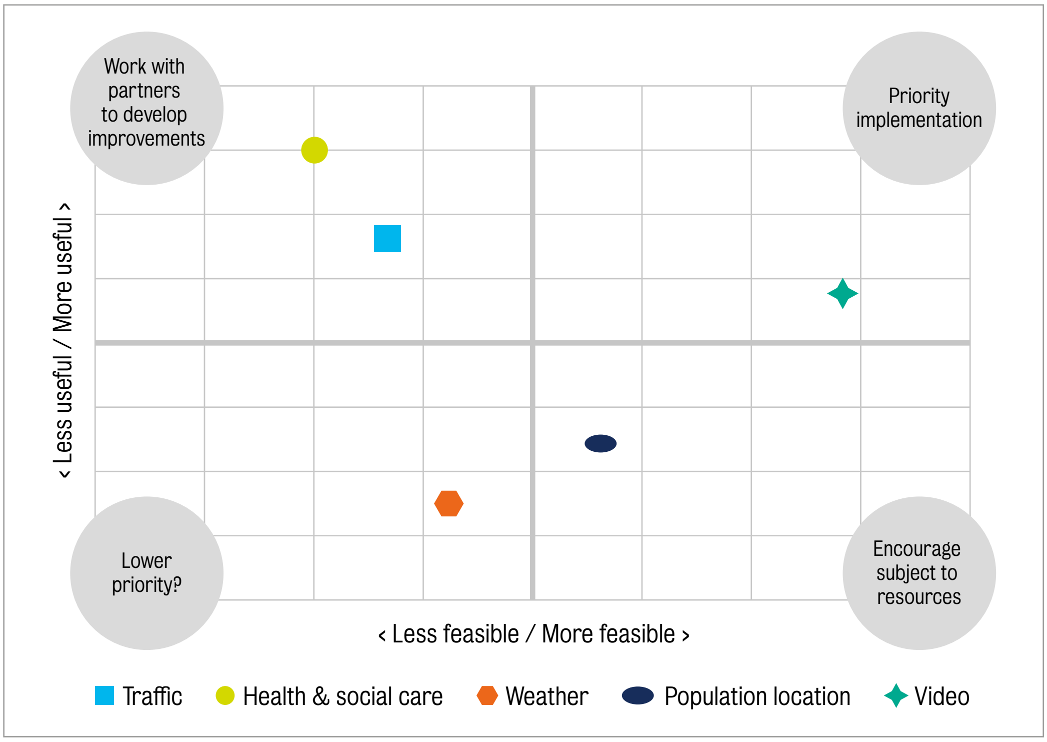
The table at **Figure 4.2.A** sets out a summary of findings, again referring to the six data types identified in **Section 2.2.1**. The table refers to: process stages described in **Section 3.1.1**; data use motivations and patient benefits discussed in **Section 4.1**; and process improvement types suggested in **Section 2.2.3**.

Section	Data Type	Process stage relevance (see Section 3.1.1)	Main motivation (see Section 4.1)	Patient benefit	Dispatch process improvement type (see Section 2.2.3)
4.1.1	Integrated health & social care datasets	Triage / Implementation	Safe increase to non-conveyance requires proper evaluative evidence for non-emergency ambulance pathway development.	LAS able to understand if they've helped you even if you haven't been taken to ED.	Segment / Transformative
4.1.2	Transport	Allocation / Implementation	Real time actual traffic conditions as a factor in route estimation accuracy improves the accuracy of vehicle dispatch decisions.	Fewer unanticipated delays when you are sent an ambulance.	Marginal
4.1.3	Air quality	Triage / Implementation	Detailed air quality information and forecasts could enable innovative care offerings to sufferers of breathing conditions.	Better support with your breathing condition rather than waiting for you to experience a crisis.	Segment
4.1.4	Mobile population location	Allocation	Knowing where people actually are in the city (as opposed to where they are assumed to be) can help anticipate calls and ensure coverage.	LAS better informed about when and where you may need an ambulance.	Marginal / Transformative
4.1.5	Video applications data	Triage / Implementation	Adding video to audio communications can improve the information available to dispatchers in some dispatch decision situations.	LAS able to use video assessments when helpful to your treatment.	Transformative
4.1.6	Weather	Allocation / Implementation	Decreasing dispatch performance vulnerability to extreme weather events.	LAS better informed about how weather effects might cause you to need an ambulance.	Marginal

FIGURE 4.2.A: SUMMARY OF DISPATCH IMPROVEMENTS BASED ON NEW DATA TYPE USES

Like other organisations, LAS needs to prioritise amongst the wide variety of potential initiatives on new and emerging data. The DASH project asked interview participants to rate the utility and feasibility of the main data types discussed and developed the matrix at **Figure 4.2.B** with the aim of supporting discussion of LAS prioritisation. Air quality is excluded from the matrix because of the relatively low coverage of air quality topics in the interviews. **The results suggest that LAS's current priority should be video communications with patients. Further priorities include health & social care data and traffic data linkage. Population location data is also identified as a worthwhile research enterprise for LAS.**

FIGURE 4.2.B: DASH DATA TYPES PRIORITIES MATRIX, BASED ON VIEWS OF LAS INTERVIEW PARTICIPANTS (N=15)[206]



The overall themes that emerged from DASH's work on LAS individual potential data initiatives can contribute to general strategic reflections on LAS technological development. They were as follows:

1. **Exploiting new data is not easy.** The nature of dispatch makes it difficult. In data terms, ambulance dispatch is stochastically dynamic as well as combinatorial: in addition to requiring a solution which contains many elements, the problem is not precisely predictable and only becomes clear as time passes. That makes it 'notoriously difficult to solve'.[207] Processing power is not sufficient, more ingenious algorithmic development is needed.[208] Perhaps most importantly, the issues involved in exploiting new data for dispatch extend out far beyond purely technical remits and demand policy attention to enable implementation.

2. **New data demands new resourcing.** LAS should emphasise dispatch as a shared enterprise, encouraging contributions from partners. In addition to conventional considerations of clinical skills, new data is making new demands on LAS resourcing including:
   - Orientation of internal analytical skills away from near-exclusive focus on performance reporting.
   - Access to advanced analytical skills externally through 'new relationships with the experts to improve the quality of support and evidence'.[209]
   - Access to specialised domain knowledge outside health/operations (eg transport, mobile communications, environment).
   - Compliance and standards development resourcing including ethical, social and political elements as well as legal/regulatory and technical development including security.

   Addressing these new demands involves innovative stakeholder engagement and research function initiatives to exploit developments in the wider public sector in a coordinated way. The discussion at **Section 4.1.1** above also suggests moving towards more 'open' data standards and practices at LAS. Specific data initiatives (eg with TfL or LAQN) could be usefully located within an overall academic partnership drawing on research impact methods and ensuring that London's brightest young technological minds and most experienced analysts are offered career opportunities at LAS. One specific DASH project suggestion was that LAS should issue a regular data research priorities bulletin to concentrate research efforts on usable results.

3. **New data demands new training.** Adding data sources means that additional training needs to take place for all personnel in the data-enhanced pipeline. This includes call handlers, ambulance crews, others in the EOC and those on the tactical and strategic teams.

4. **New data for dispatch advances London health inequality and 'Smart London' policy agendas**. LAS dispatch development in technological context demands policy activism. LAS data issues are coincident with London public health policy challenges, not just because of shared goals (reducing health inequality, effective public engagement) but because dispatch data reaches outside health ('health in all policies') and addresses Mayoral priorities (congestion, air pollution, public safety). The Smart London initiative argues that, in 'today's digital economy, data and data analytics are the fuel for future innovation in business and across London's public services'.[210] LAS can reasonably request that the Mayor and the GLA detail what that means in practice for London's ambulances.

New and emerging data is only one way to consider the opportunities arising for LAS dispatch in the rapidly-changing technological landscape. Existing dispatch communications generate large amounts of data, stored in archives as audio recordings from the triage stage of dispatch and scanned Patient Record Form (PRF) from the implementation stage of dispatch. The scale of these databases already far exceeds the analytical resources available to interrogate them for dispatch improvement purposes. LAS' priority is necessarily on data security. There is potential to extend this focus on responsible information system governance and standards innovation to enable more efficient approaches to analysis, notably development of PRF in electronic format (ePRF) to support individual data linkage (see above).

There is also significant potential to expand linguistic analysis based on call transcription and 'provide a deeper understanding of the interactional dynamics between caller and call-taker'.[211] A 2017 study using Conversation Analysis to interrogate small number of calls at one ambulance service suggested that exploring this approach might help develop 'more nuanced triage questioning strategies'.[212] Researchers in Denmark are investigating whether the application of machine learning technology in this context can help support reliable rapid identification of cardiac arrest incidents.[213]

Recommendation: **LAS should develop a strategic programme which concentrates attention and resourcing at the problem of dispatch improvement using data (including engagement with the Mayor and GLA over Smart London plans and development of more systematic academic partnerships).**

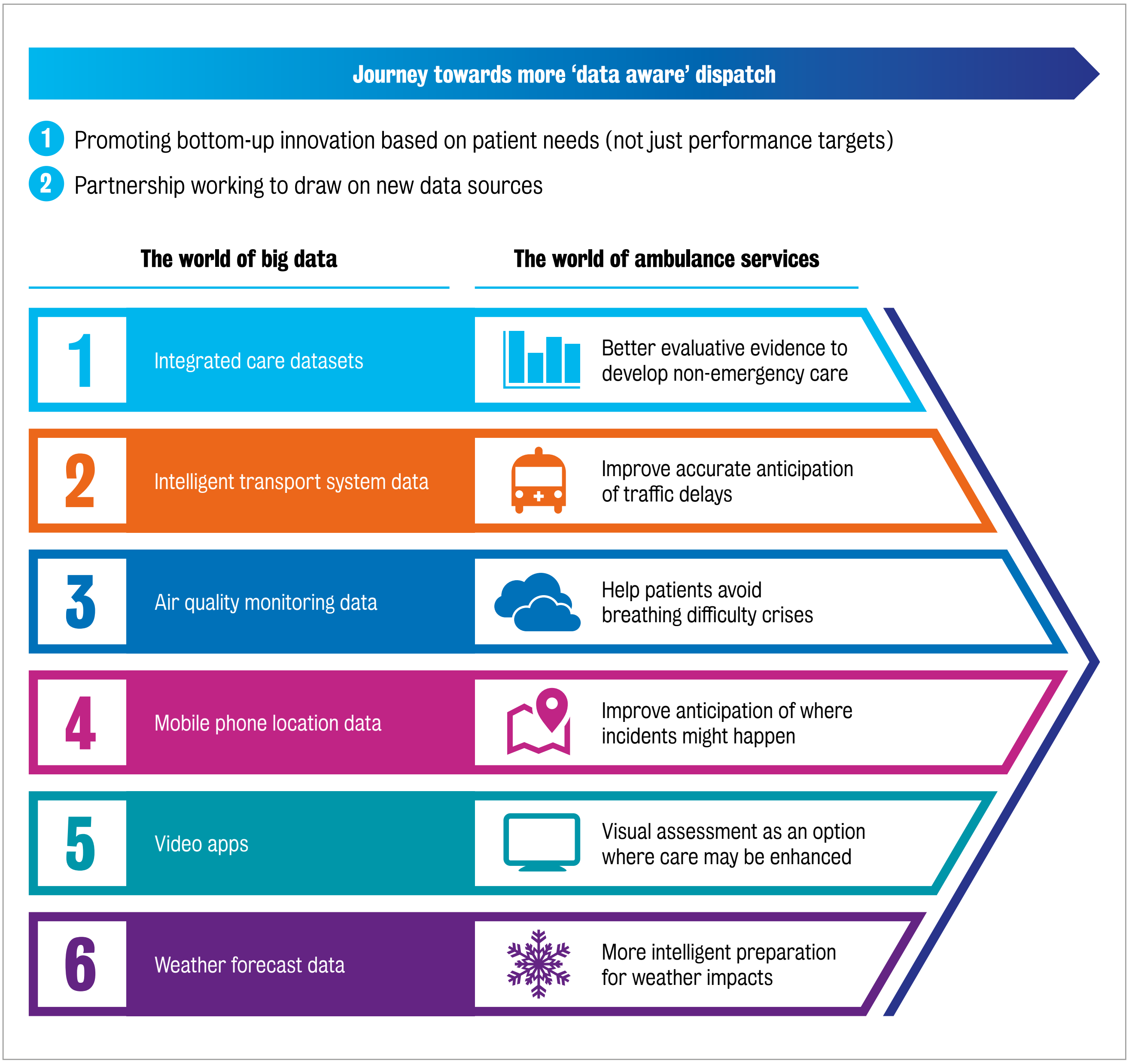


FIGURE 4.2.C:
DASH DATA INITIATIVES AMOUNT TO AN OVERALL JOURNEY TOWARDS MORE 'DATA AWARE' DISPATCH

PART C

Reflections

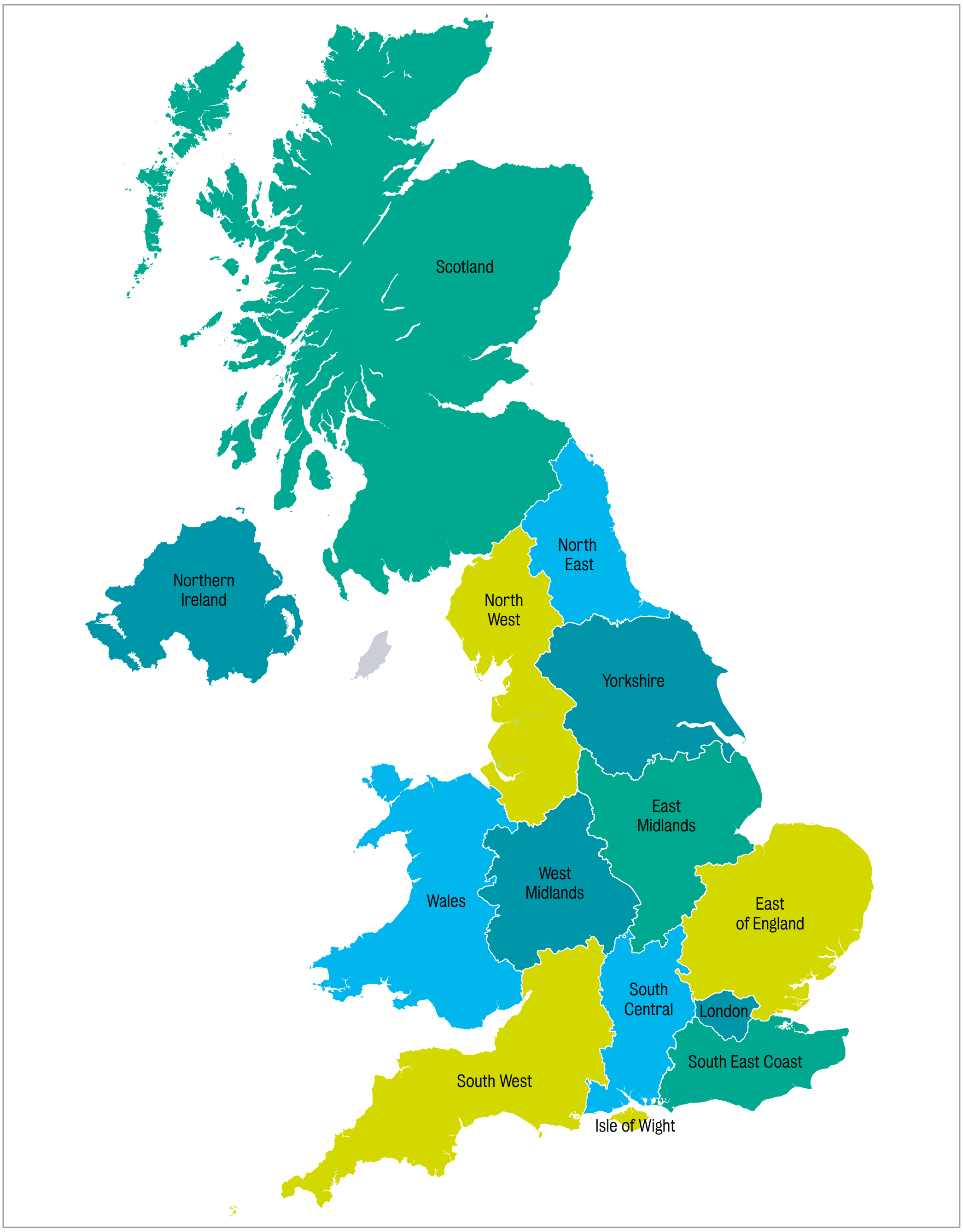
PART C: REFLECTIONS

5. Potential implications for other ambulance services and wider policy

5.1 Implications for other ambulance services

LAS is one of 11 ambulance services working regionally in England and there are a further 3 ambulance services in the UK working in each of Wales, Scotland and Northern Ireland. The map below shows the areas covered by each of the services.

FIGURE 5.1:
AMBULANCE SERVICE AREAS IN THE UK[214]



This regional division provides opportunities for learning from other areas. For example, care data integration is further advanced in Scotland and Wales than in other areas and provides interesting scope for reflections on non-emergency outcomes research to support dispatch (see **Section 4.1.1**). The basic dispatch process stages are likely to apply to all ambulance services, and the AQI performance targets apply for all service in England (see **Section 3.2**).

Whilst the data types presented in **Section 4** may be of interest to any ambulance service, the DASH project process of exploring the benefits and challenges in the LAS Case Study suggest that there are likely to be important local variations with respect to which data types are relevant for dispatch and how.

One important difference between dispatch at LAS versus other services in the UK is that the latter all cover rural areas as well as urban.[215] As discussed in **Section 4.1.5**, the incentives to develop video communications with patients are likely to be stronger for services with remote rural populations. There are also likely to be distinct applications of weather data in rural areas. On the other hand, data use motivations around transport, population location and air quality are likely to be weaker for rural areas: traffic congestion and air pollution will probably be lower priorities; and ethical concerns are likely to be stronger for population location data in sparsely populated areas. UK ambulance services other than LAS should consider rural as well as urban populations when assembling their own priorities for using new forms of data.

The DASH project has assembled recommendations for LAS in the London context of demand for 'strategic planning arrangements in large metropolitan areas with fragmented administrative and institutional boundaries'.[216] Given the relevance of health devolution (see Introduction), this may make the approach most relevant for the North West Ambulance Service (NWAS) since this covers Greater Manchester. The South West Ambulance Service (SWAS) are likely to have different priorities since health devolution in Cornwall relates to a much more rural population. Regional research capabilities are also relevant; while research itself is not necessarily region-specific, local proximity can promote collaborative relationships. For example, the South West has relatively strong environmental and translational health modelling capacity based at the University of Exeter and the West Midlands has relatively strong environmental and public health links based at the University of Birmingham.[217] The North of England has a significant ambulance research centre at the University of Sheffield; there is no real equivalent in the South.[218] Ambulance services in England also face a congruence problem: some boundaries do not coincide with other NHS administrative boundaries (even at the regional level[219]), let alone wider political or administrative boundaries. These complications are costly to address and, as well as creating opportunities, may represent inefficiency which discourage innovation.

5.2 Implications for national ambulance policy

Some of the data types and uses discussed in this report have national policy implications, notably: evaluation of non-emergency care outcomes (because of the relevance of the AQI national performance targets); mobile population location (because it implicates national telecommunications regulation); and weather (because it potentially involves the national Meteorological Office and DH&SC grant). The issues may therefore be best addressed through forums for national ambulance policy coordination, especially the Association of Ambulance Chief Executives (AACE) in England.[220]

As discussed above in **Section 5.1**, there are strong regional variations which have the potential to drive divergence in local practice on data uptake and, potentially, cross-boundary service differentials and coordination challenges. A key national challenge for AACE, the NHS, DH&SC, ambulance services and others is to maintain overall system coherence. This is not a challenge restricted to ambulance services and there is thoughtful research on how to establish frameworks for the 'scale-up, spread and sustainability' of health technology generally.[221] The DASH project has supported planning for the development of a national network for forecasting and planning including uses of new and emerging data, augmenting the activities of existing groups (notably the National Ambulance Information Group (NAIG) which is focused on ICT and data reporting issues and the National Ambulance Research Group (NARG) which handles research prioritisation and partnerships). One avenue, should less formal avenues for data innovation prove unsatisfactory, might be to apply for a given use or uses of data held within the public sector through the powers set out in Part 5 of the Digital Economy Act 2017.[222]

For wider NHS digital reforms, the DASH project can contribute to reflections on the interaction of key dynamics (fragmentation, resourcing, regulation). The government has not articulated any clear vision for ambulance services in the context of wider NHS reforms.[223] Might their remarkable qualities in data terms justify a re-evaluation of that omission? As the combination of NHS localisation and technological change tend to foster divergence in standards and practices, how far do national cohesion goals and efficiencies of scale demand renewed attention to regional structures in England, as well as the expansion of programmes like Global Digital Exemplars or practice networks like AACE?

> *'The lack of clarity [about the future format and function of … ambulance service] is currently resulting in … English ambulance services determining their own visions and starting to go down very different avenues for future models of delivery. … this may be entirely appropriate in terms of the local demographics, geography and health system infrastructure, [although] it could have consequences for national cohesion in terms of education syllabus, transferability of staff and the resilience of national ambulance service infrastructure.'* **Williams, Management of Emergency Demand (2015)**[224]

More specifically, the DASH project suggests that ambulance dispatch is a point of opportunity for various types of investment in positive technological change in public services. Although health data policy development generally is challenging for politicians, full of uncertainty and risk, it does carry the distinct advantage of clear prospective benefits which can be readily communicated to citizens. Ambulance services' prominence, existing disposition to innovation and ability to exploit non-health data for health purposes all make them an attractive option for policymakers seeking sensible ways to pursue those benefits.

As discussed above (see **Section 4.2**), supporting ambulance service technological development could constitute a useful initiative in the context of a national industrial strategy policy which accords prominence to the development of artificial intelligence (AI). Especially with proactive initiatives to engage with and integrate new data sources, ambulance dispatch offers good potential to explore and overcome the issues causing the current 'patchy' exploitation of AI in health.[225] The relevance of wide ranges of data to dispatch, its formal spatiotemporal definition and the relatively high levels of ambulance staff engagement in technological modes of thought all qualify this as an area for government to consider as it reflects on ways of Growing the Artificial Intelligence Industry in the UK.[226] Ambulance dispatch improvement links directly to UK national industrial strategy priorities, which sets out to address the 'grand challenges' including not only 'growing the AI and data driven economy', but also the 'future of mobility', the challenge of an 'ageing society' and the goal of 'clean growth'.[227] Technological innovations around ambulance service CAD systems would be suitable for support by the new GovTech Fund announced by the government in its new 'AI Sector Deal'.[228]

Finally, the DASH project examination of ambulance data policy suggests implications for data-related change in the administration of public services in the UK more generally. Because relevant administrative momentum and communities of practice have built up at the EU level rather than the UK (see for example **Section 4.1.4** above), the government should consider the impact of Brexit on ambulance performance prospects. More generally, changes to the world of data have important implications for policy on: the design and operation of performance management frameworks (targets); collaboration to promote digital innovation (beyond current programmes like the NHS Global Digital Exemplars[229]); and the handling of conceptual distinctions between policy areas (health vs transport vs communications infrastructure vs environment).

Recommendation: LAS should form a network to consider national coordination on forecasting and planning, and frame messages to central government designed to support services' exploitation of data issues around dispatch. LAS can also consider suggesting that AACE approach the government to discuss support to ambulance services on AI for dispatch under the UK Industrial Strategy, given their promise as a site of technological innovation within public services.

6. Conclusion

6.1 Summary of recommendations

This report has established a series of policy recommendations for LAS on the use of new and emerging data sources for emergency ambulance dispatch, which are summarised in the table below. Connections to the six DASH data types set out in **Section 2.2.1** and discussed in **Section 4.1** above are highlighted using the same numbering used there (1-6).

	LAS alone	LAS partnerships	LAS London policy	LAS national policy
General strategy	Develop a strategic programme which concentrates attention and resourcing at the problem of dispatch improvement using new data.			
Specific initiatives	• Continue with the ongoing video link pilot project.(5)	• Initiate a joint LAS-TfL programme of work aimed at delivering dispatch improvements drawing on TfL data and expertise. (2) • Develop a collaboration with LAQN to improve the analytical exploitation of air quality data for dispatch purposes. (3) • More systematic academic partnerships (including through continuing to develop the LAS data research partnerships bulletin) (see **Section 4.2**).	• LAS should encourage London data and policy research actors to develop broader, pan-London connections around the integration of health and social care data, to improve evidence on what works (especially in the context of non-conveyance targets). (1) • **Health inequality and Smart London engagement with the Mayor and the GLA** (see **Section 6.2**).	• Approach EE (as ESN provider) or another mobile network provider, via the DCMS 999 Liaison Committee, to request that they contribute sample aggregated mobile network population location data for proof of concept validation research.(4) • Promote the formation of a network to consider national coordination on forecasting and planning, and frame messages to central government designed to support services' exploitation of data for dispatch (see **Section 5.2**). • Request DHSC clarify how Met Office grant is advancing use of weather data for health service improvement including ambulance dispatch. (6)
For consideration		• Broaden work to consider the value of video consultation in the wider health system in the context of demand management forecasting.(5) • Challenge research actors to generate further impactful research on weather and dispatch, including specific recommendations for further process improvements including to weather-related communications initiatives.(6)		• Suggest that AACE approach the government to discuss support to ambulance services on AI for dispatch under the UK Industrial Strategy. (see **Section 5.2**).

FIGURE 6.1:
SUMMARY OF DASH RECOMMENDATIONS

6.2 Concluding reflections: the need for policymaker engagement to exploit these opportunities

The Introduction to this report framed ambulance services in the context of digital change to health services, the potential of data to drive better public services and the overall idea of 'big data'. Understanding how new and emerging data can improve ambulance services offers useful ways to consider the problems of digital change in health & care services and in public services more generally.

The DASH project approached ambulance dispatch from holistic perspective, recognising the interdependence of system elements which are sometimes treated independently: patient wellbeing and access; operational management; and clinical practice. It observes that **ambulance dispatch is a significant site of technological innovation which deserves greater attention and investment**. It suggests that there is a tension between current ambulance policy, which is mainly expressed as national performance targets based on system goals, and future ambulance policy, which seems likely to focus on fostering local technological adaptation based on patient outcomes.

DASH suggests six new data initiatives for LAS which add up to a potential **strategic programme to concentrate attention and resourcing at the problem of dispatch improvement using data**. Each of the initiatives has a distinct developmental profile; but overall the project suggests that developing more 'data aware' dispatch drawing on new sources of data offers a range of potential improvements for LAS itself and ambulance services more generally. More informed decision-making in ambulance dispatch can support improvement to: the quality of care; its cost-effectiveness; and the equality of provision across areas. In the ambulance service context, strategic development of new data uses calls for a balance between efficiency and equity goals to address the tension between targets and innovation responsibly.

DASH highlights that an effective ambulance service needs more than just financial resources and human resources; it is vital to provide and maintain appropriate data and related infrastructure, reaching well beyond LAS' organisational boundaries. It is yet another reminder that data opportunity involves much more than 'plug and play'. High value, low cost initiatives may be available, but technological change in public services is more context-specific, takes more time and requires more resources than many imagine.

> *'Policy-makers and practitioners should recognise that although single technologies can be made to work in different settings, this takes more effort than simply slotting a technology into place. Not least, technological interventions may require new resources to support their effective use, for example, requiring new roles, new organizational functions and considerable management time, all – perhaps – on an on-going basis.'* **Pope et al, NIHR (2010)**[230]

Because data-related transformation opportunities compete with operational demands for resourcing in today's health and care reform context, change depends on constructing cost-benefit analyses capable of reaching beyond established boundaries in terms of organisations and in terms of frameworks for finance or performance. The actual machinery for data transformation is technical which suggests research partnerships as well as a network of collaborations between public sector technicians in different domains. But uses of data need to be built up based on awareness and consensus rather than purely technical ambition[231], so clearly this indicates policy which is not just technically conceived. The current position of policy around dispatch requires public and policy engagement.[122] The need to establish awareness and governance innovation around creative uses of data for dispatch extends this requirement.

PART C: REFLECTIONS

DASH provokes some interesting reflections on technological change more generally. The idea of 'big data' doesn't capture the totality of what is happening; a lot of relevant data isn't that 'big' anyway. It is useful to think about the 'Internet of Things' and 'Smart Cities' too. While it is true that the technological revolution isn't magical and can't simply cut past traditional systems, there is an increasing need to develop constructive relationships between the exciting new world of technology, on the one hand, and beneficial established social and institutional systems, on the other. Citizens increasingly take technologies like efficient journey planning based on live traffic data for granted. The same technologies can make ambulances more reliable and efficient. The initiative would help affirm the beneficial effects of technological development as well as the vital role of public services.

All of this draws on policy thinking for the nascent information age which has become relatively abundant. 'What' policymaker engagement means is relatively well-established across a broad range of perspectives. Drawing on this style of policy to help LAS pursue more 'data aware' dispatch could improve effectiveness significantly, so there is a **need for policymaker engagement to exploit these opportunities**. Policymakers should consider that their responsibilities – and options – include *information* resourcing of services. LAS and other ambulance services can think about the potential to develop narratives which emphasise their performance as an expression of wider systems (health and beyond), encourage collaboration and promote policies which help resource service delivery with appropriate information.

Our concluding reflection is instead on 'who' are the policymakers. **Who is or should engage to support LAS on data at the policy level?** There are two answers to this question. The first answer is: everyone. To a surprising degree, ambulance service delivery depends not only on organisational leadership or NHS reforms but also on support in the domains like communications, transport or the environment, and on engagement by academia, the business community, the media and the public as well as by public servants. This report identifies some specific opportunities but technologists of all stripes might usefully consider how they can help ambulance services. While there are tensions between technology and government, ambulance initiatives can help affirm the beneficial effects of technological development by demonstrating positive public service applications.

The second, more specific and practical answer is: the Mayor of London and the GLA. Although there are various implications for national policy (see **Section 5.2**), the clearest concentration of policy opportunity and responsibility is in local government in London, as discussed briefly in **Section 4.2**. There are a wide variety of institutions and organisations in London with a part to play, including CCGs and Boroughs (from social care and public health perspectives) as well as members of the GLA Group, but no adjustment to formal responsibilities or delivery duties is necessary for improved strategy and coordination. The Mayor can exploit direct synergies with existing priorities including:

- Transport policy (analytical collaboration with TfL – see **Section 4.1.2**).
- Air pollution policy (collaboration with the LAQN – see **Section 4.1.3**).

Policy to support LAS using data can demonstrate the value of existing London expertise and resources. The GLA also has a statutory responsibility to promote the reduction of health inequalities, which are directly implicated in dispatch questions (see **Section 3.2**).[232] Why not consider support for data uses in ambulance dispatch as part of wider 'information resourcing' policy for health equality and promotion in London; especially to develop public communication, education and dialogue, and 'smart' cross-sectoral coordination?

An electronic copy of this report and the project policy summary are available on the project website: https://dash.kcl.ac.uk/reports/.


LONDON AMBULANCE
AMBULANCE

GLOSSARY

A&E	Accident & Emergency
AACE	Association of Ambulance Chief Executives
AED	Automated External Defibrillator
AEU	Ambulance Emergency Unit
AI	Artificial Intelligence
AML	Advanced Mobile Location
AQI	Ambulance Quality Indicators
ARP	Ambulance Response Programme
BAPCO	British Association of Public Communications Officers
CAD	Computer Aided Dispatch
CCG	Clinical Commissioning Group
CHUB	EOC Clinical Hub
COPD	Chronic Obstructive Pulmonary Disorder
CQUIN	Commissioning for Quality and Innovation (NHS commissioning framework)
CURE	University of Sheffield Centre for Urgent & Emergency Care Research
DASH	Data Awareness for Sending Help (this project)
DCMS	UK Department for Digital, Culture, Media & Sport
DH&SC	UK Department for Health & Social Care
ED	Emergency Department
EISEC	Enhanced Information System for Emergency Calls
EMD	Emergency Medical Dispatchers
EOC	Emergency Operations Control
EPR	Electronic Patient Records
EPRR	Emergency Preparedness, Resilience and Response
ESN	Emergency Services Network
FRU	Fast Response Unit
GIS	Geographic Information System
GLA	Greater London Authority
GP	General Practitioner
GPDR	General Data Protection Regulation
GPS	Global Positioning System
HLP	Healthy London Partnership
ICT	Information and Communications Technology
ITS	Intelligent Transport System
LAQN	London Air Quality Network
LAS	London Ambulance Service
LHCIE	London Health and Care Information Exchange
MDS	Minimum Data Set
MDT	Mobile Data Terminals
MEDMI	University of Exeter Medical & Environmental Data Mash-up Infrastructure
NAIG	National Ambulance Information Group
NAO	National Audit Office
NARG	National Ambulance Research Group
NHS	National Health Service
NIHR	National Institute for Health Research
NoC	Nature of Call
NWAS	North West Ambulance Service
ONS	Office for National Statistics
PHE	Public Health England
PHED	Pre-Hospital Emergency Department Data Sharing (LAS project)
PhOEBE	Pre-hospital Outcomes for Evidence Based Evaluation (CURE project)
PRF	Patient Report Forms
REAP	Resource Escalation Action Plan
SAS	Scottish Ambulance Service
SCR	Summary Care Record
SMS	Short Message Service (text message)
SWAS	South West Ambulance Service
TfL	Transport for London
UEC	Urgent & Emergency Care
VAN	Variation in Ambulance Non-conveyance (CURE project)
VoIP	Voice over Internet Protocol

LIST OF FIGURES

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NB all web links in these references were verified at 16 May 2018.

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91 Peacock & Peacock, Emergency call work-load, deprivation and population density: an investigation into ambulance services across England, Journal of Public Health | Vol. 28, No. 2, pp. 111–115 (2006); Turner et al, What evidence is there on the effectiveness of different models of delivering urgent care? A rapid review, NIHR (2015); cited in NIHR Themed Review, Care at the Scene: Research for Ambulance Services (2016). See also: Cowling et al, Access to primary care and the route of emergency admission to hospital: retrospective analysis of national hospital administrative data, BMJ Qual Saf. 2016 Jun; 25(6): 432–440; L'Esperance et al, Impact of primary care funding on secondary care utilisation and patient outcomes: a retrospective cross-sectional study of English general practice Br J Gen Pract 2017; 67 (664). In the mid-2000s, paramedic professionalisation was in fact pursued explicitly as a means of supporting primary care, as well as social care and mental health services, in response to demand pressures. (Department of Health, Taking Healthcare to the Patient: Transforming NHS Ambulance Services (2005) http://aace.org.uk/wp-content/uploads/2011/11/Taking-Healthcare-to-the-Patient-Transforming-NHS-Ambulance-Services.pdf; Woollard, The Role of the Paramedic Practitioner in the UK, Journal of Emergency Primary Health Care (JEPHC), Vol.4, Issue 1, 2006).

92 O'Cathain et al, Explaining variation in emergency admissions: a mixed-methods study of emergency and urgent care systems, Health Services and Delivery Research, No. 2.48 (2014): 'most [72%] of the variance in avoidable admission rates [between areas] is explained by deprivation but some [10%] is explained by differing practices in a range of emergency and urgent care services including ambulance services, hospitals and emergency departments'; Purdy, Avoiding hospital admissions: What does the research evidence say?, King's Fund (2010); Dejean et al, Inappropriate Ambulance Use: A Qualitative Study of Paramedics' Views, Healthc Policy. 2016 Feb;11(3):67-79; Booker et al, Why do patients with 'primary care sensitive' problems access ambulance services? A systematic mapping review of the literature, BMJ Open 2015. Although there is less attention to this perspective, some have drawn attention to 'problems of cultural awareness...; language and [other] communications difficulties; and a limited understanding of how the health system operates for some minority groups' (Race Equality Foundation, Ethnicity and prehospital emergency care provided by ambulance services (2015)). The same might be said for other groups at risk of exclusion, such as people with hearing or speech impairment. On funding, see for example: Ashworth et al, Funding for general practice in the next decade: life after QOF, Br J Gen Pract. 2017 Jan; 67(654): 4–5; Simpson, Public spending on adult social care in England, IFS Briefing Note BN200 (2017)

93 Meeting of The London Ambulance Service NHS Trust Board, Tuesday 01 August 2017, Agenda: Public Session

94 Turner et al, Ambulance Response Programme: Evaluation of Phase 1 and Phase 2 – Final Report, July 2017

95 House of Commons Committee of Public Accounts, NHS ambulance services, Sixty-second Report of Session 2016–17, Report, together with formal minutes relating to the report, Ordered by the House of Commons to be printed 24 April 2017

96 For example, a tendency to assign FRUs to calls within seconds, leaving no time for 'Dispatch on Disposition' and the assignment of more than one vehicle in about one third of physical responses. Also difficulties meeting the 75% target since 2014 and, partly in consequence, some negative CQC performance appraisals affecting morale and perceptions. These pressures are associated with LAS being placed in special measures by the CQC from November 2015 to May 2018 (http://www.cqc.org.uk/provider/RRU).

97 LAS, 5-year Strategy 2014/15 to 2019/20

98 Turner et al, Ambulance Response Programme: Evaluation of Phase 1 and Phase 2 – Final Report, July 2017; https://www.sheffield.ac.uk/scharr/sections/hsr/cure

99 Phase 3 of the ARP set new AQI time targets for the new priority categories, replacing the old 'threshold' approach to 'Category A' calls (75% of responses within 8 minutes) with a new hybrid system. The new system requires the average response time to be below a certain level (7 minutes for Category 1, 18 minutes for Category 2) plus response to 90% of these calls within other limits (15 minutes for Category 1 and 40 minutes for Category 2) (see Addendum to the NHS Constitution, September 2017 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/642390/NHS_constitution_addendum_September_2017.pdf). The target itself is an interesting case of targets in public administration. First introduced in 2001, the target successfully concentrated ambulance service performance on rapid response to high-priority incidents (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2667302/pdf/rssa0172-0161.pdf; Bevan & Hamblin, Hitting and missing targets by ambulance services for emergency calls: effects of different systems of performance measurement within the UK, J. R. Statist. Soc. A (2009) 172, Part 1, pp. 161–190). But reservations grew about its dominance. In 2011 a literature review looking at unintended consequences found that the 'focus on the eight-minute target has a potential to adversely affect the future modernisation agenda of developing clinical performance indicators and clinical education to its staff' (Wankhade, Performance measurement and the UK emergency ambulance service: Unintended consequences of the ambulance response time targets, International Journal of Public Sector Management (2011), Vol. 24 Issue: 5, pp.384-402)

100 Turner et al, Ambulance Response Programme: Evaluation of Phase 1 and Phase 2 – Final Report, July 2017; https://www.sheffield.ac.uk/scharr/sections/hsr/cure

101 King's Commission on London Final Report, March 2018: 'Lambeth DataNet, Tower Hamlets Clinical Effectiveness Group (now covering four CCGs), and recently, NW London Data Warehouse'. See: https://www.england.nhs.uk/ourwork/new-care-models/vanguards/care-models/community-sites/tower-hamlets/; https://www.kingshealthpartners.org/assets/000/000/690/FINAL_Full_End_of_SLIC_Report_original.pdf; http://integration.healthiernorthwestlondon.nhs.uk/. 'The last of these is arguably the boldest current model targeted to health in London. The scheme covers all 380 GP practices all mental health trusts and hospitals in 7 CCGs/boroughs, and social services. Anonymised data is extracted and placed into a data warehouse hosted by the Commissioning Support Unit. Data can be re-identified for 'direct patient care' but is anonymised for public health research purposes.'

102 Aringhieri et al, Emergency medical services and beyond: Addressing new challenges through a wide literature review, Computers & Operations Research 78 (2017) 349 – 368

103 Clark et al, Patient-level data linkage across ambulance services and acute trusts: assessing the potential for improving patient care, International Journal of Population Data Science (2017) 1:270

104 PHED successfully linked LAS data to data from 6 acute trusts (14 EDs) across London and is currently working to publish and support LAS service improvements using its results.

105 O'Hara et al, Decision-making and safety in ambulance service transitions, Health Services and Delivery Research 2014; Vol. 2: No. 56

106 https://www.england.nhs.uk/ahp/med-project/paramedics/

107 See for example Zorab et al, Are prehospital treatment or conveyance decisions affected by an ambulance crew's ability to access a patient's health information?, BMC Emerg Med. 2015; 15: 26

108 LAS Clinical Audit & Research Unit, A clinical audit evaluating the care provided by the London Ambulance. Service to elderly patients who have suffered a ground level fall, March 2015. LAS is remarkable in national AS in terms of not having a specific Falls Service commissioned as part of its delivery mix. For example: Wales Urgent Falls Response Service; Nottingham Falls Rapid Response Service; Scottish Ambulance Service 2014 'Making the Right Call for a Fall: Developing an Integrated Urgent Care Pathway for Older People'.

109 Snooks et al, Support and Assessment for Fall Emergency Referrals (SAFER) 2: a cluster randomised trial and systematic review of clinical effectiveness and cost-effectiveness of new protocols for emergency ambulance paramedics to assess older people following a fall with referral to community-based care when appropriate, Health Technol Assess. 2017 Mar;21(13):1-218. The SAFER2 study found that the protocol did not harm patients and led to 'some reductions in further emergency calls', although there was no evidence of improved outcomes or overall NHS emergency workload reduction. However its review of the available evidence observed that, in the context of generally poor evidence, when 'high-quality trial data were available, positive impact on patient and service outcomes was reported.' Although the trial collected information directly from participants (at 6 months and 1 year), its data was mainly restricted to records generated within the emergency care system.

110 https://healthinnovationnetwork.com/wp-content/uploads/2017/01/Hypo_Pathway_Implementation_Guide.pdf

111 In spite of falling rates of hospital death in dementia, 'ED attendance in the last year of life for people with dementia is common and is increasing': Sleeman et al, Predictors of emergency department attendance by people with dementia in their last year of life: Retrospective cohort study using linked clinical and administrative data, Alzheimer's & Dementia 14 (2018) 20-27. See also for example Manthorpe & Iliffe, The dialectics of dementia, December 2016 https://www.kcl.ac.uk/sspp/policy-institute/publications/The-dialectics-of-dementia.pdf

112 https://www.england.nhs.uk/urgent-emergency-care/nhs-111/urgent-care-workforce-development/. LAS is itself a provider of 111 services and actively engaged in 111 innovation (see for example: http://www.ilfordrecorder.co.uk/news/health/redbridge-residents-can-call-new-london-ambulance-hotline-to-get-prescriptions-and-advice-1-5359872). On primary care, see for example: http://www.bmj.com/content/358/bmj.j4345. On telecare, see: https://kclpure.kcl.ac.uk/portal/files/87498580/Utopia_project_report.pdf

113 https://www.royalvoluntaryservice.org.uk/news-and-events/news/partnership-with-london-ambulance-service-to-pilot-programme-which-aims-to-reduce-calls-to-999--

114 Note for example: INTEROpen (https://www.interopen.org/); the Fast Healthcare Interoperability Resources (FHIR) Specification (https://www.hl7.org/fhir/overview.html); and a new Local Health and Care Record Exemplar (LHCRE) scheme which has reportedly been launched by NHS England (http://www.bj-hc.co.uk/new-exemplar-scheme-drive-joined-delivery-care-across-health-system).

115 Notably through work on the Emergency Care Data Set (ECDS) https://www.england.nhs.uk/ourwork/tsd/ec-data-set/. 'There is interest in adapting the ECDS template for use in Ambulatory Emergency Care and Ambulance services'. http://www.rcem.ac.uk/docs/Informatics/ECDS%20Flyer.pdf

116 Porter et al, "Covering our backs": ambulance crews' attitudes towards clinical documentation when emergency (999) patients are not conveyed to hospital, Emerg Med J. 2008 May;25(5):292 – 5; Jones et al, The other side of the coin: Harm due to the non-use of health-related data, International Journal of Medical Informatics 97 (2017) 43–51

117 Al Sallakh M, Vasileiou E, Rodgers SE, Lyons RA, Sheikh A, Davies G. Defining asthma and assessing asthma outcomes using electronic health record data: a systematic scoping review. Eur Respir J. 2017 49: 1700204

118 Deetjen et al, "Big Data for Advancing Dementia Research: An Evaluation of Data Sharing Practices in Research on Age-related Neurodegenerative Diseases", OECD Digital Economy Papers, No. 246 (2015)

119 https://www.healthylondon.org/our-work/digital/london-health-care-information-exchange/; https://digitalhealth.london/about/

120 https://www.connectedhealthcities.org/about-us/what-we-do/

121 Based on the example of WaitLess implementation in Kent: https://www.kentcht.nhs.uk/service/waitless-2/.

122 Future National Clinical Priorities for Ambulance Services in England National Ambulance Service Medical Directors (NASMeD) April 2014

123 See for example: Oliver, Keeping care home residents out of hospital, BMJ 2016

124 Riley & Madill, Coordinate My Care: A clinical approach underpinned by an electronic solution, Progress in Palliative Care 2013 Vol. 21 No. 4

125 Williams, Management of Emergency Demand, in Wankhade & Mackway-Jones (eds.), Ambulance Services: Leadership & Management Perspectives (2015): the 'underlying increase [in demand for ambulances] is universal [across the developed world] with a number of similar themes emanating from socio-demographic changes of ageing and multiple illnesses combined with an urbanisation and fragmentation of communities. Secondly, that despite this being noted and documented consistently for the past 10 years across the world, there is still incredibly little clinically evidenced data for either explaining or managing [these] demand factors ...'. In the example of falls, a 2012 postal survey of UK ambulance services on service provision for older people who fall found 'wide variations in the provision of care': 'although service innovation for falls is widespread, clinically effective and cost-effective service models are yet to be developed' (Darnell et al, Elderly falls: a national survey of UK ambulance services, Emerg Med J. 2012 Dec;29(12):1009 – 10). Turner et al, Ambulance Response Programme: Evaluation of Phase 1 and Phase 2 – Final Report, July 2017 points out that massive increases in the scale of clinical audit might address the problem but are prohibitively costly.

126 Turner et al, Ambulance Response Programme: Evaluation of Phase 1 and Phase 2 – Final Report, July 2017. To take one example, the Metropolitan Police use a Public Attitudes Survey to help understand perceptions and local priorities; what might a comparable initiative for London health services add?

127 https://www.sheffield.ac.uk/scharr/sections/hsr/mcru/phoebe

128 https://aace.org.uk/news/good-ambulance-service-care-innovative-new-research-animation-explains-need-look-beyond-response-times/

129 This assertion is based on DASH observations from a FRU shift on 22 May 2017: when there is heavy traffic at certain intersections, other road users cannot move out of the way and ambulances can get stuck despite blue lights.

130 IESE Cities in Motion Index (2017) http://www.iese.edu/research/pdfs/ST-0442-E.pdf?_ga=2.86421848.1792964978.1496677288-573356761.1496677288

131 Transport Systems Catapult, The Transport Data Revolution: Investigation into the data required to support and drive intelligent mobility, March 2015 https://static1.squarespace.com/static/565ebf94e4b0f2a77109071e/t/56631604e4b0672d1446accf/1449334276748/Intelligent+Mobility+Data+Report+-+Final.pdf

132 London Assembly Transport Committee Olympic Delivery Authority, Evidence for Transport Committee's investigation into 2012 transport. For example, TfL has used the Siemens SCOOT system to accord buses priority at traffic lights https://www.siemens.co.uk/traffic/en/index/productssolutionsservices/strategydemandmanagement.htm

133 https://blog.tfl.gov.uk/2016/10/12/tfl-joins-the-waze-connected-citizens-programme/

134 https://tfl.gov.uk/info-for/open-data-users/unified-api; https://blog.tfl.gov.uk/2017/12/01/tfl-continues-to-engage-the-developer-community/

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136 DASH experienced difficulty in obtaining firm information on the use of and reform to MDT/satellite navigation systems in LAS vehicles. Parallel in-vehicle routing support systems were reportedly used until 2017, with potential alternatives including extension of the app developed by EE partner Mubaloo for the Air Ambulance http://mubaloo.com/case-study/londons-air-ambulance-laa-app/. LAS work on in-vehicle routing support is reportedly being undertaken in the context of wider reforms to the devices ambulance staff use, notably the new tablets through which patient information is accessed (see above). DASH found that some LAS staff already access live traffic data using their personal devices.

137 Emergency vehicle priority has been a standard option for ITS design for at least two decades (see for example Leeds University ITS, Selected Vehicle Priority in the UTMC Environment (1998) http://www.its.leeds.ac.uk/projects/spruce/utmc1rev.html#_Toc428247167 and US Federal Highway Administration,

Traffic Signal Preemption for Emergency Vehicles A Cross-Cutting Study, 2006). The most recent work on this element of ITS in the UK is the current Innovate UK-funded 'LIFE' trial in Liverpool involving the Future Cities and Transport Systems Catapults (http://gtr.rcuk.ac.uk/projects?ref=102414). Emergency vehicle priority in ITS needs to demonstrate benefits beyond blue light priority on the roads and sensitivity to the cost impact on wider congestion management (as well as potential 'wake' accident rate impacts). Ambulance priority may only be appropriate in limited circumstances, for example where severe congestion may impede large-scale mobilisation in response to a major incident.

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142 Victor Pillac, Michel Gendreau, Christelle Guéret, Andrés L. Medaglia, A review of dynamic vehicle routing problems, European Journal of Operational Research, Volume 225, Issue 1 (2013)

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147 Centre for Cities, Smart City Briefing (2014) http://www.centreforcities.org/wp-content/uploads/2014/08/14-05-29-Smart-Cities-briefing.pdf

148 http://content.tfl.gov.uk/improving-the-health-of-londoners-transport-action-plan.pdf

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152 LAS Incidents dataset 2016

153 https://www.nice.org.uk/sharedlearning/transforming-the-care-of-children-and-young-people-in-london-with-asthma

154 http://www.londonair.org.uk/LondonAir/General/about.aspx

155 https://www.kcl.ac.uk/lsm/research/divisions/aes/research/ERG/About-us.aspx; https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/how-were-cleaning-londons-air

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170 Bogomolov et al, Once Upon a Crime: Towards Crime Prediction from Demographics and Mobile Data, ICMI '14 Proceedings of the 16th International Conference on Multimodal Interaction, Pages 427-434

171 Calabrese et al, Urban Sensing Using Mobile Phones Network Data: A Survey of Research, ACM Computing Surveys, Vol. V, No. N, January 2013, Pages 1-21

172 Although the possibility of enhanced use of individual GPS trackers for certain patient segments (e.g. people with dementia) suggests that the bias issues are likely to be complex.

173 Calabrese et al, Urban Sensing Using Mobile Phones Network Data: A Survey of Research, ACM Computing Surveys, Vol. V, No. N, January 2013, Pages 1-21. The postal analogy would be counting sacks in the sorting office as opposed to counting or reading letters.

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175 https://www.gsma.com/mobilefordevelopment/programme/digital-identity/mobiledata4sg/

176 https://www.ofcom.org.uk/phones-telecoms-and-internet/information-for-industry/telecoms-competition-regulation/general-authorisation-regime

177 See for example the September 2017 vote of the European Parliament's Committee on the Internal Market and Consumer Protection (IMCO) in '112' emergency number reform (http://www.eena.org/news/european-parliament-votes-to-improve-the-112-service#.Wp3F0OjFJPZ)

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201 https://www.metoffice.gov.uk/services/public-sector/resilience/pwsa

202 https://www.metoffice.gov.uk/services/data-provision/big-data-drive

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204 McClelland et al, Psychological and Physical Impacts of Extreme Events on Older Adults: Implications for Communications, Disaster Med Public Health Preparedness. 2017;11:127-134

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