IDENTIFYING BENEFITS OF SHARED-FLEET HORIZONTAL LOGISTICS COLLABORATIONS: PATIENT SERVICE VEHICLES COLLECTING PATHOLOGY SAMPLES – A CASE STUDY IN A PUBLIC SECTOR HEALTHCARE SETTING

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Background

Road-based logistics can be associated with inefficiencies due to vehicles travelling with less-than-full loads. Shared-fleet logistics, involving horizontal collaboration between organizations to consolidate loads and improve vehicle utilization through sharing vehicle capacity, can reduce such inefficiencies, and thereby reduce costs, vehicle-kilometers (vkm), related vehicle emissions and traffic congestion.

One area where shared-fleet operations could offer benefits is logistics within healthcare settings. The United Kingdom's (UK's) National Health Service (NHS) is comprised of a wide range of publicly funded systems providing comprehensive healthcare services to the population, free at the point of delivery. As part of its remit, the NHS operates a pathology Sample Collection Service (SCS) to transport samples taken from patients at doctors' (General Practitioner; GP) surgeries to centralized pathology laboratories for analysis, typically outsourcing transport provision to external commercial courier companies operating fleets of Light Goods Vehicles (LGVs), commonly known as vans. At the same time, the NHS operates a non-emergency Patient Transport Service (PTS) using ambulances, similar in size to the vans typically used by courier companies (Figure 1), to transport eligible patients (i.e., those unable to use other transport means due to their medical condition) to/from routine hospital appointments. There is often considerable overlap between the geographical areas of operation covered by these two services, which suggests there may be scope to deploy shared-fleet logistics to consolidate loads and save costs for the NHS.

The potential for a shared-fleet operation involving the SCS sharing the vehicle capacity in the PTS ambulances as an alternative to engaging an external courier company was investigated. This situation required integrating dynamic and static transport demand, with the PTS demand being dynamic, based on ad-hoc allocation of transport tasks to accommodate variable demands from patients for transport to/from hospital appointments. This means that PTS ambulances perform different routes each day in response to each day's specific demand. The SCS demand is static, based on fixed-schedule vehicle rounds making collections from the same locations (i.e., GP surgeries) at approximately the same times each day.

FIGURE 1. Patient Transport Service (PTS) ambulance.

Research Aim

The aim of this research was two-fold: i) to assess the feasibility of integrating static and dynamic transport demand in a shared-fleet logistics collaboration involving a public sector organization as the prospective fleet provider to improve the utilization of their own-account vehicles; and ii) to quantify through a case study based on real-world data the potential benefits of such a shared-fleet logistics collaboration in terms of reduced costs, vkms and emissions of carbon dioxide (CO_2).

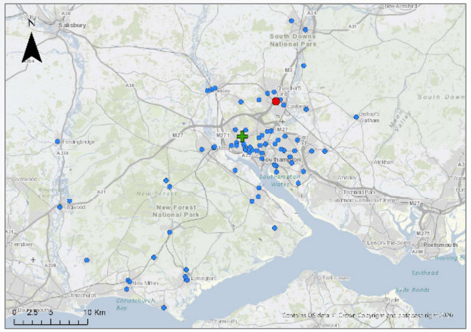

FIGURE 2. Map showing locations of PTS Eastleigh depot, GP surgeries and SGH. Red circle shows location of PTS Eastleigh depot, blue circles show locations of GP surgeries, green cross shows location of SGH.

Methodology

Business-As-Usual (BAU) Analysis

The study focused on the PTS ambulance depot in Eastleigh situated just to the North of Southampton, a city on the South coast of the UK (population ~260,000) because this depot represented the most convenient location from which to service the network of 78 GP surgeries that all send samples to the centralized pathology laboratory located at Southampton General Hospital (SGH) (Figure 2). The analysis was completed for March 2021 based on two datasets that provided details of historic vehicle routings for the PTS and the SCS. The PTS dataset described the movements of the 33 ambulances based at the Eastleigh depot. On average, these ambulances performed 26 rounds each day in BAU, with each ambulance transporting an average of 6 patients/day either to or from their routine hospital appointments (i.e., non-emergency transport). Some patients had specialist travel requirements, such as to travel in a wheelchair (standard or extra-large), travel on a stretcher or travel alone, and the ambulances were of several different types with varying capacities to accommodate patients' travel requirements (Table 1).

Pathology samples are packaged by each GP surgery into consignments consisting of a medium-sized insulated medical carrier (brand name Versapak, Figure 3) for collection twice per day, typically an early (AM) and late (PM) collection from each surgery. The SCS dataset described the movements of 10 courier company vehicles (diesel vans) performing 10 collection rounds each day in BAU, collecting up to 18 consignments (i.e., visiting up to 18 surgeries) before delivering to SGH. Vehicle-kilometers (vkm) and driver duty times were extracted from the two datasets. Cost values for drivers and vehicles, as well as a CO_2 emission factor for diesel vans, were obtained from the 'Manager's Guide to Distribution Costs' (MGDC) published in the UK by the Freight Transport Association.

Intervention Scenario

In the intervention scenario, all samples were assumed to be collected by PTS ambulances rather than by the external courier company currently engaged by the SCS. Task lists of the patient and sample collections/deliveries to be fulfilled each day were created using the historic datasets. The daily task lists were then used as inputs to commercially available route optimization software (PTV Route Optimiser) to find the optimum vehicle routings to satisfy all collections and deliveries.

Each task list (i.e., each day's unique demand profile) was imported into the software to set the specific patient and sample travel requirements for each day. It was agreed with the ambulance service that every patient had to be delivered to/collected from hospital within one hour of the start/finish of their appointment. Time windows for the early (AM) and late (PM) collections of samples from GP surgeries were fixed at 10:00-13:00 and 15:00-18:00, respectively, and this requirement remained static each day unlike patient requirements, which were dynamic, varying from day-to-day. All PTS ambulance types (Table 1) were assumed to have capacity for three consignments (i.e., three Versapaks) of samples alongside their normal patient loads. Each of the 23 working days (Mon-Fri) in March 2021 were analyzed in separate software runs to assess the capability of the PTS fleet to cope with the dynamics of daily demand. Vkm and driver duty times were extracted from route optimization software outputs, with the same MGDC cost and CO_2 emission factor values applied as those used in the BAU analysis.

TABLE 1. Capacities of ambulances based at the Eastleigh depot.

Ambulance Type ID	Number of Vehicles Based at Depot	Capacity for Patients Travelling in Vehicle Seats	Capacity for Patients Travelling in Standard Wheelchairs	Capacity for Patients Travelling in Extra-Large Wheelchairs	Capacity for Patients Travelling on Stretchers
Seated_4	3	3	0	0	0
Seated_6	1	5	0	0	0
Seated_7	9	6	0	0	0
WAV_5	5	2	2	0	0
Stretcher_4	8	3	0	0	1
Stretcher_6	4	5	0	0	1
Stretcher_7	1	6	0	0	1
Bariatric_5	2	2	0	2	0

FIGURE 3. Pathology sample packaging (left) and insulated medical carriers (right). The medium-sized carrier is the middle of the three pictured.

Results

The BAU analysis demonstrated that there was considerable overlap between the operational area of the PTS and the locations of GP surgeries sending samples to SGH via the SCS (Figure 4), suggesting good potential for a shared-fleet operation. For the intervention analysis, the optimized routes necessary to enable the PTS vehicles to provide a shared-fleet operation were produced using the route optimization software (Figure 5). Comparison of results from both BAU and intervention analyses (Table 2) suggested that deploying a shared-fleet operation could reduce costs, vkm, duty time and CO_2 emissions by 20% (£955/day; $1,146/day), 13% (767 km/day), 23% (68:04 h:m/day) and 13% (214 kg/day), respectively. The average number of PTS ambulances (24 vehicles/day) used to provide the shared-fleet operation in the intervention scenario represented a reduction of 32% (12 vehicles/day) from the combined total of PTS ambulances and courier vehicles (36 vehicles/day) used to provide independent PTS and SCS in the BAU scenario.

FIGURE 4. Maps showing movements of PTS vehicles in the BAU scenario. Left: movements of all PTS vehicles during an example day (4th March 2021). Right: movements of one example PTS vehicle during all weekdays in March 2021. Heat map shows intensity of vehicle movements, blue circles show locations of GP surgeries, green cross shows location of SGH.

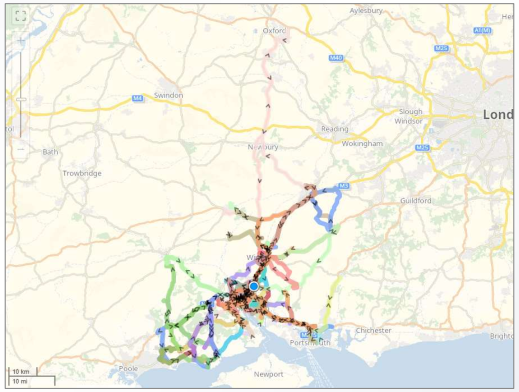

FIGURE 5. Map showing movements of all PTS vehicles during an example day (4th March 2021) in the intervention scenario. Blue circle shows location of PTS Eastleigh depot. Colored lines with direction arrows show individual vehicle routes.

TABLE 2. Summary statistics for PTS and SCS in both BAU and intervention scenarios.

Scenario & Service	Number of Vehicle Routes	Cost (£)	Vkm (km)	Duty Time (h:m)	CO_2 (kg)
BAU Daily Average					
PTS	*26*	*4,020*	*4,682*	*247:43*	*1,309*
SCS	*10*	*782*	*1,137*	*42:10*	*318*
PTS+SCS Total	36	4,803	5,820	289:53	1,627
BAU Monthly Total					
PTS	*595*	*92,470*	*107,695*	*5,697:35*	*30,113*
SCS	*230*	*17,991*	*26,156*	*969:50*	*7,309*
PTS+SCS Total	825	110,462	133,851	6,667:25	37,423
Int. Daily Average					
PTS/SCS Shared-Fleet	24	3,848	5,053	221:48	1,413
Int. Monthly Total					
PTS/SCS Shared-Fleet	558	88,503	116,215	5,101:40	32,496
Net Effect per Day					
BAU Daily – Int. Daily (% reduction)	12 (32%)	955 (20%)	767 (13%)	68:04 (23%)	214 (13%)

Discussion and Conclusions

This research has shown that a shared-fleet operation involving the integration of static and dynamic demand, utilizing public sector own-account vehicles appears feasible. The benefits indicated by the results of the research suggest that policies that actively seek-out opportunities to deploy shared-fleet solutions to improve vehicle utilization should be pursued by management and decision-makers within public sector organizations that operate own-account vehicle fleets (such as the NHS), with such policies likely to reduce public sector spending and help alleviate the considerable problems associated with road-based logistics (e.g., air pollution, climate change, traffic congestion). Whilst the study was focused on a large public sector organization in the UK (i.e., the NHS), it is also likely to have relevance to similar situations around the world where other public sector organizations (e.g., municipal authorities, healthcare providers, government departments, education providers, infrastructure providers) operate own-account vehicle fleets that could benefit from load consolidation through sharing vehicle capacity.

Whilst the size of the fleet based at the Eastleigh depot (33 vehicles) was sufficient for the shared-fleet operation to be feasible, it was found that the balance of the existing fleet-mix (Table 1) needed to be adjusted to enable all demands for transport to be met. Ambulances of the type Seated_7 were found to be under-utilized in the optimized routes, and eight vehicles of this type needed to be replaced by two more of type WAV_5 and six more of type Bariatric_5 for the shared-fleet operation to be feasible. As a whole, the ambulance service has many PTS ambulances (480 vehicles) of all types distributed at multiple depots across Southern UK and therefore it may well be possible to achieve the necessary fleet-mix in the short-term by exchanging vehicles between depots. Over the longer-term, a more gradual change towards the necessary fleet-mix could be achieved as old vehicles are replaced by new.

There are a number of practical realities that could be barriers to the deployment of a shared-fleet operation in the real-world. For example, factors such as preferred collection/delivery times, effects of unforeseen vehicle delays, the need to meet existing service level agreements, safe on-board stowage of samples, quality control for sample transport, liability for injury to patients or loss/damage of samples, allocating responsibility for route scheduling, and convincing all parties of the benefits of participation. These barriers mean that, in practice, it may be more difficult to realize fully the theoretical benefits suggested by the study. The obvious way to investigate the benefits achievable in practice would be to conduct real-world trials, and this is the apparent next step for further research.

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