Article

Patterns of Police, Fire, and Ambulance Calls-for-Service: scanning the Spatio-Temporal Intersection of Emergency Service Problems

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Abstract Independent analysis of police, fire, and ambulance calls for service demonstrates common patterns in emergency service activity. Targeted, place-focused interventions have been demonstrated to prevent future problems for emergency services. This research builds on these findings to examine the spatial and temporal intersection of police, fire, and ambulance incidents to explore the potential utility of enhanced collaboration between emergency-first responders. Using police and fire data from Surrey, BC, Canada, from 2011 to 2013, spatial and temporal patterns of police-, fire-, and ambulance-related incidents were examined. Initial analyses demonstrate that 36% of the City's area experienced 72% of incidents responded to over this 3-year study period. Focusing on this high-volume area, the spatial and temporal intersection of these incident types was explored. Spatially, lattices of varying cell sizes (250 m, 500 m, and 1,000 m) were placed over the study area. Temporally, incident volume was examined across the entire 3-year study period, and at yearly and monthly intervals. Incidents were placed within these spatial and temporal frameworks and visual inspection was utilized to assess the convergence of service demand. Regardless of the cell grid size, police, fire, and ambulance incidents were spatially and temporally concentrated, with the top 10% of cells accounting for approximately 50% of all incidents across all services. Furthermore, there was considerable spatio-temporal convergence in cells which account for the top decile of call volume for all incident types. A 2×2 typology is proposed to classify locations (in this case grid cells) based on (1) the frequency at which they generate high demand for services (sporadic versus persistent), and (2) the combination of agencies required to respond to high demand problems (single versus convergent). The spatial and temporal convergence of emergency service problems observed in this study suggests that an interagency approach to problem identification will enhance problem analysis processes. Working in conjunction with established problem-focused intervention strategies (such as problem-oriented policing), the volume-service typology provides a framework that can contribute to the development of appropriate problem-responses. This, we hope, will support emerging efforts to increase the extent to which emergency-first responder agencies collaborate to maximize efficiency and effectiveness, and reduce harm.

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Introduction

In September 2015, the UK Government commenced a consultation process to explore the capacity for police, fire, and ambulance emergency services to work in much closer partnership than previously (Home Office, 2015). This consultation asserted that, 'the profile of demand for all three emergency services is changing, with the best police and fire services managing demand earlier and investing in prevention and protection' (Home Office, 2015, p. 6). To respond to these changes, the consultation document argues that emergency services need to be increasingly adaptive and innovative, and that improved public outcomes will be produced by increasing collaboration. While other countries acknowledge the benefits of collaboration (e.g. Christchurch, NZ, has a collocated police–fire–ambulance service), the UK has the most explicit emergency service collaboration framework. For instance, the *Policing and Crime Act 2017* (UK) enables Police and Crime Commissioners to take over governance of fire and rescue services and compels emergency services to a 'high level duty to collaborate'.

Building on what little is known about the clustering of police and fire service incidents (e.g. see Wuschke *et al.*, 2013), this seems a reasonable, though largely untested, proposition. In this article, we attempt to explore the hypothesis that emergency services calls-for-service are characteristically and distributionally similar. Drawing on previously disparate research we initially demonstrate that the characteristics of problems defined by police, fire, and ambulance attendance are broadly comparable. Subsequently, using data from a large municipality in British Columbia (BC), Canada, we quantitatively assess the spatial and temporal intersection of police, fire, and ambulance incidents. Results of these analyses demonstrate that at a range of analytical scales, there is considerable spatio-temporal concentration between police, fire, and ambulance service demands. Implications of these findings are discussed with respect to enhancing interagency partnership to address common underlying issues and reduce harm.

The time and space of policing problems

As a result of rapid increases in the amounts of administrative data collected by policing agencies, the last 25 years have seen rapid growth in the quantitative analysis of crime events (Clarke and Eck, 2005). Thus, in order to provide a foundation for subsequent exploration of fire and ambulance response data, we begin by briefly introducing some well-established findings relating to police calls for service. First, much of what police deal with is not crime (Eck, 2003; Goldstein, 1979). These issues are better termed 'problems', which are 'groups of related incidents of concern to the community' (Eck, 2003, p. 82) that require police attention and resources, but do not exclusively belong to police and are often best responded to by police working in partnership with other invested parties (Eck, 2003; Scott and Goldstein, 2005). Secondly, the temporal and spatial distributions of police calls for service are non-random. Crimes cluster at predictable times of the day (Cohen and Felson, 1979; Ratcliffe, 2002), days of the week (Felson and Poulsen, 2003), months of the year (Perry and Simpson, 1987; Landau and Fridman, 1993; Cohn and Rotton, 2000), and there are relatively few places at which a large proportion of overall crime occurs (Brantingham *et al.* 1976; Ackerman and Murray, 2004; Harries, 2006; Kinney *et al.*, 2008; Groff and McCord, 2012).

The identification and explanation of these empirical regularities has contributed to the development of a targeted problem-prevention framework termed problem-oriented policing (POP, first proposed by Goldstein, 1979). The intent of POP is to shift the conventional policing paradigm towards proactive, interagency efforts to address crime and disorder by leveraging a range of available legislative powers and community resources (see Weisburd *et al.*, 2010, for a discussion). As discussed by Weisburd *et al.* (2010), to facilitate the implementation of POP by police practitioners, Eck and Spelman (1987) developed the SARA model, which involves: (1) Scanning—identifying and prioritizing potential jurisdictional problems; (2) Analysis—thorough examination of identified problems using all available data sources; (3) Response—designing and implementing problem-specific interventions which are creative and build on interagency strengths and capabilities; and (4) Assessment—undertaking process and impact evaluations of the effect of the response (see Clarke and Eck, 2005; Schmerler *et al.*, 2011, for a comprehensive discussion of these stages). POP has been widely implemented over the last 35 years and findings from a recent Campbell systematic review (Weisburd *et al.*, 2010) demonstrate that, 'POP as an approach has significant promise to ameliorate crime and disorder problems broadly defined' (Weisburd *et al.*, 2010, p. 164).

In addition to POP, hot spots policing is another targeted, place-specific problem prevention strategy that has been enhanced by awareness of the high-level findings discussed above (see Weisburd and Telep, 2014, for a full discussion of this approach). Hot spots policing uses data analysis to target police resources in a proactive way at the small units of geography that generates disproportionately high demands for police services. There is no single way to implement this approach, and across hot spots policing examples the unit of analysis has been categorized in a variety of ways that include single addresses, street segments, and clusters of street segments (Weisburd and Telep, 2014). Systematic reviews of the implementation of hot spots policing have demonstrated this approach is an effective strategy for preventing crime and disorder (Braga *et al.*, 2012). Furthermore, it does not appear to be the case that targeting problems in this manner results in the spatial displacement of crime to non-targeted areas (Johnson *et al.*, 2014). Finally, additional prevention benefits are likely when hot spots policing is implemented in conjunction with a POP-approach that draws on community partnerships and non-traditional policing responses to solve problems (Weisburd and Eck, 2004).

The time and space of fire and ambulance problems

Given these spatio-temporal trends of police problems and the potential insight they provide in designing and implementing effective interagency solutions to them, we now explore what is known about equivalent problems facing fire and ambulance emergency first responder agencies.

Fire problems

Much of the published information about fire service activity and performance focuses on fire suppression and the implications of fire for injury and death.[1] As a consequence of this focus, it is often not possible to determine the actual workload of the fire service from aggregated data sources. This is a non-trivial issue given that administrative statistics show that non-fire calls make up the majority of the incidents that professional fire services respond to: e.g. in 2013/14, NSW, Australia, 4.9% of call volume related to structure fire (Fire and Rescue New South Wales, 2014); in 2014, Surrey BC, Canada, 2.3% (Surrey Fire Services, 2014); and in 2014, New York City, NY, USA, 5.1% (Fire Department New York, 2014).

Despite the move towards intelligence-led policing and data-driven decision-making for managing crime problems (e.g. Ratcliffe, 2008), there has been limited use of similar analytical platforms to support problem-focused action for other emergency first responders. Furthermore, and building on the patterns of reporting discussed previously, the analysis that has examined the clustering of fire service activity over time and space has focused on various types of confirmed fires (as opposed to all call types that make up the bulk of fire service

[1] See the websites for the US Fire Administration (http://www.usfa.fema.gov/data/statistics/ (accessed 5 December 2016)) and the National Fire Protection Association (http://www.nfpa.org/research/ (accessed 5 December 2016)) for examples of these fire-specific statistics.

responses). From the analysis of this subset of data, however, there is good basis to believe that fire events are non-randomly distributed across space and time (Corcoran *et al.*, 2007; Corcoran *et al.*, 2010; Corcoran *et al.*, 2011; Guldåker and Hallin, 2014; Wuschke *et al.*, 2013). Fires have also been demonstrated to cluster as a function of building characteristics (such as construction type and age, e.g. Jennings, 1996) and a spatial overlap has also been found between fires and area level indicators of relative disadvantage (Chainey, 2013; Corcoran *et al.*, 2011; Guldåker and Hallin, 2014; Jennings, 1999; Wuschke *et al.*, 2013).

Arguably most significant, and mirroring research concerning police problems, is the finding that targeted fire prevention campaigns have been demonstrated to be effective across a range of contexts (see Schaenman *et al.*, 1990, for a wide range of case studies and Warda and Ballesteros, 2007, for a review). In a similar way that place-specific interventions like hot spots policing and POP have reduced crime and disorder, targeted fire-prevention home visits, and education campaigns have been found to reduce rates of fires, reduce the frequency of fire-related casualties, and increase the presence of functioning smoke alarms (Clare *et al.*, 2012; Douglas *et al.*, 1998; Haddix *et al.*, 2001; Mallonee *et al.*, 1996; McConnell *et al.*, 1996; Warda and Ballesteros, 2007).

Ambulance problems

It is also clear from analysis of ambulance service demand that there is considerable variation in the nature of the types of calls that paramedics respond to. This can be determined through the use of information about the emergency status of the response type (emergency versus non-emergency), whether patient contact was made, and whether patient transport was required (Larkin *et al.*, 2006; Wang *et al.*, 2013). Moreover, this diversity is evidenced by the triage systems commonly employed by ambulance providers throughout the developed world (e.g. O'Cathain *et al.*, 2003). Ambulance workloads also cluster in meaningful ways, with variations in respect to patient demographics such as age, minority status, rurality, and insurance status (Larkin *et al.*, 2006; Meisel *et al.*, 2011; Wang *et al.*, 2013), evidence of spatial clustering (Larkin *et al.*, 2006; Wang *et al.*, 2013), and predictable variations in temporal patterns for calls-for-service with respect to time of day (Larkin *et al.*, 2006; Manfredini *et al.*, 2002; Wang *et al.*, 2013) and day of week (Setzler *et al.*, 2009). Finally, as with the police and fire problems discussed previously, targeted place-based interventions can help prevent the types of accidents and injuries that require paramedic attention (e.g. see Chang *et al.*, 2004, for a meta-analysis of effective fall-prevention interventions).

To summarize, research demonstrates that much like their police equivalents, the types of problems that fire and ambulance responders address are wide ranging and cluster in both space and time. Furthermore, prior research has demonstrated that an understanding of these patterns has supported the effective delivery of targeted problem-oriented strategies for harm reduction.

Is there overlap between these emergency-first responder problems?

Despite this wide range of research examining these patterns *within* emergency services, little published work examines spatial and temporal convergence of these calls *between* service providers. That said, there are two relevant contemporary examples that go some way towards examining this issue. First, with a view to exploring the potential utility of increasing collaboration between UK Government agencies to tackle reoccurring public safety problems, Chainey (2013) examined the relationship between area disadvantage, incidents of deliberate fires, and malicious false alarm calls for the fire service. This analysis used a UK-specific disadvantage index (the Vulnerable Localities Index, VLI) to examine differences in the frequency of fire call types and found that areas identified as priorities for police attention based on the VLI were also areas that experienced elevated levels of deliberate fires and malicious false alarm calls to the fire service. Secondly, Wuschke *et al.* (2013) used data from Surrey, BC, Canada, to examine the spatial and temporal intersection of a residential burglaries and residential structure fires. The smallest spatial unit of analysis used was the Canadian Census spatial dissemination area boundaries, which typically contain a residential population of between 400 and 700 individuals. Although this analysis only considered these two incident types, significant overlap in the spatial distributions of police and fire data was observed. In combination, the findings from these two studies provide a good basis to believe that, 'in the spirit of partnership working, potential opportunities exist in achieving mutually beneficial gains in improving public safety through the collaboration of fire, police, and other local public service delivery' (Chainey, 2013, p. 30).

Aim of this research

Police, fire, and ambulance services all respond to problems that extend the boundaries of their core function. It is also evident that these incidents are consistently distributed in a meaningful, non-random manner across space and time. Furthermore, problem analysis and targeted prevention has been shown to reduce the type and frequency of problems that are encountered by all three agencies, particularly when working in partnership with other invested parties. Finally, the limited available analysis demonstrates there is likely to be spatio-temporal convergence in incidents across these emergency first responders. These findings set the stage for the exploratory analysis that forms the remainder of this article.

Using data from Surrey, BC, Canada,[2] which is the same location previously analysed by Wuschke *et al.* (2013), we examine the convergence of incidents involving police, fire, and ambulance responders. This work extends previous investigation by focusing on general demand, rather than being limited to particular types of incidents (e.g. actual fires, malicious false alarm calls, or residential burglaries). The presented spatial and temporal analysis is also enhanced by examining demand across a variety of spatial and temporal scales. Although this is an exploratory exercise, we proceed under the hypothesis that based on the research summarized above there will be meaningful spatial and temporal clustering of incidents between agencies.

Data and method

Our analyses utilized three core data sets relating to police, fire, and ambulance calls for service. The first described recorded volume crime (residential and non-residential burglaries, shoplifting, theft of, and theft from motor vehicles) and vehicle collision incidents occurring between 2011 and 2013 in the jurisdiction of the Royal Canadian Mounted Police (RCMP) Surrey Detachment, BC, Canada.[3] The second and third data sets were derived from all calls for service responded to by Surrey Fire Services (SFS) over the same time period. Fire incidents, which comprised 24 distinct call types, were grouped into matters concerning fires, alarms, gas leaks, assistance, and medical calls. Of these, medical calls were the largest single category of fire service calls during the study time frame. Importantly, the SFS also record medical-related incidents that were also attended by the BC Ambulance Service. Thus, in the absence of additional data, we derived medical calls for service as those recorded by SFS as co-attended by ambulance. Coding the data as described above created three independent data sets related to emergency

[2] Surrey, BC, is part of the Vancouver Census Metropolitan Area, and is one of Canada's largest, fastest growing cities. Surrey covers a total of 314 km^2 and has a population just over 5,00,000 people. The urban area is experiencing rapid redevelopment, growth, and population expansion. Surrey is bordered on the North by the Fraser River and on the South by the USA. The City contains a variety of land uses, ranging from high-density residential areas and commercial zones, through to open areas, parks, and farmland.

[3] Data made available for analysis via a portal hosted by the City of Surrey, BC, and located at http://data.surrey.ca/dataset/rcmp-crime/ (accessed 16 July 2015).

service demand: (1) police (all crime and collision incidents recorded by the RCMP and made available for public analysis); (2) medical (all fire calls-for-service which were medical in nature and were co-attended by BC Ambulance); and (3) fire (all fire calls-for-service where ambulance did not attend).

While we acknowledge that these data are imperfect (i.e. we do not know about incidents the BC Ambulance Service attended that were not recorded by the SFS), the analysis that follows focuses on service demand, and does not seek to demonstrate causal relationships or evaluate effective prevention tactics. Most importantly, an overlap in all three data sets reflects a problem location for all three emergency services, and flags the resourcing requirements associated with that convergence of responders.

All three data sets included spatial and temporal information concerning each incident (aggregated to street segment mid-point, month, and year), and incident type. Data entry errors associated with the location of 91 SFS records and 37 RCMP records were found and these incidents were removed from further analysis. This resulted in data sets containing 49,768 crime incidents, 27,914 medical incidents, and 25,645 fire incidents. Fig. 1 depicts the spatial distribution of these three data sets. Seventy-two percent of all incidents (police, fire, and medical) were concentrated in the northwest corner of the city. Focusing on these high demand locations, the remainder of the analysis is undertaken using only this sub-region, which accounts for 36% of the city jurisdiction.

Our primary analytical approach involved assessing the spatial and temporal convergence of all three incident types at varying spatial and temporal scales. This analysis was conducted using the following process:

1. Three spatial lattices of varying cell sizes were created (250 m, 500 m, and 1000 m). These lattices were each placed over the area of interest (the North West corner of the study region, as depicted in Fig. 1).
2. All police, fire, and medical incidents were placed within these lattices, and the corresponding cell counts associated with each were determined.
3. Varying temporal windows were then created (one 3-year window, three 1-year windows, and thirty-six 1-month windows). These temporal windows were combined with the three spatial lattices to calculate the total number of police, fire, and medical incidents that occurred within each cell at each time period.
4. Each cell was ranked for each incident type according to the number of incidents of that type occurring within it over the given time window. Cell ranking was derived from percentage rank, computed as the percentage of other cells with that number of incidents or more. Thus, the cell with the highest count of incidents was ranked 0 (as zero cells contained more incidents) and the cell with the fewest incidents was ranked 1 (as 100% of cells contained more incidents).
5. Major patterns of service demand intensity and agency overlap were identified. Rather than applying conventional summary descriptive statistics, we opted to use visualization techniques that displayed the maximum amount of data. As is typical in data related to social problem, the underlying distributions of calls for service were skewed, undermining conventional measures of central tendency.

Results

Fig. 1 (above) strongly suggests a spatial concentration in service demand and further suggests there is similarity in the areas experiencing higher levels of service demand across all three emergency first responder agencies. However, because the spatial distribution is computed using kernel density estimation, this is an indirect measure. To explore this more completely, the distribution of incidents, by incident type, was directly compared. Because the

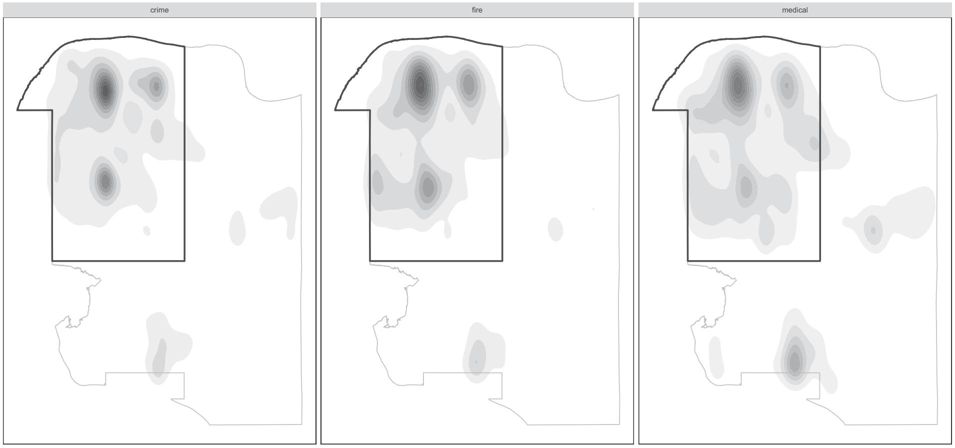

Figure 1: Service demand is concentrated in northwest corner of Surrey. The subregion used for the remainder of this analysis is indicated by the thicker border.

volume of incidents differed by incident type, we used the cumulative distribution. An additional advantage of this approach is the impact of different cell sizes can be assessed in relative terms.

Fig. 2 displays the empirical cumulative distribution of service demand by incident type across the entire study period. Following a simple Lorenz curve, the solid line running 45deg indicates a uniform distribution of service demand (i.e. all incidents are uniformly distributed amongst all cells). Initially exploring the impact of varying spatial scales, the three panels correspond to the different incident types and the individual lines refer to the resulting distributions computed using the 250 m, 500 m, and 1000 m cell sizes.

It is clear from Fig. 2 that all incident types exhibit comparatively skewed distributions, with the top 10% of cells accounting for about 50% of crime, fire, and medical incidents. The different grid sizes do not generate radically conflicting results. Regardless of size, service demand seems concentrated among a small number of cells. While the skewed nature of service demand appears consistent across incident type, it is not clear the degree of intersection in service demand. Thus, we are unsure if the top-ranked cells for crime incidents are similarly ranked for fire and/or medical incidents. In assessing convergence we focus on the top decile of cells for each incident type and determine how many of these feature multiple times.

There are 15, 59, and 235 cells in the top decile for each incident type for the 1,000 m^2, 500 m^2, and 250 m^2 grids, respectively. In determining the degree of service convergence, we established the theoretical range of overlap possible in combining the top decile for the three different incident types. If there is complete overlap, where the cells in top decile for crime, fire, and medical incidents are all the same, then we should expect 15, 59, and 235 unique cells. If, however, there is no overlap, these numbers would triple meaning we would observe 45, 177, and 705 cells. Fig. 3 displays the observed number of unique cells in the top decile for the three incident types, for each grid size. Examination of Fig. 3 demonstrates that, regardless of grid size, there is considerable intersection of the high demand locations across all three incident types. The observed number of unique cells was 18, 70, and 258 corresponding to 1,000 m^2, 500 m^2, and 250 m^2 cells, respectively.

The results presented thus far relate to the volume of service demand occurring in the study area for the entire 3-year time window. On a more practical level is the question of how consistent

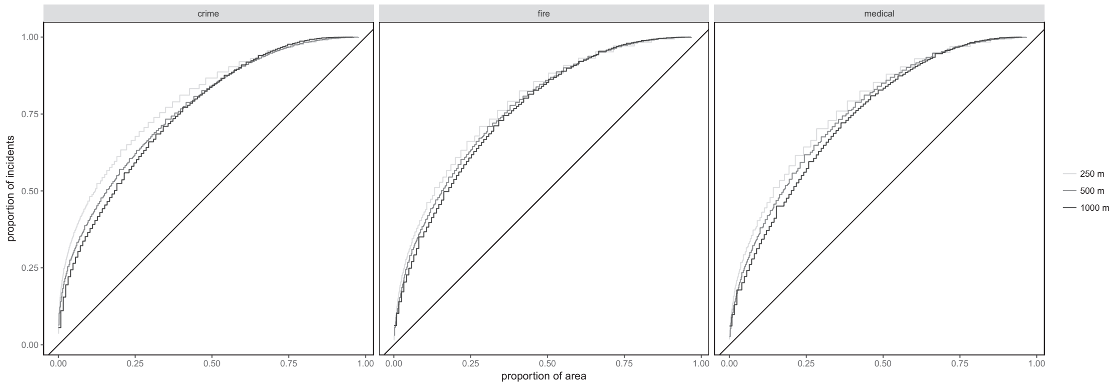

Figure 2: The cumulative proportion of incidents in cells at different cell sizes.

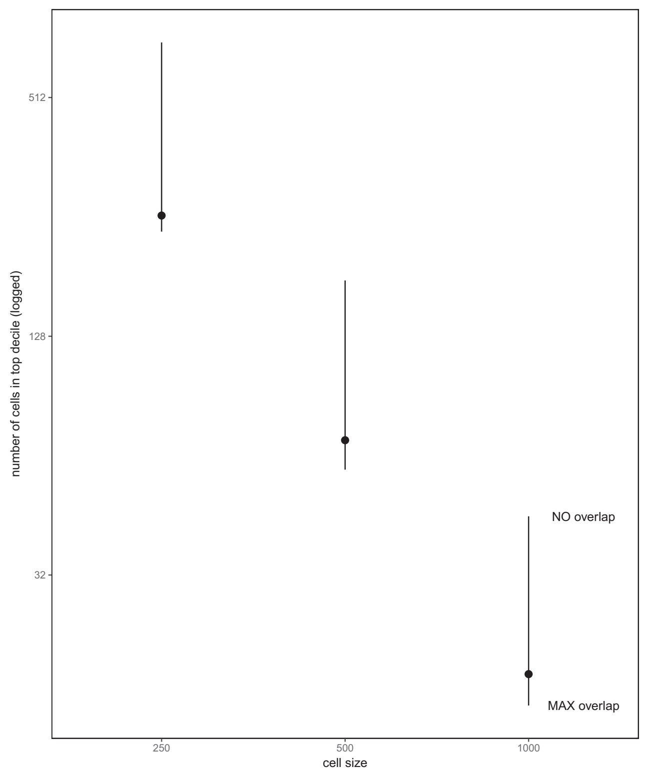

Figure 3: Considerable incident intersection observed for areas with high-service demand, independent of cell size.

service demand in the top decile is over time? Perhaps a location is an outlier for 1 or 2 months a year, but displays very low demand at other times. Consequently, the stability in service demand is an important factor to examine.

To explore the consistency of service demand in high-demand locations over time, we repeated the above analysis for each month in the 3-year period of analysis. That is, we counted the number of incidents (and their type), occurring in each month in

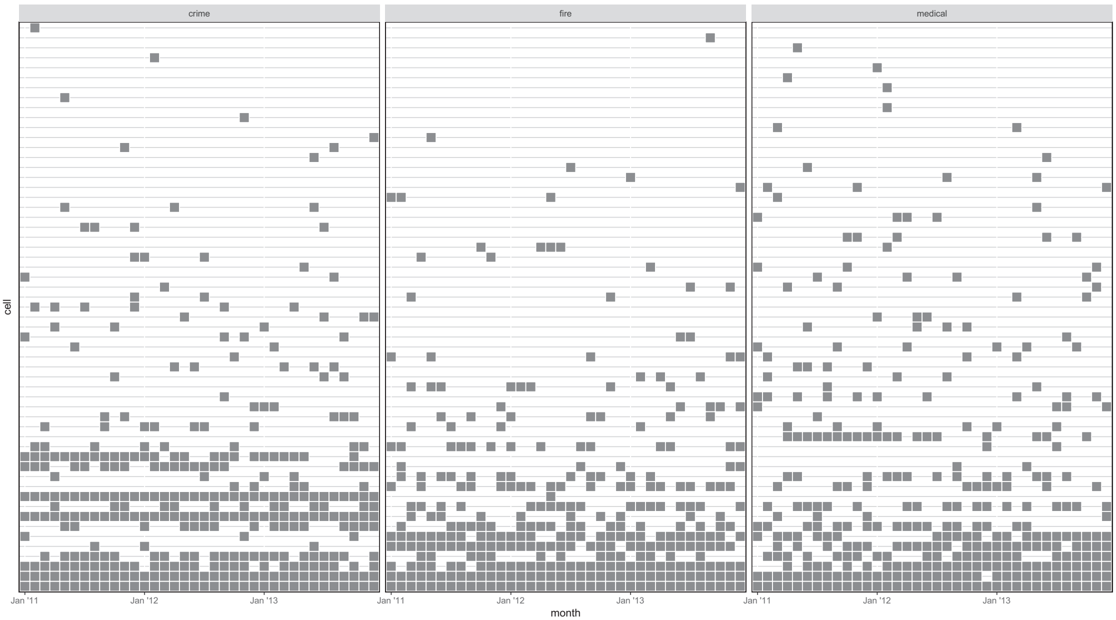

Figure 4: Shaded cells indicate presence in top decile by incident type by month.

each grid cell. As before, we rank ordered the cells according to number of incidents contained therein. The results displayed below relate to the 1,000 m^2 grid, primarily due to ease of visualization. The findings for the other grid sizes are highly consistent. Fig. 4 summarizes the results of these analyses.

In Fig. 4, the columns form the months of the year (with the 3 years of crime data presented first, followed by the fire data and the medical data), and individual grid cells comprise the rows. Between years and across incident types, the rows are ordered consistently, so the same cell is represented from incident panel to incident panel in the same way. The shaded squares indicate that cell was located in the top decile for that incident type in that month. To illustrate, looking at the crime panel the bottom two rows are shaded for all 36 columns (months), which means they were in the top decile every month during the time window. Extending this and looking at the bottom two rows in both the fire and medical panels, it can be seen that the same two cells appeared in the top decile for these call types in every month except for medical calls in December 2012.

Fig. 5 overlays the individual service types depicted in Fig. 4 to allow easier visualization of service convergence. The left panel displays the top decile of cells by all services, with the colour of the cell denoting the number of services for which this cell represents a problem location. The right panel depicts the proportion of total demand (across all services, across the 3-year study period) that a particular cell is responsible for. To illustrate, the third row from the bottom of the plot in 2012 represents a 1,000 m^2 cell that is in the top decile for a single service type in January 2012, two service types in July 2012 and December 2012, and all three services for the remainder of 2012; moreover, the demand associated with this cell represents just under 3% of the total service demand across police, fire, and ambulance during the study period.

In addition to its marked resemblance to an especially daunting game of Alexey Pajitnov's

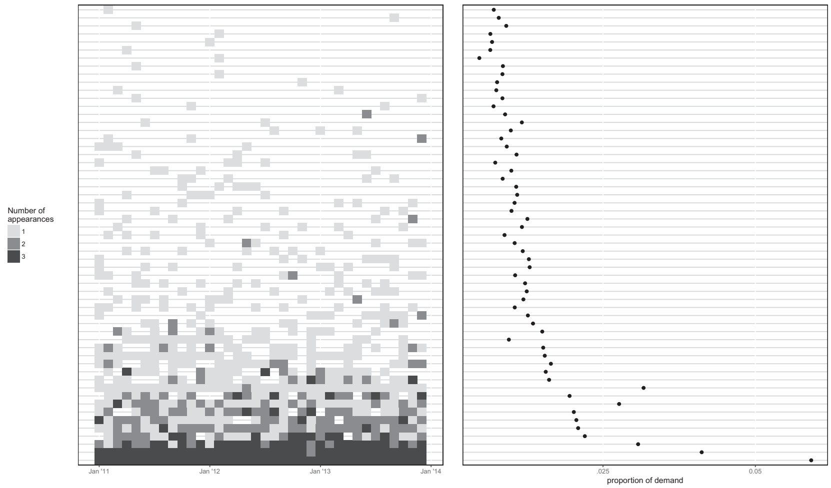

Figure 5: Convergence of service demand, and proportion of total demand by cell (top decile of cells only).

Tetris, Fig. 5 appears to depict four varieties of cells and their associated service demands. First, looking at the top quarter of the plot, there are a group of cells that only feature in the top decile for a single month of the study period and for a single incident type; we denote this group *single sporadic*. The second and third types of cells are located further down in the plot, and as such represent a greater number of incidents. The second group (*single persistent*) is distinguished by consistently appearing in the top decile over the 3-year period for a single incident type. The third group (*convergent sporadic*) consists of cells that are in the top decile for multiple incident types, but for a small number of consecutive months. The fourth and final group (*convergent persistent*), located at the very bottom of the graph, are in the top decile for all three incident types for most of the study period. Following on from these observations, Table 1 depicts a proposed 2 × 2 typology, whereby locations are denoted by (1) the associated frequency of high-demand for emergency first responder services (sporadic versus persistent), and (2) the combination of first responder agencies required to respond (single versus convergent).

Discussion

In this article, we demonstrate that there is considerable overlap in the spatial and temporal concentration of police, fire, and medical incidents occurring in Surrey, BC, between 2011 and 2013. These results are robust to varying spatial and temporal analytical bandwidths. Moreover, our analyses reveal several distinct problem types with respect to emergency service responder and the spatio-temporal properties of those incidents they respond to. As a result we propose a typology of service demand convergence, classifying geographic areas based on (1) the number of first responder agencies that repeatedly attend a problem area; and (2) the frequency at which that area places a high-demand on first responder resources.

Building on the approaches to place- and time-specific problems outlined above, we believe that the interagency analysis presented here is consistent with SARA's scanning phase of the POP framework. The techniques described above present means to identify, and characterize hot spots for problem intervention across multiple agencies. The identification of multi-agency problem intersection through such scanning should improve the efficiency and effectiveness of interagency

Table 1: Typology of service–demand intersection and suggested analytic approach

	Frequency of high demand	
Responding services	Sporadic	Persistent
Single	Single Sporadic Single-agency scanning	Single Persistent Single-agency scanning, analysis, response, and assessment
Convergent	Convergent Sporadic Multi-agency scanning	Convergent Persistent Multi-agency scanning, analysis, response, and assessment

collaboration. This collaboration seeks to leverage existing infrastructure to address common problems that fall beyond the purview of single agencies operating in isolation. It also hopes to offer more efficient and effective uses of resources, such that collaborative problem analysis is likely less resource intensive and more insightful than that carried out by multiple isolated agencies.

Importantly, our results suggest that those factors that contribute to problems and, in turn, service demand are somewhat consistent between incident types. These factors may be the result of risk heterogeneity and/or state dependency. Regardless, these locations are self-selecting for additional, revised, interagency attention. In much the same way as Pease's self-selection of prolific identification works (e.g. see Chenery *et al*., 1999; Roach, 2007)—this is about identifying prolific consumers of emergency responder resources and working on interagency solutions to alleviate the source of the problem. In seeking to utilize this information and move towards problem-solving at these locations, it is important to draw on the recent work of Weisburd and Eck (2004) and Lum *et al*. (2011) who have sought to identify the strategic principles from prior prevention-focused research with a view to generalizing findings about 'what works' in order to solve problems in novel contexts.

Limitations and future research

As made clear from the outset of this article, the limitations that exist with the approach taken here relate to the data that was available to undertake this research. As the police data was sourced from a publicly available portal, this information was not as temporally or geographically specific as the SFS data (restricted to street segment mid-points and aggregated to the month). This influenced space and time bandwidth for analysis for crime data, which subsequently limited analysis of the other agency data. Further to this, the police incidents that could be analysed were restricted to the subset of crimes and collisions made available to the public, and consequently did not capture the broader, non-crime, problem-response that makes up much of what police deal with (Eck, 2003; Goldstein, 1979). In a similar vein, the medical calls for service represented a subset of the ambulance calls that were also attended by the fire service. While these limitations are not ideal, they do not, we believe, detract from the importance of our findings. Instead, it can be suggested that future research build on this approach and develop links with the relevant first responder agencies to access data with finer spatial and temporal accuracy. Furthermore, should our results be replicable in other jurisdictions, it would be important to progress research in close collaboration with first responders, with the hope of supporting design, implementation, and evaluation of appropriate targeted problem-prevention interventions.

Conclusions

As discussed from the outset, the UK Government has passed legislation that introduces a duty on emergency services to collaborate to improve efficiency and effectiveness. Consistent with this intent, this exploratory research set out to identify the degree to which three independent emergency services were likely called to the same problem areas at the same problem times. By understanding this spatio-temporal convergence of resourcing it hoped to inform future research and importantly open a research area that seeks to harness existing data and resources to support practical targeted solutions to reoccurring community problems. Significantly, the research we have presented does not require the merger of services and can be built on existing first responder infrastructure. Given the current climate of global economic austerity and acknowledging the increasing demands likely for all emergency services as a consequence of the impending demographic 'time bomb' (BCStats, 2011) that is the ageing population, approaches that produce greater insight from existing resources are likely worthy of serious consideration.

While our results suggest that increased emergency agency collaboration may produce positive benefits, we stress that they represent only a first step in this direction. The emergency services undoubtedly share an interest in social problems with common or linked causes, but their respective approaches, orientations, and subcultures dictate that meaningful efforts to address these problems will result only where a concerted effort is made by all. Currently, much of the impetus towards emergency service collaboration is underpinned by efficiency gains (shared IT, human resources, procurement). Yet what matters to the public are gains in effectiveness, which are likely best supported by unified vision that draws on and consolidates knowledge and capability of all partners through a problem-, not service-, oriented approach. Until this capability is intentionally developed, the full benefits of multi-agency collaboration will remain unrealized.

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