Which factors most influence demand for ambulances in South West England?

Daniel Chalk[1*], Sarah Black[2], Martin Pitt[3]

[1]Dr Daniel Chalk PhD, Research Fellow in Applied Healthcare Modelling and Analysis, NIHR CLAHRC for the South West Peninsula, University of Exeter Medical School, South Cloisters, St Lukes Campus, Heavitree Road, Exeter, Devon, UK, EX1 2LU. Email : d.chalk@exeter.ac.uk. Telephone : (01392) 726081 (*Corresponding Author)

[2]Sarah Black, Research and Audit Manager, South Western Ambulance Service NHS Foundation Trust. Exeter, UK

[3]Professor Martin Pitt, Associate Professor of Healthcare Modelling and Simulation, NIHR CLAHRC for the South West Peninsula, University of Exeter Medical School. Exeter, UK

Abstract

Ambulance demand in South West England is increasing year-on-year, but the driving forces behind such increases are poorly understood. We developed a System Dynamics model to simulate the factors that influence a call being made for an ambulance. We used data from the South West Ambulance Service NHS Foundation Trust (SWAST), the Office of National Statistics (ONS) and quantitative relationship data in both national and international literature to parameterise the model. We compared predicted ambulance demand over 12 months in the base case model with scenarios in which each influencing factor was removed in turn.

The model predicts that the prevalence of regular falls amongst older people most influences the level of demand for ambulances. The model also predicts that the number of users of adult mental health services could be a significant contributor to ambulance demand.

Additional focus on and investment in falls prevention strategies could help to significantly alleviate increasing levels of demand for ambulance services in South West England. In addition, efforts to understand why those with mental health needs tend to use ambulances more than those without such needs could also be beneficial.

Key Words

Computer Simulation, Operational Research, Ambulance Demand, Falls, System Dynamics

Key Points

- Demand for ambulances is growing year-on-year, but the key driving forces behind such increases are poorly understood
- We developed a computer simulation to estimate the factors that most influence demand for ambulances in South West England
- Our model estimates that the prevalence of falls amongst older people is by far the most significant contributor to demand for ambulances in South West England
- Our model also estimates that the increased predisposition of those with mental health problems to access ambulance services is significantly influencing demand for ambulances
- Our results imply that a focus on falls prevention strategies and better understanding the way in which those with mental health needs access health services could help to significantly reduce ambulance demand

Introduction

Demand for ambulance services is prone to within-day, within-week and within-year fluctuations (Cantwell et al, 2013) that are well understood. However, increasing year-on-year demand has also been widely reported in the literature (Cadigan and Bugarin, 1989; Wrigley et al, 2002; Lowthian et al, 2011) demonstrating a national pattern, but has received only limited research attention (Clark and FitzGerald, 1999; Lowthian et al, 2011). In South West England, the ambulance service has seen a rolling growth in the activity of its A&E service line of between 4 – 5%. This increased growth has occurred over the last six years, and includes all incidents originating both from members of the public and Health Care Professionals calling 999. The reasons behind this escalating overall demand are less clear, and whilst it has been postulated that broad factors such as an ageing society (Clark and Fitzgerald, 1999) and increasing alcohol-related incidents (Brokaw et al, 1998) might be responsible, it is difficult to determine the predominant drivers of ambulance demand without quantifying and comparing the impact of these factors on ambulance demand.

Previous studies that have looked at factors that potentially influence demand for ambulance services have typically focused on the influence of single factors (Bray et al, 2011; Wong and Lai, 2012; Holzer et al, 2012) or small subsets (Aldrich et al, 1971; Clark and FitzGerald, 1999). Modelling studies that have looked more widely across a range of factors typically only consider ambulance demand as a component of the demand for Accident and Emergency Services (Brailsford et al, 2004), but this does not capture considerations that are exclusive to the ambulance service, such as attendances that do not result in a subsequent conveyance to a hospital.

System Dynamics (or Whole Systems Modelling) is a computer simulation method that offers a means of modelling high-level or abstracted systems, and the flows between elements in

these systems (e.g. the movement of patients or the flow of information between organisations (Lattimer et al, 2004)). Such models can be useful in broadly determining the elements that most affect the rates of flow around a system. In the context of ambulance demand, a System Dynamics model can represent the flow of people who call an ambulance, and the interlinking factors that determine the rate of this flow. In this paper, we present such a model, and demonstrate how we used this model to determine the most significant factors contributing to the level of demand for ambulance services.

Methods

Determining the influencing factors and their relationships to ambulance demand

In order to determine the factors that might influence ambulance demand, we searched the literature and sought expert opinion via multiple meetings with representatives from the South West Ambulance Service NHS Foundation Trust (SWAST). We conducted a search across the Medline, Embase, CINAHL, BNI, HMIC and SPP databases using the keyword "ambulance" along with "use", "usage", "demand" or "utilisation", and "influence", "factor", "driver" or "correlation". This search resulted in 210 unique hits. The abstract from each publication was studied manually to identify those studies that discussed potential factors that influence demand for ambulance services. 18 publications met this criterion, and all other publications were rejected.

We constructed a map of the influences described in the literature by identifying any potential factors along with their links to both ambulance demand and each other (Figure 1). We included any relationships that were mentioned in the literature, even if there was no quantitative description of the relationship, or if the relationship was only postulated.

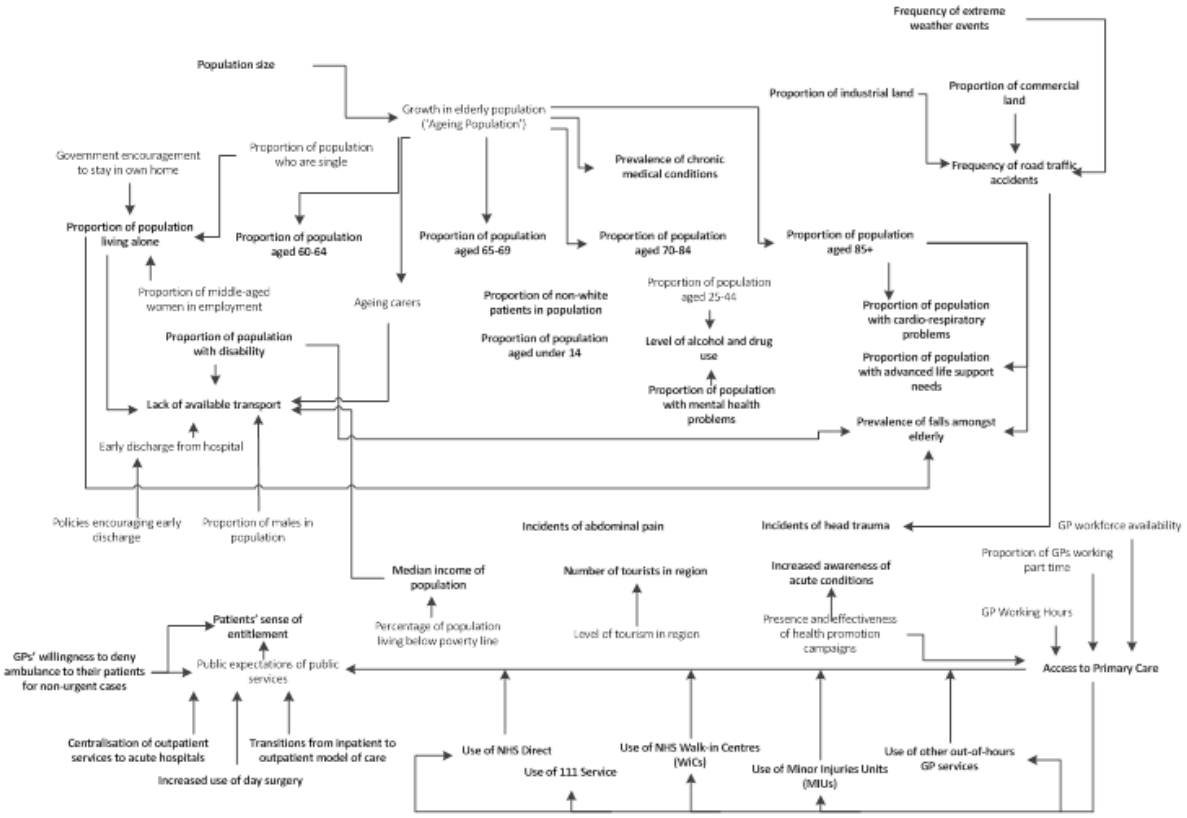

Figure 1. Map of all identified potential factors that might influence demand for ambulance services. Factors in bold are direct determinants of ambulance demand.

The influence map was shared with stakeholders from the ambulance service and modified based on their expert opinion. Such methods have been used before (Brailsford et al, 2004) and are a useful means of promoting discussion about a complex system using a common starting point.

Finally, we removed any relationships from the influence map that could not be represented in the model because of a lack of data about those relationships (such as the impact of a GP's unwillingness to deny their patient non-urgent ambulance transportation (Clark and FitzGerald, 1999)), or because the literature indicated that such relationships do not significantly influence demand for the ambulance service. For example, the presence of health promotion campaigns such as the FAST campaign for stroke – a UK campaign to

increase awareness of key signs of the onset of stroke – may increase awareness but have limited impact on changing behaviours (Lecouturier et al, 2010). Figure 2 shows the final influence map used by the model.

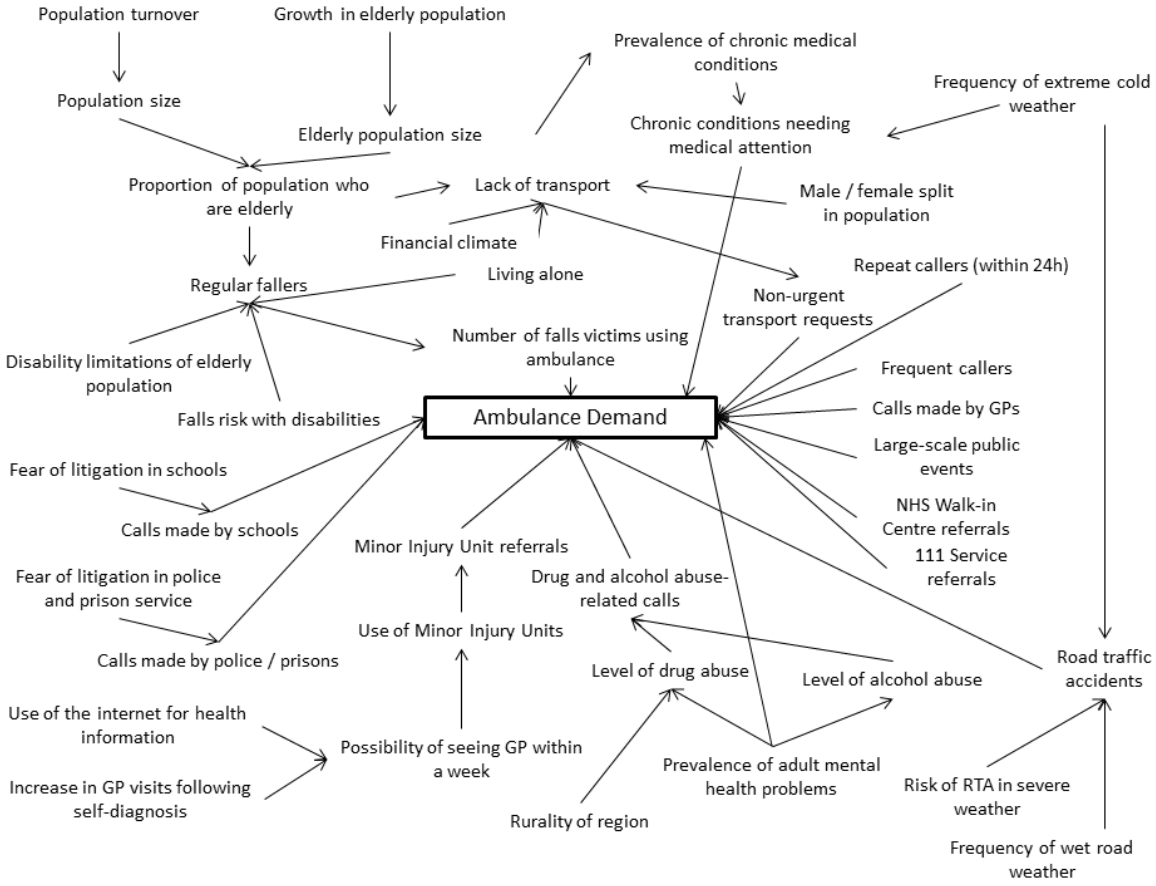

Figure 2. Finalised map of influences on ambulance demand used by the model, representing those influences for which quantitative data is available or can be inferred. For example, the map shows that an increase in GP visits from self-diagnosis can affect GP availability and therefore the possibility of a patient seeing their GP within seven days, which in turn can increase attendances at Minor Injury Units, thereby potentially increasing calls from Minor Injury Units to the ambulance service.

Model structure

The fundamental structure of the model is represented in Figure 3. Patients transition from a population that has not called for an ambulance, to a population that has, at a rate determined by influencing factors that both directly and indirectly influence ambulance demand. Time advances in one month intervals over the course of 12 months. Table 1 describes the specific data used to parameterise the modelled relationships.

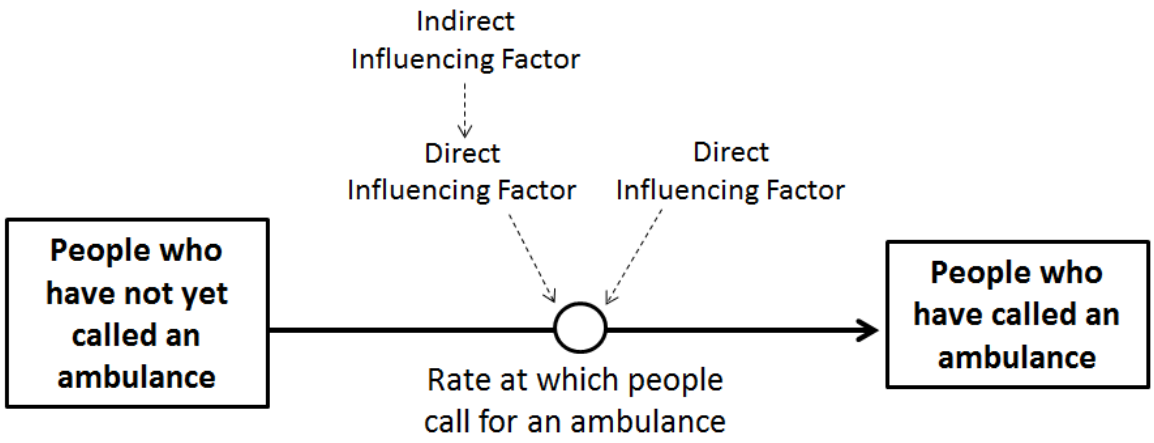

Figure 3. Structure of the model. The transition of patients into a population that has called for an ambulance is determined by numerous direct and indirect influencing factors. The rate at which people call for an ambulance represents the number of people calling for an ambulance over a given time period.

Description of Data	**Data Value Used**	**Source(s) of Data**
Population		
Size of population in SW England in 2011	5,288,935	Office for National Statistics (2011 Census)
Net annual migration into SW England	19,400	Office for National Statistics (Internal Migration by Local Authorities in England and Wales, Year Ending 2012)
Size of population in SW England in	5,327,735	Size of population in 2011 + two years of

2013		net migration
Percentage of SW population aged 60 or over	26.42%	Office for National Statistics (2011 Census)
Annual increase in 60 or over population	2.05%	Office for National Statistics (National Population Projections, 2012-based projections)
Percentage of males in the population	49.5%	Office for National Statistics (2011 Census)
Access to Transportation		
Percentage of adult males that do not own a car	18%	Department for Transport (National Transport Survey)
Percentage of adult females that do not own a car	22%	Department for Transport (National Transport Survey)
Percentage of those aged 65 or over who do not own a car	34%	Office for National Statistics (2011 Census)
Percentage of population that live alone	29%	Office for National Statistics (2011 Census)
Percentage of those aged 65 or over who live alone	44.56%	Office for National Statistics (Statistical Bulletin: Families and Households 2012)
Percentage of single occupancy households that have no car	61%	Office for National Statistics (2011 Census)
Percentage of people at lowest income level who do not own a car	2.65%	Department for Transport (Travel by car availability, income, ethnic group, household type and NS-SEC (NTS07))
Percentage of people at highest income level who do not own a car	0.64%	Department for Transport (Travel by car availability, income, ethnic group, household type and NS-SEC (NTS07))

Current income level relative to pre-recession income level	95.5%	Median income has fallen by 3.8% since economic downturn (Office for National Statistics, Middle Income Households, 1977-2011/12). Therefore, we assume current income = 96% of pre-recession levels
Number of calls per month for non-urgent transport	773.2	SWAST
Percentage of people without transport or means to pay for transport who use the ambulance service for non-urgent requests each month	0.01%	773.2 calls represents 0.01% of the population of SW England (2011 Census). We assume that 100% of non-urgent transport requests are from people without their own transport.
Disabilities and Falls		
Percentage of older people 'limited a little' by disability	28.7%	Office for National Statistics (2011 Census)
Percentage of older people 'limited a lot' by disability	29.5%	Office for National Statistics (2011 Census)
Percentage of those 'limited a little' by disability who regularly fall	31%	Tinetti et al (1986) – assuming 4-6 disabilities = 'limited a little'
Percentage of those 'limited a lot' by disability who regularly fall	100%	Tinetti et al (1986) – assuming 7-9 disabilities = 'limited a lot'
Percentage of people aged 65 or over who have multiple falls within 12 months	17%	Kharicha et al (2007)
Number of calls per month coded as falls	7,094	SWAST

Estimated number of older people in SW England who regularly fall over the course of a year	536,535	Those 'limited a little' by disability who regularly fall = 28.7% of those 'limited a little' = 124,321. Those 'limited a lot' by disability who regularly fall = 100% of those 'limited a lot' = 412,214. Total = 536,535.
Estimated percentage of falls that result in an ambulance call	16%	Regular fallers averaged over 12 months = 44,711 per month. 7094/44711 = 16% of falls result in ambulance call each month.
GP and Minor Injury Unit Referrals		
Average number of attendances per year to a Minor Injury Unit in Devon	7,250	Busiest MIUs in Devon receive around 11,500 attendances per year, compared to 3,000 attendances at the quietest (NHS Devon, Minor Injury Units in Devon: Opening Hours). Average taken between these extremes.
Number of calls per month from Minor Injury Units	283.8	SWAST
Number of calls per month from NHS Walk-In Centres	11	SWAST
Percentage of patients attending MIUs because wait to see GP is too long	13.1%	Dolan and Dale (1997)
Percentage of patients who have to wait a week or more to see their GP	15%	Royal College of General Practitioners (2013)
Percentage of population that use the	58%	Iverson et al (2008)

internet to obtain health information		
Percentage of population using internet to obtain health information who increase GP visits as a result of self-diagnosis	37%	Iverson et al (2008)
Number of calls per month from GPs	789	SWAST
Chronic Medical Conditions		
SW England 65 and over prevalence rate of chronic medical conditions (atrial fibrillation, asthma, cancer, coronary heart disease (CHD), chronic kidney disease (CKD), chronic obstructive pulmonary disease (COPD), dementia, diabetes, hypertension and stroke)	14.2%	Public Health England (Chronic disease prevalence by age, sex and region in 2008)
SW England under 65 prevalence rate of chronic medical conditions	2.5%	Public Health England (Chronic disease prevalence by age, sex and region in 2008)
Estimated percentage of those with chronic medical conditions who call ambulance each month	0.288%	On average, each month SWAST receives 166 calls relating to atrial fibrillation, 308 calls relating to asthma, 378 calls relating to COPD, 441 calls relating to diabetes and 633 calls relating to stroke. This represents an average of 0.288% of those with chronic medical

		conditions.
Additional calls per month from those with chronic medical conditions during coldest months (January and February)	76	SWAST
Road Traffic Collisions and Extreme Weather Events		
Average number of road traffic collisions per month in SW England	982	Devon County Council (2012 Year End Report)
Likelihood of RTC on wet road compared to dry road	1.74 times more likely	Andrey (2010)
Likelihood of RTC in snowy conditions compared to dry conditions	1.89 times more likely	Andrey (2010)
Percentage of RTCs in SW England that are on wet roads	32.8%	Department for Transport (RAS10)
Percentage of RTCs in SW England that are in snowy or icy conditions	1.78%	Department for Transport (RAS10)
Illicit Drug and Alcohol Abuse		
Percentage of population who use illicit drugs	8.2%	Home Office (Drug misuse: findings from the 2012 to 2013 CSEW)
Percentage of population who consume alcohol to an excess that is potentially harmful	24%	NHS Choices (Alcohol Misuse)
Percentage of 16 to 59 year olds in urban areas who use illicit drugs	8.6%	Home Office (Drug misuse: findings from the 2012 to 2013 CSEW)
Percentage of 16 to 59 year olds in	6.4%	Home Office (Drug misuse: findings

rural areas who use illicit drugs		from the 2012 to 2013 CSEW)
Population of SW England who live in rural area	33%	Office for National Statistics (Rural and urban areas: comparing lives using rural/urban classifications)
Percentage of those with mental health problems who abuse substances	40%	Mental Health Foundation (The Fundamental Facts)
Percentage of population who use adult mental health services	2.5%	Health and Social Care Information Centre (HES-MHMDS Data Linkage Report, Additional analysis – 2011-12, Experimental statistics)
Percentage of illicit drug users who call ambulance within a year	1.5%	In Devon in 2010, there were 1,485 ambulance callouts relating to drug overdoses (NHS Devon, Substance misuse needs assessment 2012). If we assume that 8.2% of the population of Devon use illicit drugs, then the callouts for drug overdoses over a year represent 1.5% of illicit drug users.
Percentage of those who abuse alcohol who call ambulance within a year	0.4%	In Devon in 2010, there were 1,191 callouts relating to alcohol overdoses (NHS Devon, Substance misuse needs assessment 2012). If we assume that 24% of the population of Devon abuse alcohol, then the callouts for alcohol overdoses over a year represent 0.4% of those who abuse alcohol.

Other Factors

Percentage of adult mental health service users who use ambulance service each month	3.51%	78% of users of adult mental health services attend hospital at least once in a year (assume 6.5% each month), and 54% of those who arrive at A & E arrive by ambulance or helicopter (Health and Social Care Information Centre, HES-MHMDS Data Linkage Report, Additional analysis – 2011-12, Experimental statistics).
Percentage of calls from schools for ambulance attendance deemed 'avoidable'	47%	SWAST
Percentage of calls from police or prison service for ambulance attendance deemed 'avoidable'	35%	SWAST
Number of calls per month from patients who have been treated at scene and discharged within previous 24 hours	1,147	SWAST
Number of calls per month from patients deemed 'inappropriate' for ambulance attendance	888	SWAST
Number of calls per month referred from 111 Service	2,325	SWAST
Number of calls per month to attend large-scale public events	22	SWAST

Table 1. Description of the parameter values used in the model, and the sources used to populate them

Calculating the rate of ambulance calls

In order to calculate the number of people who call an ambulance each month in the model, we calculate the sum of all factors that directly influence ambulance demand. It is important to note that the resultant rate of ambulance calls per month is likely to underestimate reality because the model does not take into account all of the originally identified factors that influence ambulance demand. However, this approach is very useful in helping us to identify which factors might be the most influential amongst those included in the model, and the results of this analysis should be interpreted accordingly.

Testing and ranking influences on demand

In order to establish which factors most influence levels of ambulance demand, we systematically removed each influencing factor included in the model in turn (such that only one factor was removed at any time), and recorded the difference in total demand in the simulation after 12 months compared to the base case scenario, in which all influencing factors are included.

Results

The model predicts that the number of regular fallers amongst older people is the most influential contributor to demand for ambulances in South West England. This factor is predicted to be over three times more influential than referrals from the 111 Service. Furthermore, the majority of the ten most influential factors predicted by the model are directly related to falls amongst older people. The proportion of the population who are users

of adult mental health services is also predicted to significantly influence demand for ambulance services.

Table 2 shows the full list of factors in order of their estimated influence on ambulance demand, along with the absolute magnitude of the difference in predicted ambulance demand, as compared with the base case.

Rank	Influencing Factor	Absolute Magnitude of Difference in Demand from Base Case (%)
1	Number of people who are regular fallers	34.3%
2	Initial Older People Population Size	28.8%
3	Proportion of older people limited a lot by disability	26.4%
4	Proportion of 'limited a lot by disability' sub-population who regularly fall	26.4%
5	Proportion of population who are users of adult mental health services	21.2%
6	Number of adult mental health service users who are ambulance users per month	21.2%
7	Number of calls referred from 111 Service per month	10.5%
8	Proportion of older people limited a little by disability	8%
9	Proportion of 'limited a little by disability' sub-population who regularly fall	8%
10	Proportion of population using Minor Injury Units per month	5.7%
11	Number of calls referred from Minor Injury Units per month	5.7%
12	Number of road traffic accidents per month	5.6%
13	Number of people who call an ambulance more than once within 24	5.2%

	hours per month	
14	Number of "frequent callers" per month	4.0%
15	Number of chronic condition patients needing medical attention per month	4.0%
16	Number of chronic condition sufferers using ambulance per month	4.0%
17	Prevalence of chronic medical conditions	4.0%
18	Number of calls for ambulance made by GPs per month	3.6%
19	Number of drug and alcohol abuse ambulance users per month	3.5%
20	Prevalence of chronic medical conditions amongst over 65s	2.8%
21	Number of people who misuse alcohol	1.7%
22	Number of illicit drug users	1.7%
23	Number of calls for ambulance made by schools per month	1.4%
24	Proportion of 16 to 59 year old urban dwellers who use illicit drugs	1.3%
25	Prevalence of chronic medical conditions amongst under 65s	1.3%
26	Frequency of wet road weather conditions	1.1%
27	Relative Risk of RTC in wet road weather conditions	1.1%
28	Appropriate calls from schools per month	0.7%
29	Total Inappropriate Calls from Schools Per Month	0.6%
30	Proportion of 16 to 59 year old rural dwellers who use illicit drugs	0.5%
31	Number of calls for ambulance made by prisons or police per month	0.4%
32	Number of people without transport	0.4%
33	Number of people with no transport who use ambulance per month	0.4%
34	Growth rate in population of older people	0.3%
35	Appropriate calls from police per month	0.3%
36	Proportion of population living alone	0.2%
37	Proportion of one person households without a car	0.2%
38	Percentage of region which is rural	0.2%

39	Total inappropriate calls from police or prison service per month	0.2%
40	Proportion of males in population	0.1%
41	Number of calls made from large scale public events per month	0.1%
42	Frequency of extreme cold weather conditions	0.1%
43	Relative Risk of RTC in cold weather conditions	0.1%
44	Net migration into region	0.1%
45	Number of calls referred from NHS Walk In Centres per month	0%
46	Proportion of patients able to see GP within a week	0%
47	Proportion of people using the internet for health information	0%
48	Proportion of internet 'self-diagnosers' who increase GP visits	0%
49	Proportion of males without a car	0%
50	Proportion of females without a car	0%
51	Proportion of people over 65 who do not own a car	0%
52	Proportion of people who live alone who are 65 or over	0%
53	Median Income as proportion of non-recession income	0%
54	Proportion of people at lowest income level who do not own a car	0%
55	Proportion of people at highest income level who do not own a car	0%
56	Proportion of people with mental health problems who abuse substances	0%

Table 2. List of tested factors in the model, ranked in order of their predicted influence on the level of demand for ambulance services. The absolute magnitude of difference in demand from base case represents the proportional difference between the predicted demand when this factor was removed from the model, and the base case in which all factors can potentially influence ambulance demand.

Discussion

The results of our model strongly suggest that the prevalence of regular fallers amongst older people has a significant impact on demand for ambulance services in South West England, and would appear to be more influential than other known sources of high demand, such as the introduction of the 111 telephone service (a service run by the NHS to provide advice to those with an urgent but non-life threatening medical need). This would suggest that the uptake of and adherence to falls prevention strategies, such as the guidance published by the National Institute for Health and Care Excellence (2014), could significantly reduce ambulance demand if such strategies are effective.

Whilst it is difficult to speculate about the absolute magnitude of the reduction in ambulance demand that could be achieved if the prevalence of falls was reduced, the results of the model show that the number of people who are regular fallers, along with the associated size of the older people population and the proportion of older people who are 'limited a lot' by their disability are far more influential on the total level of ambulance demand than the other factors considered by the model. In addition, we know that in 2012 SWAST received an average of 7,094 calls per month that were coded as 'falls', which represents 10.94% of the 64,822 average calls per month received by SWAST that year. Furthermore, this is likely to underestimate the true number of ambulance calls related to falls, because many paramedics code the case according to the injury sustained as a consequence of the fall, rather than the fall itself (local clinical opinion).

The model also predicts that ambulance use amongst those with mental health problems could be significant, primarily because they are more likely to call for an ambulance or seek emergency medical attention for incidents for which this level of response may not be appropriate (Larkin et al, 2006). This population also has higher rates of alcohol abuse and illicit drug use (Mental Health Foundation, 2007), but this is not predicted by our model to influence ambulance demand as significantly, being over six times less influential.

Therefore, efforts to identify and address the reasons why those with mental health problems may use ambulance services inappropriately could be very beneficial in terms of reducing overall demand for ambulance services.

Limitations

It should be reiterated that there are known factors that might influence ambulance demand that our model does not capture, largely because we were unable to find a quantitative relationship or suitable proxy to capture these influences. Also, it is likely that there are other factors not considered in this study that might influence demand for ambulance services. As such, our results should be interpreted in the context of their importance relative to the other influencing factors included in the model. However, we are confident that the combination of our literature review and expert opinion from SWAST has yielded at least the key influences on ambulance demand.

It should be noted that, given the range and volume of data sources used to parameterise the model, uncertainties in the estimates derived from the various studies we have used could be compounded, leading to inaccuracies in our results. However, it should be emphasised that the purpose of this model is not to predict the reduction in the number of ambulance calls that would be made if certain influencing factors were removed, but rather to provide a general sense of how these influences compare to each other. In this sense, it is important not to interpret our results as precise quantitative predictions.

Furthermore, a number of those influences that were dropped from the model after being identified during the initial literature review or after consultation with SWAST were removed because subsequent evidence indicated that there was no impact on ambulance demand. For example, the presence of health promotion campaigns is not considered to have an impact on ambulance demand because evidence suggests that even large-scale campaigns, such as the

'FAST' campaign for stroke, have had minimal or no impact on demand for ambulance services (Lecouturier et al, 2010). Other studies have found that there is no statistically significant effect on GP demand resulting from the use of NHS Walk-in Centres (Chalder et al, 2003), and therefore the use of such Walk-in Centres is unlikely to significantly impact overall GP capacity.

It is possible that our prediction that falls is the biggest contributing factor to demand for ambulance services may be unique to the study population of South West England. The South West is a largely rural region with a significant population of older people (Office for National Statistics, 2011), and in more urban regions, with younger demographics, it is possible that there are other factors that have a bigger influence on ambulance demand than fall rates. On the other hand, we are observing an increasing ageing society globally (Cohen, 2003). Therefore, unique clinical issues associated with an ageing population are becoming increasingly relevant everywhere, and our predictions could have more general applicability in this context.

Conclusions

Our findings suggest that falls amongst older people and access of ambulance services by those with mental health needs may be significantly contributing to overall demand for ambulance services. At the least, we would encourage other ambulance trusts to use such methods as we have presented in this study to establish the reasons behind increasing demand in their own areas.

Acknowledgements

The authors would like to thank James Wenman, Kerron Allen, Jessica Lynde and Paul Quick of the South Western Ambulance Service NHS Foundation Trust for providing invaluable feedback and data for this project.

This study was funded by the National Institute of Health Research (NIHR) Collaboration for Leadership in Applied Health Research and Care for the South West Peninsula. The views and opinions expressed in this paper are those of the authors, and not necessarily those of the NHS, the National Institute for Health Research, or the Department of Health.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

Andrey J (2010) Long-term trends in weather-related crash risks. *J Transp Geogr* **18**:246-258

Aldrich C A, Hisseric J C, Lave L B (1971) An analysis of the demand for emergency ambulance service in an urban area. *Am J Public Health* **61**:1156-1169

Brailsford S C, Lattimer V A, Tarnaras P et al (2004) Emergency and on-demand health care: modelling a large complex system. *J Oper Res Soc* **55**:34-42

Bray J E, Mosley I, Bailey M (2011) Stroke public awareness campaigns have increased ambulance dispatches for stroke in Melbourne, Australia. *Stroke* **42**:2154-2157

Brokaw J, Olson L, Fullerton L, et al (1998) Repeated ambulance use by patients with acute alcohol intoxication, seizure disorder, and respiratory illness. *Am J Emerg Med* **16**:141-144

Cadigan R T, Bugarin C E (1989) Predicting demand for emergency ambulance service. *Ann Emerg Med* **18**:618-621

Cantwell K, Dietze P, Morgans A E et al (2013) Ambulance demand: random events or predicable patterns? *Emerg Med J* **30**:883-887

Chalder M, Sharp D, Moore L et al (2003) Impact of NHS walk-in centres on the workload of other local healthcare providers: time series analysis. *BMJ* **326**:532-536

Clark M J, FitzGerald G (1999) Older people's use of ambulance services: a population based analysis. *J Accid Emerg Med* **16**:108-111

Cohen J E (2003) Human population: the next half century. *Science* **302**:1172-1175

Department for Transport. National Transport Survey. https://www.gov.uk/government/collections/national-travel-survey-statistics. Accessed August 2014

Department for Transport. Travel by car availability, income, ethnic group, household type and NS-SEC (NTS07). https://www.gov.uk/government/statistical-data-sets/nts07-car-ownership-and-access. Accessed August 2014

Department for Transport. Reported road accidents (RAS10). https://www.gov.uk/government/statistical-data-sets/ras10-reported-road-accidents. Accessed August 2014

Devon County Council. 2012 Year End Report. http://www.devon.gov.uk/chapter1.pdf. Accessed August 2014

Dolan B, Dale J (1997) Characteristics of self referred patients attending minor injury units. *J Accid Emerg Med* **14**:212-214

Health and Social Care Information Centre. HES-MHMDS Data Linkage Report, Additional analysis – 2011-12, Experimental statistics. http://www.hscic.gov.uk/catalogue/PUB11514. Accessed August 2014

Holzer B M, Minder C E, Schätti MD et al (2012) Ten-year trends in intoxications and requests for emergency ambulance service. *Prehosp Emerg Care* **16**:497-504

Home Office. Drug misuse: findings from the 2012 to 2013 CSEW. https://www.gov.uk/government/statistics/tables-for-drug-misuse-findings-from-the-2012-to-2013-csew. Accessed August 2014

Iverson S A, Howard K B, Penney B K (2008) Impact of internet use on health-related behaviors and the patient-physician relationship: a survey-based study and review. *J Am Osteopath Assoc* **108**:699-711

Kharicha K, Iliffe S, Harari D et al (2007) Health risk appraisal in older people 1: are older people living alone an 'at risk' group? *Br J Gen Pract* **57**:271-276

Larkin G L, Claassen C A, Pelletier A J et al (2006) National study of ambulance transports to United States Emergency Departments: importance of mental health problems. *Prehosp Disaster Med* **21**:82-90

Lattimer V, Brailsford S, Turnbull J et al (2004) Reviewing emergency care systems I: insights from system dynamics modelling. *Emerg Med J* **21**:685-691

Lecouturier J, Rodgers H, Murtagh M J et al (2010). Systematic review of mass media interventions designed to improve public recognition of stroke symptoms, emergency response and early treatment. *BMC Public Health* **10**:784-793

Lowthian J A, Cameron P A, Stoelwinder J U et al (2011) Increasing utilisation of emergency ambulances. *Aust Health Rev* **35**:63-69

Mental Health Foundation. The Fundamental Facts. http://www.mentalhealth.org.uk/content/assets/PDF/publications/fundamental_facts_2007.pdf?view=Standard. Accessed August 2014.

National Institute for Clinical Excellence. Falls: Assessment and prevention of falls in older people. http://www.nice.org.uk/guidance/cg161. Accessed August 2014

NHS Choices. Alcohol misuse. http://www.nhs.uk/conditions/alcohol-misuse/Pages/Introduction.aspx. Accessed August 2014

NHS Devon. Minor Injury Units in Devon: Opening Hours (Report for Devon Health and Wellbeing Scrutiny Committee). http://www.devon.gov.uk/loadtrimdocument?url=&filename=CS/11/9.CMR&rn=11/WD655&dg=Public. Accessed August 2014

NHS Devon. Substance misuse needs assessment 2012. http://www.devonhealthandwellbeing.org.uk/wp-content/uploads/2011/07/Substance-Misuse-Health-Needs-Assessment_v2.3_Web1.pdf. Accessed August 2014

Office for National Statistics. 2011 Census http://www.ons.gov.uk/ons/guide-method/census/2011/census-data/index.html. Accessed August 2014

Office for National Statistics. Internal Migration by Local Authorities in England and Wales, Year Ending June 2012. http://www.ons.gov.uk/ons/rel/migration1/internal-migration-by-local-authorities-in-england-and-wales/year-ending-june-2012/stb-internal-migration-for-england-and-wales--year-ending-june-2012.html. Accessed August 2014

Office for National Statistics. National Population Projections, 2012-based projections. http://www.ons.gov.uk/ons/rel/npp/national-population-projections/2012-based-projections/index.html. Accessed August 2014

Office for National Statistics. Statistical Bulletin: Families and Households 2012. http://www.ons.gov.uk/ons/dcp171778_284823.pdf. Accessed August 2014

Office for National Statistics. Middle Income Households, 1977-2011/12. http://www.ons.gov.uk/ons/rel/household-income/middle-income-households/1977---2011-12/index.html. Accessed August 2014

Office for National Statistics. Rural and urban areas: comparing lives using rural/urban classifications. https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CC4QFjAA&url=http%3A%2F%2Fwww.ons.gov.uk%2Fons%2Frel%2Fregional-trends%2Fregional-trends%2Fno--43--2011-edition%2Frural-and-urban-areas--comparing-lives-using-rural-urban-classifications.pdf&ei=_WaLUu_NGseo0QXnjICwBw&usg=AFQjCNFQ8Nx7uwWkJLkqC_ytGsMMxf6Ajg&sig2=tiujA-4QTDhMGbeXuF7QZA&bvm=bv.56643336,d.d2k. Accessed August 2014

Public Health England. Chronic disease prevalence by age, sex and region in 2008. http://www.erpho.org.uk/viewResource.aspx?id=20574. Accessed August 2014

Royal College of General Practitioners. 27m patients to wait a week or more to see GP in 2014 due to diversion of doctor posts to hospitals. http://www.rcgp.org.uk/news/2013/december/27m-patients-to-wait-week-or-more-to-see-gp-in-2014.aspx. Accessed August 2014

Tinetti M E, Williams T F, Mayewski R (1986) Fall risk index for elderly patients based on number of chronic disabilities. *Am J Med* **80**:429-434

Wong H T, Lai P C (2012) Weather inference and daily demand for emergency ambulance services. *Emerg Med J* **29**:60-64

Wrigley H, George S, Smith H (2002) Trends in demand for emergency ambulance services in Wiltshire over nine years: observational study. *BMJ* **324**:646-647