Access to GP services supported by IT infrastructure readiness: Analysing publically available GP practice data

Lengu, D, Sapountzis, S, Smith, R, Kagioglou, M and Kobbacy, KAH

ACCESS TO GP SERVICES SUPPORTED BY IT INFRASTRUCTURE READINESS: ANALYSING PUBLICALLY AVAILABLE GP PRACTICE DATA

Dr. David Lengu

University of Salford[1]
D.Lengu@salford.ac.uk

Mr. Stelios Sapountzis

University of Salford[1]
S.Sapontzis@ salford.ac.uk

Mr. Rob Smith

University of Salford[1]
R.Smith@salford.ac.uk

Prof. Mike Kagioglou

University of Salford[1]
m.kagiouglou@ salford.ac.uk

Prof. Khairy Kobbacy

University of Salford[1]
K.Kobbacy@salford.ac.uk

ABSTRACT

The overuse of hospital accident and emergency (A&E) departments has long been an issue of concern in most Western countries. Patients who attend A&E with non-urgent needs consume limited A&E resources and they may impede access for other patients with urgent and emergency needs. A number of studies have found that patients often turn to A&E for care because they lack timely access to general practitioner (GP) services. Recent advances in technology may help GP improve patients' access to GP services and allow them to be more responsive their patients' needs. Digital and online technology can ease interaction and information-sharing between patients and their GPs.

In this study, exploratory data mining is carried out in order to better understand the relationship between A&E attendance and various GP practice characteristics. The data used in this exercise is GP practice data publically available from the NHS Information Centre website. This data covered 39 different practice attributes related to IT infrastructure, patient care experience, patient deprivation and disease prevalence rates. Cluster analysis is used to divide GP practices into meaningful clusters and the attributes that define each cluster are identified. The differences between the five identified clusters suggest that the problem of non-urgent A&E attendances should be addressed in a more targeted fashion. Our analysis also suggests that GP practices with poor patient satisfaction levels are adopting online technologies at a slower pace when compared with others that have higher patient satisfaction levels.

Keywords: Primary care access, Cluster analysis, Data mining

1 INTRODUCTION

Hospital accident and emergency (A&E) departments are designed to provide medical treatment to those who need urgent or emergency care. However, A&E departments in most western countries are

[1] School of the Built Environment, University of Salford, 4th Floor, Maxwell Building, The Crescent, Salford, Greater Manchester, M5 4WT

caring for more patients, including those with non-urgent needs that could be treated in alternative, more cost-effective settings such as general practitioners (GP) surgeries. Inappropriate use of A&E is considered to result in overcrowding A&E (Shih *et al.*, 1999) and to contribute substantially to increased health care costs (Kellermann, 1994) and to decreased quality of care (Derlet and Richards, 2000). Non-urgent visits to A&E have been attributed, in part, to patients having difficulties in accessing general practitioner (GP) services within the community (Afilalo *et al.*, 2004; Howard *et al.*, 2005). These findings would suggest that the number of non-urgent A&E visits could be reduced by improving access to GP services.

Information technology can greatly enhance patients' ability to access local GP services. For example, online services can simplify the more routine aspects of care, such as booking appointments and requesting repeat prescriptions. Electronic health records (EHRs) allow GPs to share patient information with patients and hospital staff more easily and quickly. Patient prescriptions can also be sent electronically to pharmacies. The Department of Health in the UK recognises the potential for digital and online technology to improve GP access and, in May 2012, the department launched an information strategy to harness information and other new technologies in order to achieve higher quality care and improve the patient experience (http://informationstrategy.dh.gov.uk/, accessed 26 March 2013). The goals of this strategy include:

- Giving patients online access to their GP records by 2015,
- Connecting patient records within and between health organisations, and across the health, care and support sector,
- Capturing more GP practice data and indicators including patient experiences and views of care.

These changes will allow patients to have greater control of the health information they need.

The objective of this study is to use data mining techniques to identify the hidden patterns in GP practice characteristics. Cluster analysis is used to sort the practices and to group them into clusters of practices with shared characteristics, such as A&E attendance and the adoption of online technology. In doing so, cluster analysis will help us identify how practices with different characteristics should use online technology in order to help address the problem of non-urgent attendance at A&E. The software used to carry out this analysis is Microsoft SQL Server Enterprise 2008.

Section 2 below provides a discussion of the data used for the cluster analysis. This data was obtained from the NHS Information Centre website. The results of the cluster analysis are given in Section 3 and the clusters identified are defined. Then in Section 4, we propose a number of approaches that practices in the different clusters may take in order to address non-urgent attendance at A&E. Finally, Section 5 provides the conclusions of our study.

2 DATA AND METHODS

Our study was carried out according to the process illustrated in Figure 1. Data relating to over 8,603 GP practices in England was downloaded from the NHS Information Centre website (https://indicators.ic.nhs.uk/webview/, accessed 26 March 2013). The data covered a number of attributes in the following areas:

(a) Patient demographics: Deprivation rates among registered patients, rurality of the practice location, the number of GPs and registered patients and the prevalence rates of 19 medical conditions.
(b) A&E attendance: A&E attendance and referral rates per 1,000 registered patients.
(c) Practice IT infrastructure: Whether the practice has a number of technical capabilities that allow for the electronic transfer of patient medical records, electronic transmission of prescriptions and, for patients, electronic access to their medical records.
(d) Patient experience: Patient responses to the GP Patient Survey on issues such as waiting times, trust in their GP, ability to get appointments and satisfaction with practice opening hours and the care provided.

A complete list of all the GP practice attributed considered in this study is given in Appendix A.

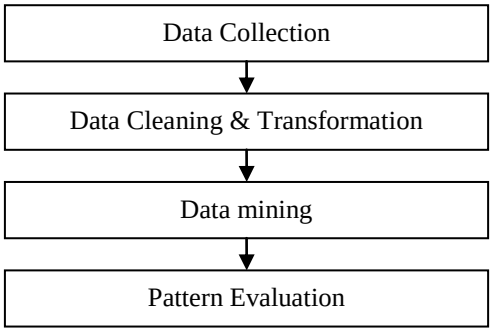

Figure 1 *Data mining process*

The data was then cleaned and transformed as follows:

(1) GPs may sometimes conclude that a patient has urgent or emergent needs and refer patients straight to A&E. A new A&E attendance rate that excludes GP referrals to A&E was added to our data set. This attribute (known as A&E self-referral attendance rate) was calculated by subtracting the A&E referral rate (attribute number 25 in Appendix A) from the total A&E attendance rate (attribute number 26).

(2) There were some practices that had an exceptionally high A&E self-referral rate. As Figure 2 below shows, A&E self-referral rates for most of the practices fell between 0 and 600 attendances per 1,000 registered patients. There were, however, some practices with extremely large A&E self-referral rates (the largest observation was 8,605 attendances per 1,000 registered patients). A closer examination of these practices revealed that some of them were set up specifically to serve the homeless. A cut-off point was set at an A&E self-referral rate of 700 attendances per 1,000 registered patients and the 42 practices with a higher rate were discarded from our data set.

There were 8561 practices left after this data cleaning and transformation process. These practices constitute our study population and the data for these practices were imported into a database for data mining.

Data Mining is defined as the process of discovering interesting knowledge from large amounts of data stored either in databases, data warehouse or other information repositories (Han *et al.*, 2006). There are a number of data mining techniques available but the ones used in this study was cluster analysis. Cluster analysis is defined as "the analysis of the unknown structure of a multidimensional data set by determining a (small) number of meaningful groups of objects or variables according to a chosen (dis)similarity measure" (Anderberg, 1973). The objective in cluster analysis is to place objects into clusters, suggested by the data and not defined a priori, such that objects in a given cluster tend to be similar to each other in some sense and dissimilar to objects in other clusters. Cluster analysis simply discovers (possibly hidden) structures in data without necessarily explaining why they exist.

Clustering is an unsupervised data mining task. No single attribute is used to guide the training process and so all input attributes are treated equally. The number of clusters was not specified a priori in this study; SQL Server's clustering algorithm was allowed to explore and identify the optimal choice using a heuristic embedded within the program. The cluster-assignment algorithm used in this study was the Expectation Maximization (EM). This assignment method uses a probabilistic measure to determine which objects belong to which clusters. The clustering algorithm considers multiple cluster models with different initialisation parameters and cluster numbers and identifies the best one. The results obtained from the cluster analysis in our study are discussed in the next section.

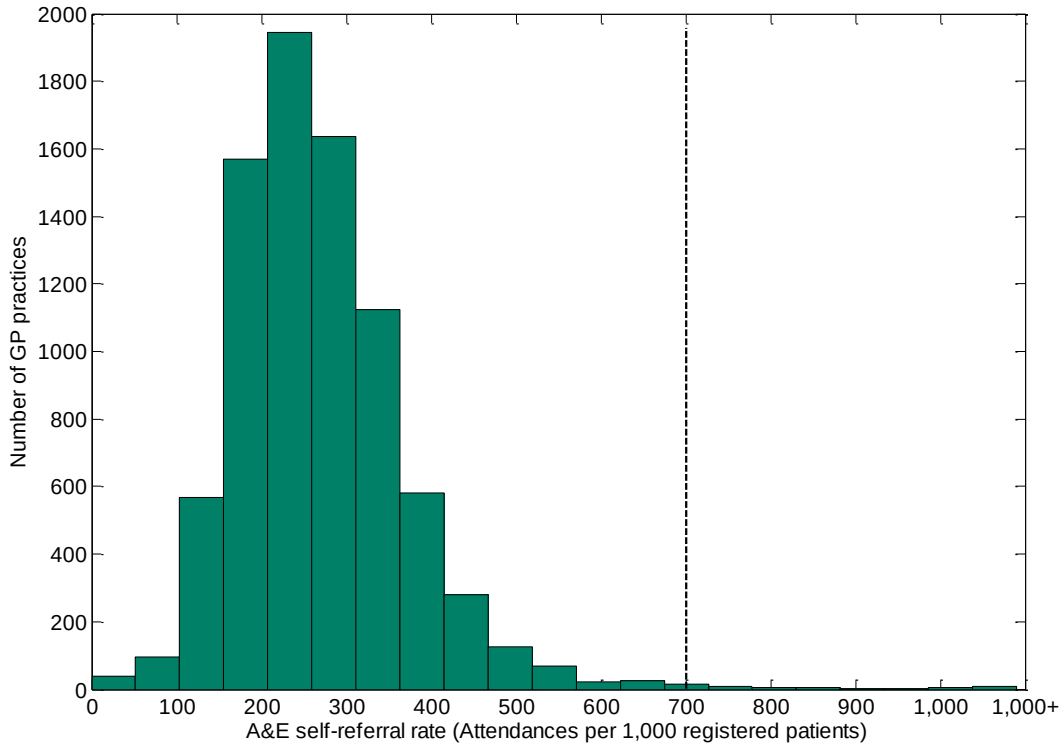

Figure 2 *Distribution of A&E Self-referral rates*

3 RESULTS

The clustering algorithm identified five distinct clusters in our data set. The algorithm also identified deprivation (attribute number 1), A&E self-referral rate and patient experience (attributes numbers 33 to 39) as the characteristics that distinguished the different clusters. Summary statistics for each of these attributes were calculated and an examination of the cluster profiles was undertaken. This involved comparing how the clusters performed with respect to each of the distinguishing attributes. The five clusters identified are described in the following paragraph and the associated cluster diagrams and summary statistics are given in Figures 3 and 4 and Table 1. The cluster diagrams are conceptual representations of the relationships between the different clusters. These relationships are inferred from the summary statistics in Table 1. The statistic given in the case of the IT infrastructure attributes is the percentage of practices that have adopted the identified online technology. For all the other attributes, the three statistics given are, respectively, the median, 5^{th} and 95^{th} percentiles.

The clusters can be characterised as follows:

(a) **'Affluent'**: This cluster is defined by low levels of deprivation among the patient population and exceptionally low level of A&E self-referral attendance. Practices in this cluster generally have patient populations with low deprivation rates (attribute 1). According to the GP Survey responses, patients registered at these practices also hold very positive views of the service provided at their local GP practice (attributes 33 to 39). When compared to all the other clusters, practices in this cluster have not only lower A&E self-referral rates (attribute 2) but also higher adoption rates for online (attributes 27 to 32).

(b) **'Impressed'**: This cluster is defined by the exceptionally high levels of patient satisfaction. Practices falling in this cluster achieved remarkably positive results in terms of patient experience of care (attributes 33 to 39). The deprivation rates in this cluster are slightly higher than those in the Affluent cluster and the adoption rates for online technology are lower. The A&E self-referral rates are markedly higher when compared to the Affluent cluster but they are also lower than the other three clusters.

(c) **'Dissatisfied'**: This cluster is in many respects the opposite of the Impressed cluster. This cluster performs worse than all the other clusters in terms of patient experience. A&E self-referral rates and deprivation rates among the patient population are also high. An examination of the IT infrastructure attributes reveals that this cluster performs particularly poorly on attributes 30 and 31 (booking or cancelling appointments online electronically and ordering repeat prescription electronically).

(d) **'Maverick'**: This cluster is the most mystifying of all five clusters. Patients registered at practices falling in this cluster have a fairly good experience of care at their local GP practice. The patient experience responses are even more positive when compared to those of the Affluent cluster. However, despite these positive patient experience results, this cluster also exhibits A&E self-referral rates as high as those observed for the Dissatisfied cluster. Our data does not allow us to find out why this is the case but one possible explanation might be that there are some patients associated with this cluster who have favourable views of the service provided by their local GP but still prefer going to A&E. The levels of deprivation in this cluster are similar to those in the Dissatisfied cluster.

(e) **'Nondescript'**: This cluster does not have any particular characteristics that distinguish it from the four other clusters. It is however more similar to the Dissatisfied and Maverick clusters than the two other clusters. The Nondescript cluster has relatively high A&E self-referral rates and mediocre performance for patient care experience. Deprivation rates are high but noticeably lower than those observed in the Dissatisfied and Maverick clusters.

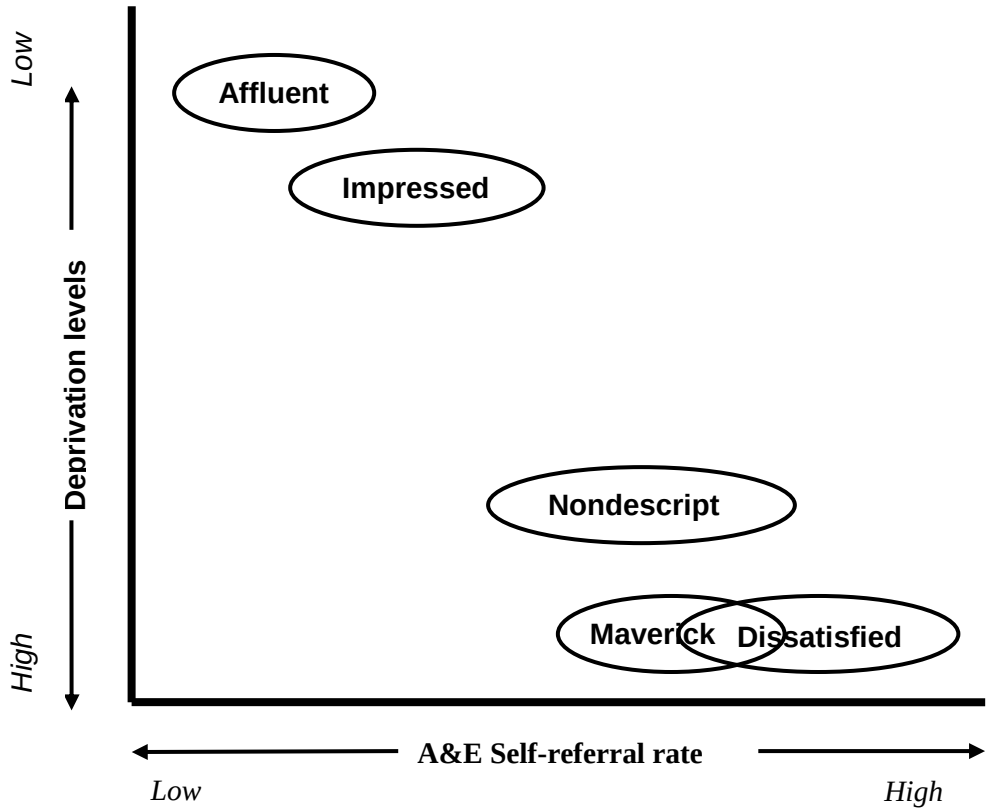

Figure 3 *Deprivation levels and A&E Self-referral rate*[2]

[2] Deprivation levels (Attribute 1); A&E Self-referral rates (Attribute 26 minus 25).

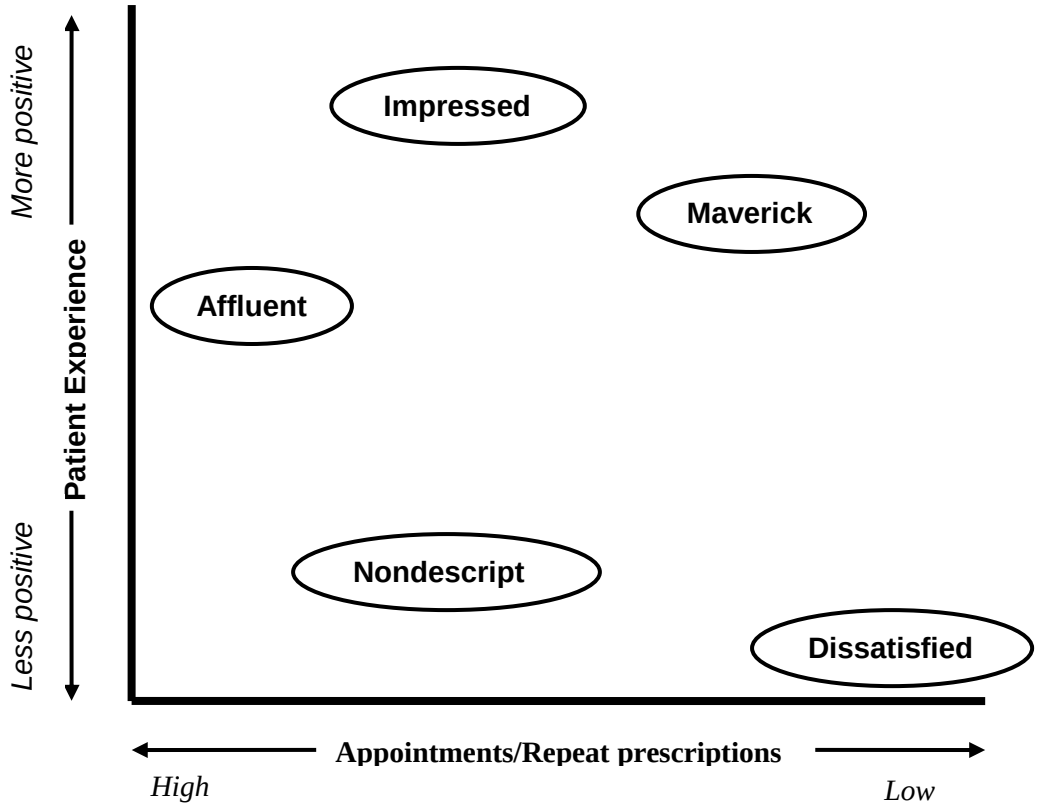

Figure 4 *Patient experience and Functionality to book/cancel appointments & order repeat prescriptions electronically*[3]

[3] Patient experience (Attributes 33-39); Appointments/Repeat prescriptions (Attributes 30 & 31).

Table 1 *Summary Statistics For Attributes Distinguishing The Clusters*

Attri-bute No.	Description	Clusters[4]				
		Affluent	**Impressed**	**Dissatisfied**	**Maverick**	**Nondescript**
	Cluster size (Number of practices)	1,798	1,441	1,592	1,950	1,778
1	Index of Multiple Deprivation (IMD)	11.8 (6.3, 19.7)	14.7 (7.2, 35.5)	29.5 (10.8, 50.3)	29.5 (14.6, 49.7)	25.4 (11.8, 46.3)
(26–25)	A&E Self-referral rate	192.7 (115.5, 278.9)	211.7 (124.3, 370.2)	295.4 (164.1, 462.5)	294.9 (189.9, 472.2)	286.2 (179.1, 432.4)
27	Uploading Summary Care Records	56.7%	52.2%	57.6%	53.4%	54.1%
28	GP2GP	57.0%	52.4%	57.7%	53.5%	54.4%
29	Electronic Prescription Service	0.9%	1.1%	1.0%	1.2%	2.0%
30	Booking or cancelling appointments	49.9%	38.9%	27.1%	32.9%	40.2%
31	Ordering repeat prescriptions	52.9%	46.2%	28.6%	36.3%	41.3%
32	Viewing full medical records	0.8%	1.0%	0.6%	0.6%	0.9%
33	Satisfaction with opening hours	77.5% (68.7%, 85.1%)	85.5% (77.6%, 94.3%)	71.7% (59.8%, 81.3%)	82.8% (74.4%, 90.4%)	76.5% (67.8%, 84.9%)
34	Experience of waiting times	72.7% (48.9%, 87.4%)	82.4% (45.7%, 94.6%)	60.8% (31.6%, 82.8%)	76.3% (47.6%, 90.8%)	67.9% (41.1%, 85.9%)
35	Being able to see doctor fairly quickly	82.8% (67.5%, 93.6%)	93.1% (81.5%, 100%)	70.0% (50.2%, 88.4%)	84.1% (69.0%, 95.8%)	75.7% (59.8%, 89.0%)
36	Being able to book ahead for appointments	73.8% (48.8%, 88.6)	89.4 (68.8%, 98.7%)	62.2% (37.9%, 84.9%)	78.4% (58.3%, 92.3%)	62.1% (39.4%, 78.3%)
37	Getting through to the practice on the phone	70.5% (48.6%, 84.5%)	84.1% (70.8%, 92.4%)	62.4% (31.0%, 81.2%)	78.1% (63.0%, 88.0%)	59.4% (36.2%, 76.4%)
38	Patient confidence and trust in the doctor	95.7% (91.6%, 98.4%)	96.8% (91.0%, 99.5%)	87.8% (78.5%, 93.3%)	93.9% (85.9%, 98.1%)	93.4% (89.4%, 97.1%)
39	Satisfaction with care received	92.0% (86.4%, 95.9%)	95.8% (89.6%, 99.2%)	78.9% (66.9%, 84.5%)	91.4% (83.9%, 96.2%)	87.9% (82.2%, 93.1%)

[4] Further details on these attributes can be found in Appendix A. The results given for attributes number 27-32 correspond to the percentage of practices in each cluster that had the identified functionality. In the case of all the other attributes (excluding the cluster size), the results are given in the form 'Median (5% percentile, 95% percentile)'.

4 DISCUSSION

The findings above provide some insights that may help health care managers develop more targeted strategies for addressing the problem of non-urgent A&E attendances. GP practice characteristics should be taken into account when developing such strategies. The results from the cluster analysis suggest that non-urgent A&E attendance is less likely to be a problem among practices falling in the Affluent cluster. This cluster is associated with low A&E self-referral rates and high levels of satisfaction among the patient population. When compared to the other four clusters, there are comparatively more practices in this cluster that have adopted online capabilities that allow patients to have easier access to their GP. This is particularly the case with respect to facilities that allow patients to book or cancel appointments electronically (attribute number 30) and to order repeat prescriptions electronically (attribute number 31). Non-urgent A&E attendances may fall as more practices adopt online capabilities. However, a more in-depth analysis of this cluster needs to be carried out in order to determine the scope for reducing non-urgent attendance in this cluster. The Impressed cluster presents similar challenges in terms of identifying suitable interventions for reducing non-urgent A&E attendances. A&E self-referral rates may be higher in the case of the Impressed cluster but this cluster is similar in all other respects to the Affluent cluster.

The Nondescript, Dissatisfied and Maverick clusters offer more clearer opportunities for reducing non-urgent attendances. In all three cases, there may be a connection between non-urgent attendances and deprivation levels among the patient population. Other studies (including Hull *et al.*, 1997; Beattie *et al.*, 2001) have found that there is a correlation between deprivation and A&E attendance (urgent or otherwise). Further studies, however, need to be carried out to assess whether there is a relationship between deprivation and *non-urgent* attendances. In the case of the Dissatisfied cluster, there is scope for reducing non-urgent A&E attendances by improving the quality of GP services. Opening hours could be increased and staff added in order to reduce waiting times. Practices in the Impressed cluster may have important lessons to offer in this area. Adoption rates for online technologies are lower for the Dissatisfied cluster as compared to all the other clusters. This is unfortunate because practices in the Dissatisfied cluster have got the most gain from online technologies in terms of patient experience of GP services. Online capabilities such as allowing patients to book and cancel appointments or ordering repeat prescriptions electronically may ease patient access and improve their experience of care at GP practices.

In the case of the Maverick cluster, A&E self-referral rates seem to be relatively high despite the positive impressions that patients have of GP services. More needs to be done to educate the patients on the appropriate use of A&E. Patient education campaigns can build on the positive impressions that patients already have of GP services. Besides public education, other interventions may be required in order to change patient behaviour. Hospitals serving patients registered at practices in this cluster may also redirect non-urgent attendances back to the GPs where it is safe to do so.

There were a number of limitations in this study. Firstly, the data used for cluster analysis was collected over a two year period. IT infrastructure data was collected more recently (2012) whereas data on other attributes such as attendance and referral rates was collected in 2010. Our analysis is therefore valid only in so far as there has not been significant change in GP practice characteristics over the two year period. Furthermore, our findings with respect to the adoption of IT capabilities may have been valid in March 2012 but more practices would have adopted the identified online capabilities by the time of this paper is published. Unfortunately, the data used in this study is the most up-to-date data available.

5 CONCLUSIONS

A&E departments are caring for more patients, including those with non-urgent needs that could be treated in alternative, more cost-effective settings such as general practitioners (GP) surgeries. Such non-urgent A&E visits may be reduced by providing patients with better access to GP services. Recent advances in online and digital technology may allow patients to have greater access to GP services. However, GP practices have different characteristics with respect to A&E attendances rates, deprivation rates among the patient population, patient experiences of care and other factors. Cluster analysis was carried out in this study in order to partition GP practices in England into meaningful groups based on GP practice characteristics.

The clusters identified suggest that a targeted approach would be helpful in addressing the problem of non-urgent A&E visits. There are some practices with relatively high A&E self-referral rates and poor patient experiences of care at GP practices. These practices are adopting online technologies at a slower rate when compared to other practices despite the potential for online technologies to improve patient care experiences. More needs to be done to encourage these practices to adopt online technologies that may improve their patients' care experience.

A APPENDICES

The attributes considered in the data mining exercise are given below. Further information on these attributes can be found at https://indicators.ic.nhs.uk/webview/:

Demography

1. Estimates of Index of Multiple Deprivation (IMD) 2010 for GP practices. (This attribute provides a measure of the level of deprivation in the community served by the practice. The Index of Multiple Deprivation is made up of contributions from 7 domains: Income; Employment; Health and disability; Education, skills and training; Barriers to housing and services; Crime; and Living environment).
2. Rural/Urban definition of GP practice, December 2011 (Based on the DEFRA 8(4) category system for defining rurality. The location of the practice is classified as Urban (>10,000 people), Town & Fringe, Village or Hamlet & Isolated dwelling.
3. Number of GPs (headcount), January 2011.
4. Number of patients register at the practice, January 2011.
5. Number of GPs per registered practice population, 2010.
6. Asthma prevalence: Percentage of registered patients on the Asthma register, 2010-11.
7. Atrial fibrillation prevalence: Percentage of registered patients on the Atrial Fibrillation register, 2010-11.
8. Cancer prevalence: Percentage of registered patients on the Cancer register, 2010-11.
9. Cardiovascular disease prevalence: Percentage of registered patients on the Cardiovascular Disease register, 2010-11.
10. Chronic kidney disease prevalence: Percentage of registered patients 18 years or older on the Chronic Kidney Disease register, 2010-11.
11. Coronary heart disease prevalence: Percentage of registered patients on the Coronary Heart Disease register, 2010-11.
12. Chronic obstructive pulmonary disease prevalence: Percentage of registered patients on the Chronic Obstructive Pulmonary Disease register, 2010-11.
13. Diabetes mellitus prevalence: Percentage of registered patients 17 years or older on the Diabetes Mellitus register, 2010-11.

14. Epilepsy prevalence among: Percentage of registered patients 18 years or older on the Epilepsy register, 2010-11.
15. Heart failure prevalence: Percentage of registered patients on the Heart Failure register, 2010-11.
16. Hypertension prevalence: Percentage of registered patients on the Hypertension register, 2010-11.
17. Hypothyroidism prevalence: Percentage of registered patients on the Hypothyroidism register, 2010-11.
18. Learning disabilities prevalence: Percentage of registered patients 18 years or older on the Learning Disabilities register, 2010-11.
19. Depression prevalence: Percentage of registered patients 18 years or older on the Depression register, 2010-11.
20. Dementia prevalence: Percentage of registered patients on the Dementia register, 2010-11.
21. Mental health prevalence: Percentage of registered patients on the Mental Health register, 2010-11.
22. Obesity prevalence: Percentage of registered patients 16 or older on the Obesity register, 2010-11.
23. Palliative care prevalence: Percentage of registered patients on the Palliative Care register, 2010-11.
24. Stroke or transient Ischaemic attacks (TIA) prevalence: Percentage of registered patients on the Stroke or TIA register, 2010-11.

A&E attendance

25. Accident and emergency referrals per 1,000 of the GP Practice's registered patients, 2010.
26. Accident and emergency attendances per 1,000 of the GP Practice's registered patients, 2010.

IT Infrastructure

27. Whether the practice has commenced Uploading Summary Care Records, March 2012. (The Summary Care Record supports patient care by providing healthcare staff in urgent and emergency care settings with the essential medical information they need to support safe treatment).
28. Whether the practice has gone live with GP2GP and is Actively using GP2GP, March 2012. (GP2GP enables patients' electronic health records (EHRs) to be transferred directly from one GP practice to another).
29. Whether the practice has gone live with Release 2 of the Electronic Prescription Service, March 2012. (The Electronic Prescription Service (EPS) is an NHS service that enables GP practices to send prescriptions electronically to the pharmacy of the patient's choosing).
30. Whether the practice provides functionality for patients to book or cancel appointments electronically, March 2012.
31. Whether the practices provides functionality for patients to view or order repeat prescriptions electronically, March 2012.
32. Whether the practice provides functionality for patients to view their full medical record electronically, March 2012.

Patient experience

33. Patient satisfaction with opening hours from the GP Patient Survey: Percentage of patients who indicated that they were satisfied with the opening hours at their GP practice, 2010/11.
34. Patient experience of the waiting time at surgery from the GP Patient Survey: Percentage of patients who indicated that they were seen within 15 minutes after their appointment time, 2010/11.
35. Patient experience of being able to see a doctor fairly quickly from the GP Patient Survey: Percentage of patients who indicated that they were able to see a doctor on the next 2 days the surgery was open, 2010/11.
36. Patient experience of being able to book ahead for an appointment with a doctor from the GP Patient Survey: Percentage of patients who indicated that they were able to get an appointment with a doctor more than 2 full weekdays in advance, 2010/11.

37. Patient experience of getting through to their practice on the phone from the GP Patient Survey: Percentage of patients who indicated found it easy to get through on the phone, 2010/11.
38. Patient confidence and trust in the doctor from the GP Patient Survey: Percentage of confidence who responded that they have trust in their doctor, 2010/11.
39. Patient satisfaction with care received at the surgery from the GP Patient Survey: Percentage of patients who indicated that they were satified with the care they received at the practice, 2010/11.

AUTHOR BIOGRAPHIES

DAVID LENGU received a MSc Operations Research and Applied Statistics from the University of Salford in 2007. He completed his PhD at the same University in 2012. He is currently a researcher in the School of Built Environment. His research interests are in stochastic processes and simulation modelling.

STELIOS SAPOUNTZIS is a Research Fellow at the Health and Care Infrastructure Research and Innovation Centre (HaCIRIC) at the University of Salford. He studied Manufacturing Engineering and Management and Advanced Manufacturing Systems and has extensive industrial experience as an operation/production manager within the electronics sector. During that time he was also the organisation's UK champion for lean implementation in production processes and supporting functions. He is conducting his PhD research on benefits realisation and management for the UK healthcare sector, his other research interests including process optimisation, change management and the applications of lean theory in service planning and delivery. He has published in journals, books and conferences and has delivered keynotes to healthcare events and project management practitioners. He was a reviewer for the new edition of Managing Successful Programmes (MSP) and member of the scientific committee for the HaCIRIC and International Group of Lean Construction (IGLC) conferences.

ROB SMITH graduated from the University of Manchester Institute of Science and Technology (UMIST) in 1971, worked in the design and construction industry becoming a Chartered Engineer attaining membership of the Institutions of Civil and Structural Engineering before returning to UMIST to undertake ESRC funded research and gain an MSc. He worked in the NHS from 1986 to 2002 in strategic planning, operational management, delivery of major projects and change programmes holding a number of posts including that of Chief Executive of a large NHS Trust and Project Director for the delivery and commissioning of the first Private Finance Initiative Teaching Hospital in England. He joined the Department of Health working as Director of Estates and Facilities responsible for policy for the NHS in England, including the ProCure 21 Framework contract used by the NHS and the application of the Office of Government Commerce Gateway Review process. In 2012 he joined Salford University as a Visiting Professor in the School of the Built Environment as part of the EPSRC HaCIRIC programme. For two years he was President of the Institute of Healthcare Engineering and Estate Management and is currently Honorary President of the Health Estates and Facilities Management Association.

KHAIRY A.H. KOBBACY is a Professor of Management Science in the School of Built Environment, University of Salford, UK. He has long-standing interest in 'applied' operational research. He previously lectured at Strathclyde University after gaining industrial experience in the Strategic and Production Planning Department of a major oil company. His research interests are in modelling and simulation in healthcare, maintenance modelling and the development of intelligent management systems in operations. His research has been funded by industry and the research councils. He chaired four European conferences on Intelligent Management Systems in Operations, since 1997 with the 5th planned for 2013. He will be chairing the next International Conference on Industrial Logistics (ICIL) 2014. He was awarded the Operational Research President's medal in 1990 and the Literati Club Award in 2001. He was a Vice President of the Operational Research Society, UK (2002–2004).

MIKE KAGIOGLOU is the Head of School of the School of the Built Environment (SoBE), University of Salford. He is an Academic Director for the £11M EPSRC funded interdisciplinary IMRC in Health and Care Infrastructures Research and Innovation Centre (HaCIRIC) and PI for Salford University. Partners include Imperial College, Salford, Loughborough and Reading Universities. He was previously the Director of the £8M EPSRC (Engineering and Physical Sciences Research Council) funded Salford Centre for Research and Innovation (SCRI) in the Built and Human Environment. He is a Professor of Process Management, Director of Protocol Lab, a spin out company resulting from the process protocol research and a Fellow of the Higher Education Academy. He has published more than 120 academic refereed papers, many industrial reports and two books. His current research is around healthcare infrastructure and better decision making in complex setting, following an outcomes/benefits-based philosophy.

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