Community fire prevention via population segmentation modelling

Mark Taylor, Emma Higgins, Paulo Lisboa, Ian Jarman, Abir Hussain

Computing and Mathematical Sciences
Liverpool John Moores University,
Byrom Street
Liverpool
L3 3AF
UK

Email m.j.taylor@ljmu.ac.uk

ABSTRACT

In this paper we examine the use of population segmentation modelling for targeting fire prevention to the needs of the community. A population segmentation approach based upon socio-economic characteristics data was developed to provide a deeper understanding of the fire risks associated with different social groups by a partnership consisting of a UK fire and rescue service, a National Health Service trust, a local council, and a police force. This approach supported more targeted and co-ordinated community fire prevention measures by the agencies involved. This approach was used to target those most at risk, and improve intra-agency co-ordination and collaboration between the agencies involved. The modelling enabled differences in terms of the risk of fire related injuries and fatalities between the population segments to be examined. Overall, the research examines how and why population segmentation was undertaken by the fire and rescue service studied, and how this was implemented and used operationally to support fire prevention activities. The project was funded by the UK Department of Communities and Local Government.

1. INTRODUCTION

Population segmentation modelling has been used by health and social services agencies as a means of attempting to understand the levels of related risks for different social groups within the community (Tapp et al, 2006; Boslaugh et al, 2005; Abendstern et al, 2011; Demydas, 2011). Sanky et al (2012) commented that there is great potential for population segmentation approaches in the field of health interventions. Population segmentation can support the identification of distinct, definable population subgroups whose members have common socio-economic characteristics that can be used to inform the different messages or incentives to implement risk management strategies in the community. This can assist in the analysis of population vulnerabilities (Bonvicini et al, 2012).

In this paper we examine the use of population segmentation modeling to provide an understanding of the needs of the different communities present in the region covered by

the fire and rescue service studied. The work was funded by a grant from the UK Department of Communities and Local Government between 2010 and 2012. Population segmentation was used in order to examine the distribution of different population segments across the region studied. This supported fire prevention initiatives targeted to specific populations in specific geographic areas within the region. The research and development work was commissioned by a multi-agency partnership that included the fire and rescue service, an NHS (National Health Service) primary care trust, a local council and a police force.

There can be different approaches underlying fire prevention strategies utilized by fire and rescue services. Some approaches may be based upon spatial analysis of previous fire incidences, others may be based upon analysis of causal factors associated with fires (Taylor et al, 2011). The use of population segmentation to underlie a fire prevention strategy is a new area of research.

The population segmentation approach examined in this paper was based upon socio-economic characteristics of the population within the area covered by the fire and rescue service studied. The approach involved the use of k-means clustering (a statistical technique commonly used for population segmentation) to create ten distinct population segments. The number of population segments used was not based upon 'optimal statistical' reasoning for why this would be the 'best' set of clusters (population segments) but rather the overriding operational need for a usable number of population segments. Fewer than ten population segments would be in operational terms too coarse grained a classification, which would not have supported sufficient selective targeting of fire prevention resources. More than ten populations segments would have been unwieldy to use operationally. The decision to adopt ten population segments was made by experienced senior fire officers within the fire and rescue service studied.

The researchers developed a population segmentation approach based upon population characteristics data that supported identification of community segments that could be used to address dwelling fire risk within the community. Population segmentation modelling was used in order to attempt to understand the needs of the local community in terms of fire prevention. In particular, population segmentation was used to identify the distribution of different population segments across the region covered by the fire and rescue service. This supported fire prevention initiatives targeted to specific population segments being delivered to those geographical areas within the region containing such population segments. Different population segments require different approaches to fire prevention. For example, fire risks relating to elderly individuals and young families are different and therefore would benefit from different fire prevention approaches.

Population segmentation modelling was also used to support enhanced intra-agency partnership working, which assisted in improving the identification of vulnerable individuals and supporting 'joined-up' delivery of 'prevention' interventions for at-risk citizens. Identifying vulnerable or high risk individuals at an early stage can reduce the need for more costly, 'reactive' interventions later on.

The population segmentation modelling was undertaken using k-means cluster analysis (Armstrong et al, 2012; Higgins et al, 2013) using the SPSS (SPSS, 2014) statistical software package. K-means cluster analysis (where k represents the number of means desired) is a statistical technique that uses an iterative approach that minimizes the squared Euclidean distance between cluster centres and the observations associated with them. A z transformation was used to standardise the variables before k-means cluster analysis was undertaken in order to attempt to prevent variables with the largest ranges from unduly influencing the cluster analysis.

Data sharing agreements between the partner organizations and a geographical information system were developed to support enhanced referral and advocacy services as part of a programme of enhanced intra-agency co-operation for community fire prevention between the agencies involved in the project.

The originality of the research reported in this paper is the application of a population segmentation approach for community fire prevention, and the utilization of this approach for co-ordinated intra-agency collaboration in order to more effectively and efficiently target fire prevention measures to at-risk groups in the local community.

This research supported more targeted co-ordinated intra-agency fire prevention measures to reduce fire incidents and associated injuries and deaths and also the underlying health and social care problems relating to vulnerable individuals within the community. This research extends the theoretical knowledge base in terms of community fire prevention strategies, via a population segmentation approach for fire risk management, and utilization of this approach for enhanced intra-agency collaboration and implementation of fire prevention measures.

2. LITERATURE REVIEW

2.1 Population segmentation modelling

Population segmentation approaches have been used in a marketing context for some time (Soiuden at el, 2013; Macharia et al, 2013; Webber, 2011). However, population segmentation approaches are only more recently being used by public sector agencies in areas such as health (Sanky et al, 2012; Gracia-Marco et al, 2011), social services (Davies and Sherriff, 2011; Abendstern et al, 2011), and public health (Demydas, 2011).

Population segmentation modelling can be used to inform more targeted provision of public services, enabling delivery of an appropriate level of service to those most in need. Population segmentation modelling can inform all aspects of operation from generating a strategic understanding of communities, to managing performance, through to understanding the target audience for particular services (IDeA, 2014, Experian, 2014). Population segmentation modelling allows analysis of the characteristics of different groups within the community and their needs, which may relate to the provision of

services by a number of different public sector agencies (Ball et al, 2010), for example, partnerships between health and social care agencies.

Jennings (2013) discussed the use of social and economic characteristics as determinants of residential fire risk in urban neighborhoods, and the use of geographical information systems to analyse such. The US Fire Administration has examined the socioeconomic characteristics associated with fire risk (FEMA, 2013). The US Vision 2020 fire community risk reduction programme addresses the fire risk associated with different communities (Jennings, 2013). Corcoran et al (2013) examined the use of a geodemographic classification in an exploratory analysis of variations in fire incidence in South Wales in the UK.

2.2 Public sector collaborative working

Current reductions in government spending necessitate the targeting of reduced resources in more effective ways by public sector agencies (Stuckler et al, 2010a). Improved approaches to intra-agency public sector co-operation can potentially achieve more efficient overall utilisation of resources by the partner agencies (Stuckler et al, 2010b; Sorrentino and Simonetta, 2011; Niehaves and Krause, 2010). For example, in terms of intra-organizational data sharing in the public sector (Yang and Maxwell, 2011) in order to attempt to improve policy and practice (Florence et al, 2011; Quigg et al, 2010).

There is increasing necessity for government agencies to act in a more collaborative, integrated manner (Ryan and Walsh, 2004). However, Greasley et al (2008) warned that, whilst there can be clear benefits of public sector partnerships working, achieving successful collaboration may not be straightforward. Greasley et al (2008) further commented that further research should be undertaken to explore this phenomenon.

2.3 Public sector risk management

Hood and Smith (2012) commented that the use of risk management in the public sector has grown in recent years. Lizhi and Aizhu (2008) had discussed the use of k-means cluster analysis of fire incidence data that included the time of occurrence, the number of fires, the economic losses and the number of casualties for fire risk analysis purposes. Risk analysis has been undertaken by a variety of individual government agencies representing the emergency services, healthcare and social services for some time (Taylor et al, 2011; Holborn et al, 2003; Card et al, 2012). Gielen et al (2013) commented that community health workers and community partnerships can be useful in promoting fire departments' fire safety initiatives. The use of population segmentation modelling for supporting community fire prevention is a new area of research.

Grote (2012) commented that different aspects of organizational functioning should be taken into account when designing or evaluating risk management strategies across different sectors. This has been done in individual government agencies, for example, fire

and rescue services (Holborn et al, 2003) and healthcare (Cagliano et al, 2011). However, there appears to less research into such with regard to partnerships of public sector agencies.

The UK government provides various guides for fire safety (FS, 2014), for example, Fire: make your home safe, Fire safety for students in rented accommodation, Fire safety for parents and child carers, and Fire safety for people with sight, hearing or mobility issues. However, many people in the UK are not aware that their local fire and rescue service will visit their home, free of charge to conduct a home fire safety check (FSA, 2014).

The research reported in this paper examines the use of population segmentation modelling for community fire prevention by a multi-partner group of public sector bodies. The research involved the development of a population segmentation approach for fire risk management. The research also examined the utilization of the population segmentation model for supporting more targeted and co-ordinated provision of fire prevention measures by the multi-agency partnership.

3. RESEARCH METHOD

The researchers adopted the case study research method (Gerring, 2007) for the research project reported in this paper. The case study research method was used by the researchers as it allowed an in-depth examination of the development of a statistical population segmentation model (based upon k-means clustering) and the process of utilizing the population segmentation model to support fire prevention in actual practice. K-means cluster analysis is a statistical technique that identifies relatively homogeneous groups of cases based on particular variables. The researchers undertook an eighteen month case study between 2010 and 2012 of a project funded by the UK Department for Communities and Local Government involving a UK fire and rescue service, a local council, a National Health Service trust, a local council, and a police force.

The research questions posed by the researchers were:

- How can population segmentation modelling inform fire prevention?
- How can population segmentation modelling support community fire prevention by a multi-agency partnership?
- How can population segmentation modelling assist in managing fire risks in practice?

In the current climate of reduced public sector spending these research questions are important since more effective and efficient means of public sector resource utilization is becoming increasingly necessary. The use of statistical population segmentation models can improve the identification of fire risks associated with different social groups, which

can support improved targeting of overall lower cost fire prevention initiatives at an earlier stage.

The actual research techniques utilised for the case study included interviews and discussions with management and operational staff in the partner organizations. A wide variety of staff in the partner organizations involved in the fire risk management project were interviewed.

The researchers collected case study data via meetings and interviews with relevant staff involved in the fire risk management project within the organizations studied. The data collected was content analyzed by identifying themes within the interview and project meeting texts. For example, themes such as: how population segmentation modelling data could inform fire prevention. This approach allowed an understanding of the issues associated with using population segmentation modelling for fire prevention. In particular, the approach supported understanding of:

- The process of community fire risk analysis using population characteristics data
- The process of the development of a statistical population segmentation model
- The application of population segmentation modelling for community fire prevention in actual practice.

The fire and rescue service had previously undertaken analysis of local fire incident data to identify causal scenarios and their association with geographic areas in the form of fire incidence and fire fatality maps. A segmentation modelling approach was developed in order to attempt to address fire prevention to socio-economic community groups rather than just geographic areas. However, the very nature of segmentation modelling implies that the issue of ecological fallacy needs to be addressed in that the interpretation of the statistical data in terms of inferences about the nature of individuals being deduced from inferences about the group can only be generic in nature, since any such group will include a variety of similar but different individuals.

Available socio-economic data for population segmentation modelling within the region consisted of 90 datasets covering 130 data variables concerning the socio-economic characteristics of citizens within the region studied at the output area (OA, 2014) level of geography. An output area typically contains around 120 households. K-means cluster analysis was used to create clusters of the socio-economic variables. Cluster analysis is widely used as a technique to separate populations into mutually exclusive groups (Brida et al, 2010). The k-means cluster analysis statistical technique was used since it is a well-established statistical technique for cluster analysis in the area of risk management (Kort-Butler and Tyler, 2013; Rudmo et al, 2013; Kendall et al, 2013; Fugas et al, 2013). The z scores of the values of the variables were used to standardize the variables prior to k-means cluster analysis in order to attempt to ensure that variables with the largest range did not unduly influence the analysis. The k-means cluster analysis was performed using the SPSS (Statistical Package for the Social Sciences) statistical analysis software

package (SPSS, 2014). Box plots of the variables were used to visually analyze and illustrate the differences between the clusters. The combined set of boxplots for the variables used provided an overview of the cluster differences. For each of the socio-economic data variables available the metric or measure was either a percentage or number of citizens representing a particular characteristic within each area within the region studied.

Co-linearity between the variables and the range of values of the different data variables was used to select appropriate data for cluster analysis. This resulted in twenty variables being selected for the cluster analysis based upon their statistical suitability and their suitability for representing social groups in terms of age, housing type, health indicators, and level of deprivation.

It was important to check for co-linearity between variables being considered for cluster analysis. Where variables had a high level of co-linearity (the Pearson Product Moment Correlation Coefficient greater than 0.8) one of these was retained in the cluster analysis based upon its practical usefulness, and the other removed, since such co-linearity between variables could have distorted the results. Binary data variables (for example, data with a yes or no value) and data variables with a small range of discrete values were also removed, since such variables could also distort the results of the cluster analysis.

The spatial environment in the region studied included both urban and rural areas, and also included areas of nationally recognized affluence and deprivation. This provided the opportunity to examine these variations in the population segmentation modelling.

The case study approach supported an in depth examination of the utilization of population segmentation modelling for community fire prevention by the partnership agencies. The main weakness of the case study approach utilized for the research reported in this paper was the potentially limited generalizability of the findings. Using small areas as the baseline communities at risk could lead to some of the variables being unreliable and less representative of the area (Watson et al, 2009). Qualitative interviews may have limitations resulting from the content analysis approach used. In addition, limitations on multi-agency data sharing may be imposed by the UK Data Protection Act 1998 (DPA, 1998; Higgins et al, 2014) or similar legislation

4. RESEARCH RESULTS

4.1 Community fire prevention via a multi-agency partnership

The community fire prevention approach developed involved:

- The sharing of relevant data between the partnership agencies (via data sharing agreements)

- The analysis of shared data to create distinct population segments
- The creation of community profiles for the identified population segments
- The analysis of the distribution of the population segments via a geographical information system
- The analysis of fire risk associated with identified population segments
- The use of home fire safety checks (HFSC, 2014)) within identified at-risk geographical areas to target identified at-risk population segments. A home fire safety check involves a member of the local fire and rescue service visiting a household to undertake an inspection of the home. This focuses upon the identification of and awareness raising of the potential fire risks within a home, provision of information regarding how to reduce of prevent such risks, and ensuring that there are working smoke alarms in the home.
- The use of referral and advocacy services following a home fire safety check visit to signpost at-risk individuals to partner agencies.

Relevant available socio-economic characteristics data was collected from the partner organizations and also from UK national organizations such as the UK Department for Work and Pensions and the UK Office of National Statistics.

Analysis of the data was conducted by the fire and rescue service in order to ascertain which variables were appropriate for cluster analysis as described in the research methods section previously. Population segments were then created using k-means cluster analysis using the SPSS statistical package. Community profiles were then developed based upon the developed population segments. A fire risk management geographical information system was then created to display map based information relating to the population segments.

4.2 Using population segmentation modelling to inform community fire prevention

The types of population characteristics data available for the region studied included population demographics, health, disability, social benefits, housing, deprivation and community safety. The following variables were deemed suitable (as described previously in the research methods section) for use within a k-means cluster analysis.

Average life expectancy at birth in the output area
Percentage of population in the output area aged 0-15
Percentage of population in the output area aged 16-24
Percentage of population in the output area aged 25-49
Percentage of population in the output area aged 50-64
Percentage of population in the output area aged 65 Plus

Number in receipt of other income benefits in the output area
Combined health and deprivation indicator for the output area
Number of emergency admissions to hospital in the output area
Percentage of population in the output area living in fuel poverty
Percentage of households receiving child benefit in the output area
Percentage of population in the output area receiving severe disablement allowance
Number of households with housing in poor condition
Percentage of pension claimants in the output area aged under 70
Percentage of pension claimants in the output area aged70-74
Percentage of pension claimants in the output area aged 75-79
Percentage of pension claimants in the output area aged 80 plus
Number of Department of Adult Social Care (DASS) claimants in the output area
Number of residents in the output area claiming council tax benefits
Number of households with a social landlord

The above variables were available for the 4585 output areas (OA, 2014) within the region studied. The population segments were created using the k-means cluster analysis technique using the SPSS statistical package. When performing k-means clustering it is important to determine an appropriate number of clusters for the data set being analysed. Ten clusters was determined appropriate from the operational needs of the fire and rescue service in terms of the number of population segments appropriate for community fire prevention. Ten clusters were viewed as providing a more appropriate model for practical operational activities in terms of risk reduction via preventative measures. The ten clusters resulting from the k-means cluster analysis (based upon the operational requirement for 10 clusters) are shown in Table 1 and Table 2.

Number of Cases in each Cluster

Cluster	1	859
	2	293
	3	671
	4	546
	5	690
	6	80
	7	163
	8	385
	9	131
	10	767
Valid		4585
Missing		0

Table 1. The number of cases in each cluster from the k-means cluster analysis.

Final Cluster Centers

	Cluster									
	1	2	3	4	5	6	7	8	9	10
Persons_Life_expectancy_at_birth	.88	-.23	-1.00	.05	.55	-1.40	-.91	.34	-.87	-.24
%Aged_0_15	-.66	.61	.36	.96	-.28	-2.35	1.02	-.18	-1.51	.13
%Aged_16_24	-.61	.07	.35	-.07	-.37	6.08	-.03	-.13	.96	.01
%Aged_25_49	-1.06	-.04	.36	.78	-.30	-.91	.14	.05	2.43	.23
%Aged_50_64	.73	-.34	-.47	-.58	.70	-2.69	-.26	.13	-1.07	-.04
%Aged_65_Plus	1.3	-.2	-.5	-.8	.4	-1.6	-.6	.1	-1.1	-.2
Number_Other_Income_Benefits	-.24	.01	.27	-.08	-.23	.30	.40	-.27	.15	.26
Combined_Health_Deprivation_and	-.89	.48	1.10	-.26	-.84	1.09	.83	-.23	.67	.50
Emergency_Admissions_to_Hospital	-.40	.64	.81	-.10	-.70	.65	-.33	-.38	.20	.36
%Fuel_Poverty	-.59	-.12	1.20	-.40	-.76	.99	.86	-.27	.51	.39
%All_Child_Benefit_recipients	-.72	.46	.39	1.10	-.34	-1.81	.82	-.17	-1.25	.13
%Severe_Disablement_Allowance	.66	-.19	-.37	-.03	-.10	-.30	-.34	.12	-.36	-.12
Housing_In_Poor_Condition	-.59	.06	1.03	-.53	-.80	.91	.40	-.22	.60	.66
%Pension_Claimants_Under_70	-.58	-.15	.33	.56	.76	.09	.45	-.32	.43	-.68
%Pension_Claimants_70_74	-.43	.48	.63	.19	.13	.32	-.13	.07	.08	-.56
%Pension_Claimants_75_79	.33	.44	-.36	-.26	-.57	.09	-.34	.10	-.20	.52
%Pension_Claimants80	.7	-.4	-.5	-.5	-.6	-.3	-.2	.2	-.4	.7
DASS_Claimants	-.43	-.51	.17	-.19	-.11	-.24	-.19	1.95	-.28	-.10
Revenue&Benefits	-.30	-.34	.00	-.22	-.21	-.08	4.59	-.15	-.09	-.07
Social_Landlord	-.27	3.07	-.12	-.23	-.25	-.15	-.09	-.29	-.21	-.15

Table 2. Centres for the transformations from the k-means cluster analysis.

The final cluster centres are computed as the mean for each variable within each final cluster. The final cluster centres reflect the characteristics of the typical case for each cluster. For example, cluster 1 consists mainly of wealthy individuals aged over 50.

When the population segments had been generated by using the k-means clustering approach, profiles were developed for the population segments. This was achieved by

banding the characteristics represented by the variables used for k-means clustering (and other available variables), into high, medium and low classifications. This was done from an operational perspective of the fire and rescue service. From this a set of profiles for the ten population segments was developed. The ten community profiles generated were (Higgins et al, 2013):

1. Wealthy over 50 population living in semi-rural locations
2. Older retirees
3. Middle income residents living in privately owned properties
4. Average income older residents
5. Students living in city centre locations
6. Young families
7. Young families with high benefit need
8. Residents living in social housing with high need for benefits
9. Transient population living in poor quality housing
10. Younger, urban population living in high levels of deprivation.

The population segments generated by the cluster analysis appeared to present clear differences in terms of levels of accidental dwelling fire risk (Higgins et al, 2013). Over the three year period 2010 to 2013, the number of dwelling fires (per 10,000 households) associated with the different population segments ranged from 386 (young families) to 12.64 (students living in city centre locations). The number of dwelling fire injuries associated with the different population segments varied from 44 (per 10,000 households) for young families to 0.58 (per 10,000 households) for students living in city centre locations. This highlighted the clear differences in fire risk between the different population segments. The population segments assisted the fire and rescue service in understanding the characteristics of individuals within the region most vulnerable to dwelling fires. Knowledge of the socio-economic characteristics of the different population segments, for example, age profile, urban or rural, wealthy or deprived informed policy regarding the type of fire prevention appropriate for the different groups.

A detailed profile description document was then created utilizing all 130 data variables highlighting the risks and needs present and the relative risk levels for that population segment, for example, this could relate to an elderly population, deprivation, benefit need, poor housing. This assisted in making the population segments developed more accessible to a wider audience within the partner organizations for targeting specific fire prevention initiatives to the community.

4.3 Multi-agency community fire prevention in practice.

The community profiles were used to analyze the fire risks relating to the different community profiles. In order to utilize population segmentation modelling for supporting fire prevention it was necessary to appreciate how the different risk profile groups within the region studied (the population segments) differed in terms of the level of fire risk. A geographical information system was developed using the MAPINFO (MAPINFO, 2014) geographical information systems software development tool to identify where the different population segments were located within the region studied via a community ice

This aimed to assist in the co-ordinated targeting of resources by the agencies within the partnership to specific population segments in specific geographic areas within the region. For example, smokers identified during home fire safety check were referred to NHS primary care trust smoking cessation services. In addition, individuals identified as having housing and social care issues were referred to the social services department of the local council. Overall the population segmentation modelling supported targeted interventions to be undertaken either by the fire and rescue service (e.g. fitting of smoke detectors or fire safety advice) or by partner agencies in healthcare (e.g. smoking cessation services) or social services in the local council (e.g. social care and housing problems) and in the police force (e.g. reporting of anti-social behavior affecting an individual or household).

The different profile groups were examined in the operational contexts of the partner agencies. For example, with regard to different incident types associated with different profile groups it was identified that:

- The group "young families" had high levels of accidental dwelling fires. In particular, young families with high benefit needs accounted for the largest percentage of accidental dwelling fires, and had the second largest percentage of fire fatalities.

- The group "middle income residents living in privately owned properties" had a high fire fatality rate (the largest percentage of fire fatalities), but the rate of accidental dwelling fires was approximately average. This group included a significant proportion of elderly individuals, who are less likely to survive burns injuries.

The logic behind the community-based intervention strategy for fire prevention was that different segments of the population represented different forms of fire risk. For example, the fire risks associated with elderly individuals were different to families with young children. By using a population segmentation approach, the fire and rescue service could examine the communities (based upon the population segments) within the region covered, and adapt fire prevention activities to the needs of the different communities. The community profiles were used to target initiatives directly towards relevant communities by analysing the number and types of fires affecting the different community groups. Community profiles were found to be advantageous compared to other geodemographic classifications, since a community profile approach can make use of locally available information and knowledge regarding fire risks. The fire and rescue

service used the community profiles to target areas of greater risk of fires in the kitchen. Analysis of 2011 kitchen fire data found that 90% of kitchen fires occurred within three of the community profile groups. Operational crews targeted geographical areas classified with those community profile groups. The community profile descriptions enabled the operational crews to deliver fire safety information in a manner appropriate to the audience contained within the community profile groups concerned.

The effectiveness of the population segmentation modelling approach was assessed by the UK Department of Communities and Local Government that recommended the approach as a model of good practice for other UK fire and rescue services (LGA, 2012).

Overall the knowledge provided by analysis of the different population segments and their geographic distribution was pro-actively utilized to initiate targeted fire prevention interventions that could improve the quality of life and independence for citizens within the region.

5. CONCLUSIONS

In this paper we have examined the adoption of a population segmentation modelling approach for supporting fire prevention, and the benefits of such an approach. In many countries the reduction in government spending is necessitating improved management of public service provision. One approach to improving the management of public service provision can be the ability to identify those in greatest need, or those at most risk within communities, and to target the reduced resources accordingly via a co-ordinated approach by public sector agencies working in partnership. The case study demonstrated that effective use of co-ordinated pro-active preventative measures has the potential to reduce fire risk. For example, in terms of pro-active reduction of fire risks associated with smoking through smoking cessation referral services, and with regard to more effective fire prevention that uses enhanced understanding of socio-economic factors to more effectively target those at greatest risk from fire. Individuals referred to smoking cessation services by a fire safety officer via a home fire safety check might not have otherwise considered such services.

Fire risk should be viewed in a holistic manner, that is appreciating that there can be a wide variety of overlapping and interacting factors that affect fire risk. In order to attempt to manage fire risk it may be insufficient to concentrate upon individual causal factors but rather it may be necessary to view the problem situation as a mesh of interacting and overlapping factors. This can assist in understanding the sets of interrelated causal factors that need to be addressed as a 'whole' rather than individually in isolation. For example, smoking and excessive alcohol consumption increase fire risk, however, the fire and rescue service was not in a position to be able to reduce smoking or binge drinking rates. The NHS trust partner agency did however provide such services. By working together the NHS trust was able to reduce health risks associated with smoking and binge drinking and the fire and rescue service could reduce the underlying causal factors associated with fire risk. In a similar manner, elderly and disabled individuals living alone are more at

risk of fire, however, this was not something that the fire and rescue service could alter. However, the local council could provide services for such individuals. By working together the council could be advised of individuals in need of support, for example, elderly and disabled individuals living alone might be referred to social services in the local council, and the fire and rescue service could reduce the risk of fire associated with elderly and disabled individuals living alone.

The research presented in this paper examines the use of population segmentation as the basis for a fire prevention strategy. This research examines how and why population segmentation was undertaken by the fire and rescue service studied, and how this was implemented and used operationally to support fire prevention activities.

It is hoped that the community based approach to fire prevention based upon population segmentation modelling described in this paper may be useful for other fire and rescue services, and more generally as a template for how other public sector agencies might analyze and target their provision of resources in the area of risk management.

REFERENCES

Abendstern, M., Hughes, J., Clarkson, P., Sutcliffe, C., Challis, D. (2011) The Pursuit of Integration in the Assessment of Older People with Health and Social Care Needs, British Journal of Social Work, 41, 3, 467-485.

Armstrong, Zhu, M., Hirdes, J., Stolee, P. (2012) K-Means Cluster Analysis of Rehabilitation Service Users in the Home Health Care System of Ontario: Examining the Heterogeneity of a Complex Geriatric Population, Archives of Physical Medicine and Rehabilitation, 93, 12, 2198-2205.

Ball, R., Forbes, Parris, Forsyth (2010) The Evaluation of Partnership Working in the Delivery of Health and Social Care, Public Policy and Administration, 25, 4, 387-407.

Bonvicini, B., Ganapini, S., Spadoni, G., Cozzani, V. (2012) The description of population vulnerability in quantitative risk analysis, Risk Analysis, 32, 9, 1576-1594.

Boslaugh S., Kreuter M., Nicholson R., Naleid K. (2005) Comparing demographic, health status and psychosocial strategies of audience segmentation to promote physical activity. Health Education Research, 20, 430-438

Brida, J., Osti, L., Borquet, A. (2010) Segmenting resident perceptions towards tourism, a cluster analysis with a multinomial logit model of a mountain community, International Journal of Tourism Research, 12, 591-602.

Cagliano, A., Grimaldi, S., Rafele, C. (2011) A systematic methodology for risk management in healthcare sector, Safety Science, 49, 5, 695-708.

Card, A., Ward, J., Clarkson, P. (2012) Successful risk assessment may not always lead to successful risk control: A systematic literature review of risk control after root cause analysis, Journal of Healthcare risk management, 31, 3, 6-12.

Corcoran, J., Higgs, G. Anderson, T. (2013) Examining the use of a geodemographic classification in an exploratory analysis of variations in fire incidence in South Wales, UK, Fire Safety Journal, 62, 37-48.

Davies, J., Sherriff, N. (2011) The gradient in health inequalities among families and children: A review of evaluation frameworks, Health Policy, 101, 1, 1-10.

Demydas, T. (2011) Consumer segmentation based on the level and structure of fruit and vegetable intake: an empirical evidence for US adults from the National Health and Nutrition Examination Survey (NHANES) 2005–2006, Public Health Nutrition, 14, 6, 1088-1095.

DPA (1998) UK Data Protection Act 1998, http://www.legislation.gov.uk/ukpga/1998/29/contents

Experian (2014) Improve outcomes through applied customer insight, Experian, Cardinal Place, 80 Victoria Street, London, SW1E 5JL.

FEMA (2013) Fire risk in 2010, Topical Fire Report Series, US Fire Administration, 14, 7, 1-8.

Florence, C., Shepherd, J., Brennan, I., Simon, T. (2011) Effectiveness of anonymised information sharing and use in health service, police and local government partnership for preventing violence related injury: experimental study and time series analysis, British Medical Journal, 342:d3313.

Fugas, C., Silva, S., Melia, J. (2013) Profiling safety behaviours: exploration of the sociocognitive variables that best discriminate between different behavioural patterns, Risk Analysis, 33, 5, 838-850.

FS (2014) Fire safety guidance, https://www.gov.uk/government/collections/fire-safety-guidance

FSA (2014) Fire safety advice, http://www.fireservice.co.uk/safety

Gacia-Marco, L., Vicente-Rodriguez, G., Borys, J., Le Bodo, Y., Pettigrew, S., Moreno, L. (2011) Contribution of social marketing strategies to community-based obesity prevention programmes in children, International Journal of Obesity 35**,** 472–479.

Gerring, J. (2007) Case study research: Principles and practices, Cambridge University Press, New York, NY, USA.

Gielen, A., Shields, W., Frattaroli, S., McDonald, E., Jones, V., Bishai, D., O'Brocki, R., Perry, E., Bates-Hopkins, B., Tracey, P., Parsons, S. (2013) Enhancing fire departmental home visiting programs: Results of a community intervention trial, Journal of Burn Care and Research, 34, 4. doi: 10.1097/BCR.0b013e3182685b3a

Greasley, K., Watson, P., Patel, S. (2008) The formation of public-public partnerships: A case study examination of collaboration on a 'back to work' initiative, International Journal of Public Sector Management, 21, 3, 305-313.

Grote, G. (2012) Safety management in different high risk domains – All the same?, Safety Science, 50, 10, 1983-1992.

HFSC (2014) Home Fire Safety Check, UK Fire Service Resources http://www.fireservice.co.uk/safety/hfsc

Higgins, E., Taylor, M., Jones, M., Lisboa, P. (2013) Understanding community fire Risk: A spatial model for targeting fire prevention activities, Fire Safety Journal, 62, 20-29.

Higgins, E., Taylor, M., Lisboa, P., Arshad, F. (2014) Developing a data sharing framework: a case study, Transforming Government, People, Process and Policy, 8, 1, 151-164.

Holborn, P., Nolan, P., Golt, J. (2003) An analysis of fatal unintentional dwelling fires investigated by London Fire Brigade between 1996 and 2000, Fire Safety Journal, 38, 1-42.

Hood, J. Smith, T. (2012) Perceptions of quantifiable benefits of local authority risk management, International Journal of Public Sector Management, 26, 4, 309-319.

IDeA (2014) Insight: understanding your citizens, customers and communities, UK improvement and Development Agency, IDeA, Layden House, 76-86 Turnbull Street, London, EC1M 5LG.

Jennings, C. (2013) Social and economic characteristics as determinants of residential fire risk in urban neighborhoods: A review of the literature, Fire Safety Journal, 62, 13-19.

Kort-Butler, L., Tyler, K. (2012) A cluster analysis of service utilization and incarceration among homeless youth, Social Science Research, 41, 3, 612-623.

Kendall, H., Kuznesof, S., Seal, C., Dobson, S., Brennan, M. (2013) Domestic food safety and the consumer: A segmentation analysis, Food Quality and Preference, 28, 1, 396-406.

Le Grand, J. (2007), The giants of excess, a challenge to the nation's health, Journal of the Royal Statistical Society (Series A) http://www.healthengland.org/legrand/Beveridge_Memorial_Lecture_2007.pdf

LGA (2012) Customer led transformation programme, Case study – Merseyside Fire and Rescue Service, Local Government Association, Local Government House, Smith Square, London, UK.

Lizhi, W., Aizhu, R. (2008) Urban fire risk clustering method based on fire statistics, Tsinghu Science and Technology, 13, 1, 418-422.

Macharia, J., Collins, R., Sun, T. (2013) Value-based consumer segmentation: the key to sustainable agri-food chains, British Food Journal, 115, 9, 1313-1328.

MAPINFO (2014) MAPINFO, http://www.mapinfo.com/

Niehaves, B., Krause, A. (2010) Shared service strategies in local government – a multiple case study exploration, Transforming Government: People, Process and Policy, 4, 3, 266-270.

OA (2014) Output areas, UK Office for National Statistics, http://www.ons.gov.uk/ons/guide-method/census/census-2001/data-and-products/output-geography/output-areas/index.html

Quigg, Z., Hughes, H., Bellis, M. (2012) Data sharing for prevention: a case study in the development of a comprehensive emergency department injury surveillance system and its use in preventing violence and alcohol-related harms, Injury Prevention, 18, 315-320.

Rundmo, T., Nordfjaern, T., Roche-Cerasi, I. (2013) Objective and perceived risk estimates of travel modes in the Norwegian public, Human and Ecological Risk Assessment: An international Journal, 19, 6, 1664-1681.

Ryan, C., Walsh, P. (2004) Collaboration of public sector agencies: reporting and accountability challenges, International Journal of Public Sector Management, 17, 7, 621-631.

Sanky, M., Berger, P., Weinberg, B. (2012) A segmentation approach to patient health intervention, Journal of Medical Marketing, 12, 4, 221-228.

Sorrentino, M., Simonetta, M. (2011) Assessing local partnerships: an organisational perspective, Transforming Government: People, Process and Policy, 6, 2, 188-205.

Souiden, N., Abdelaziz, F., Fauconnier, A. (2013) Nutrition labelling: Employing

consumer segmentation to enhance usefulness, Journal of Brand Management, 20, 267-282.

SPSS (2014) Statistical Package for the Social Sciences, http://www.ibm.com/software/uk/analytics/spss/

Stuckler, D., Basu, S., McKee, M., Suhrcke, M. (2010a) Responding to the economic crisis: a primer for public health professionals, Journal of Public Health, 32, 3, 298-306.

Stuckler, D., Basu, S., McKee, M. (2010b) Budget crises, health, and social welfare programmes, British Medical Journal, 2010, 340, c3311.

Tapp A., Powell J., Farr M., Orme J. (2006) Social marketing and the geography of Obesity, Primary Health Care Research and Development 8, 22-35

Taylor, M., Higgins, E., Francis, M., Lisboa, P. (2011) Managing unintentional dwelling fire risk, Journal of Risk Research, 14, 10, 1207-1218.

Watson, J., Croft, S., Heard, H., Mills, P. (2009) Using small area data in public health Intelligence, Association of Public Health Observatories, Public Health England http://www.apho.org.uk/resource/item.aspx?RID=74894

Webber, R., (2011) In which contexts do different market segmentation strategies work best? Journal of Direct, Data and Digital Marketing Practice 12, 310–314.

Yang, T., Maxwell, T. (2011) Information-sharing in public organizations: a literature review of interpersonal, intra-organizational and inter-organizational success factors, Government Information Quarterly, 28, 164-175.