

A Thesis Submitted for the Degree of PhD at the University of Warwick

Permanent WRAP URL:

<http://wrap.warwick.ac.uk/132215>

Copyright and reuse:

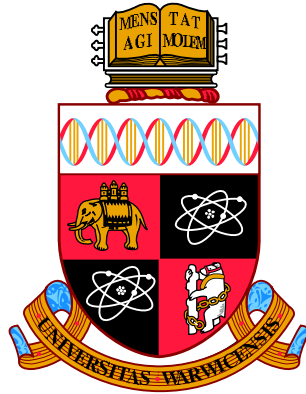
This thesis is made available online and is protected by original copyright.

Please scroll down to view the document itself.

Please refer to the repository record for this item for information to help you to cite it.

Our policy information is available from the repository home page.

For more information, please contact the WRAP Team at: wrap@warwick.ac.uk



Social Care Service Provision using Spatial-Temporal Data Analytics

by

Sarunkorn Chotvijit

A thesis submitted to The University of Warwick

in partial fulfilment of the requirements

for admission to the degree of

Doctor of Philosophy

Department of Computer Science

The University of Warwick

April, 2019

Abstract

There is significant national interest in tackling issues surrounding the needs of vulnerable children and adults. At the same time, UK local authorities face severe financial challenges as a result of decreasing financial settlements and increasing demands from growing urban populations. With an ageing population, local authorities were reported to have spent £168 million more than budgeted in 2015/16 and had struggled to maintain care quality and manage unprecedented demand. This research employs state-of-the-art data analytics and visualisation techniques to analyse six years of local government social care data for the city of Birmingham, the UK's second most populated city. We analyse the management and delivery of social care services by Birmingham City Council, which itself is the largest local authority in Europe, to discover patterns and insights that may assist in the understanding of service demand, support decision making process and the resource allocation management.

In a data-led study, using data derived from personal social care records and obtaining knowledge of what drives the demand for services, we strive to use data as the cornerstone to evidence-based planning delivery. This research intends to: (i) demonstrate how data analytic tools can be applied to the administrative data held by the local government to help identify service cost profiles, provisioning and its geographical dimensions; (ii) connect the data with business plan budget documents to gain better impact over specific groups of vulnerable service users and consider how this analysis can support service planning changes; and (iii) validate and highlight the decision-making processes, complexity, and continuity of data records within the system - from referral through the assessment process.

The use of data in this manner could also inform the approach a local authority has to its data, its capture and use, and the potential for supporting data-led management, service improvements, and potential resource savings. This data analysis resulted from a two-year study commissioned by Birmingham City Council as part of the 'case for change' following several poor Ofsted reports. In response to recent fiscal challenges, the Council is expected to make savings of £815 million over the nine-year period 2011/12 to 2019/20. Delivering savings of this scale, whilst protecting and safeguarding the most vulnerable citizens within a growing urban population, is one of the biggest challenges facing the local authority.

Dedicated to the memory of my grandfather
Jongmet Sapkiree

Acknowledgements

First of all, I would like to express my gratitude to my supervisor, Prof. Stephen Jarvis, for his guidance, patience, motivation and support throughout my MSc and PhD journeys. I am really grateful to Malkiat Thiarai for his great friendship and expert advice to enhance the level of detail and understanding of the analyses in every contribution.

Very special gratitude goes out to all down at UK Engineering and Physical Sciences Research Council (EPSRC) for helping and providing the studentship funding throughout my degree. This research also would have been impossible without the support of Birmingham City Council for providing data access and giving me the opportunity to work in the public sector organisation and experience life as intern data scientist.

To my family, particularly my parents - Veeravouth and Ruttima Chotvijit. I am thankful for the financial support, belief in my skills and ability and encouraging me to pursue this programme. All their continuing support at all circumstance is the greatest present. Thank you to my siblings, Rawinpa and Sinsupa Chotvijit, who always cheered me up in general and provided alternative answers to different problems whenever I encountered difficulties. With a special mention to Nat Luengrattanakorn, my girlfriend. It was fantastic to have the positive encouragement and useful feedback from another domain aspect.

I am also grateful to the following people: Dr. Songklod Rastapana, Dr. Nuttapol Risangud, Chakrit Jongsuebchoke, Neha Gupta, Henry Crosby and many more from Warwick Thai Society and Warwick Institute for the Science of Cities for listening, sharing and supporting me with great friendship through the study period. Special thanks also go to John Rahilly and Dr. Petch Sajja-cholapunt for their constant support on the outline of my thesis.

Declarations

This thesis is submitted to the University of Warwick in support of my application and is presented in accordance with the regulations for the degree of Doctor of Philosophy. It has been composed by myself and has not been submitted in any previous application for any degree. The work in this thesis has been undertaken by myself under the supervision of Prof. Stephen Jarvis. Some parts of this thesis are written based on previously published papers (as corresponding author). Detail of all publications are described below,

- Spatial-temporal analysis of six-years of social care data from Birmingham City Council, presents in Chapter 3, is published in:
 - **Chotvijit, S.**, Thiarai, M. and Jarvis, S. 2018. “Maintaining social care provision in the context of financial austerity.” *International Journal of Population Data Science*. <https://doi.org/10.23889/ijpds.v3i1.585>
 - **Chotvijit, S.**, Thiarai, M. and Jarvis, S. 2018. “Big data analytics in social care provision: spatial and temporal evidence from Birmingham.” *dg.o18 Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age*. <https://doi.org/10.1145/3209281.3209300> (Winner of Best Paper award)
- Additional data-led research in the context of budgetary saving proposals, presents in Chapter 4, is documented in:
 - **Chotvijit, S.**, Thiarai, M. and Jarvis, S. 2018. “Assessing the viability of budget saving proposals for social care delivery.” *Digital Government: Research and Practice*. (submitted and under review)

-
- The analysis of data continuity and information flow in the social care assessment process, presents in Chapter 5, is published in:
 - **Chotvijit, S.**, Thiarai, M. and Jarvis, S. 2018. “A Study of Data Continuity in Adult Social Care Services.” *The British Journal of Social Work*. <https://doi.org/10.1093/bjsw/bcy083>
 - During my PhD I have also contributed to the following academic papers:
 - Tkachenko, N., **Chotvijit, S.**, Gupta, N., Bradley, E., Gilks, C., Guo, W., Crosby, H., Shore, E., Thiarai, M., Procter, R. and Jarvis, S. 2017. “Google trends can improve surveillance of type 2 diabetes.” *Scientific reports*, 7(1), p.4993. <https://doi.org/10.1038/s41598-017-05091-9>

Sponsorship and Grants

The research presented in this thesis was made possible by the support of the following benefactors and sources:

- UK Engineering and Physical Sciences Research Council (EPSRC) for the Centre for Doctoral Training in Urban Science and Progress under Grant number [EP/L016400/1].

Abbreviations

ACAP Adults and Communities Access Point

ADASS Association of Directors of Adult Social Services

AS Assessment

ASC-CAR Adult Social Care Combined Activity Return

BCC Birmingham City Council

BNG British National Grid

CA Contact Assessment

CL Closure

CR Community Referral

ENB Enablement

EPSG European Petroleum Survey Group

ESRI Environmental Systems Research Institute

FA Further Assessment

GIS Geographical Information Systems

HR Hospital Referral

ICT Information and Communications Technology

IA Initial Assessment

IT Information Technology

ITDS Information, Technology and Digital Services

LGA Local Government Association

Ofsted Office for Standards in Education, Children's Services and Skills

OS Open Services

QGIS Quantum GIS

RAP Assessments and Packages of Care Return

RE Reassessment

SQL Structured Query Language

SP Support Plan

UK United Kingdom

Contents

Abstract	ii
Dedication	iii
Acknowledgements	iv
Declarations	v
Sponsorship and Grants	vii
Abbreviations	viii
List of Figures	xv
List of Tables	xvii
1 Introduction	1
1.1 Thesis Contributions	4
1.2 Thesis Outline	6
2 Literature Review	8
2.1 Smart Cities	8
2.2 Birmingham City Council	10
2.3 Social Care Services	11
2.4 Public Sector Interest	13
2.5 Austerity	15
2.6 Data Analytics and Spatial-Temporal Analysis	17
2.7 Challenges of Analysing Social Care Data	19
3 Exploring the Variation in Social Care Agreement Services	21
3.1 Care Service Agreements	22

3.1.1	Data Cleansing and Data-Processing	25
3.2	Analysis derived from Temporal Analysis	27
3.2.1	Identifying the Top Ten Service Elements over time	28
3.2.2	Choosing the Case Studies	30
3.2.3	Case Study 1 - The Impact of a New Contractual Framework	32
3.2.4	Case Study 2 - Residential Respite Care for Disabled Chil- dren	35
3.2.5	Case Study 3 - Care Services for Older Adults	36
3.3	Analysis derived from Spatial Analysis	39
3.3.1	Identification of Three Regional Hot Spots	39
3.3.2	Discussion	45
4	Assessing the viability of budget saving proposals for social care delivery	49
4.1	Care Service Agreements	49
4.2	The Choice of Case Studies	50
4.3	Data Analysis Strategies	50
4.4	Data Cleansing and Pre-Processing	51
4.5	Key Findings	52
4.5.1	Case Study 1 - MIA3: Promote Independent Travel and Reduce Reliance on Council Funded Transport	52
4.5.2	Case Study 2 - MIA5: Internal Care Services - Younger Adults Day Care	55
4.5.3	Case Study 3 - MIA17: Internal Care Review - Home Care Enablement	59
4.6	Discussion	62
5	Data Continuity and the Assessment Process	65
5.1	Performance of Social Care Assessments	65
5.2	Assessment Process	66
5.2.1	Referrals	67

5.2.2	Assessments	68
5.2.3	Agreements	68
5.3	Adult Social Care Eligibility	69
5.4	Care Service Assessments and Agreements	69
5.4.1	Process completion	71
5.4.2	Data cleansing and pre-processing	71
5.5	Initial Findings	72
5.6	Case Study 1: Qualitative Exploration of Dataflow in the Assessment Process	73
5.7	Case Study 2: Identifying Anomalies in the Assessment Process	75
5.8	Case Study 3: Characteristics of Completed Stages	79
5.9	Discussion	83
6	Applications and Impact of Research	86
6.1	Uniqueness of the Research	86
6.2	Assessing Practice	87
6.3	On-going Project	87
6.3.1	The Children’s Trust	87
6.3.2	Care Service Children Assessment Data	88
6.3.3	Methodology	89
6.4	Embedding the Research back to BCC	89
6.5	Planning of Social Care Services	91
6.6	Generalisability of the Research	92
7	Conclusion and Recommendations	94
7.1	Future Research	96

List of Figures

2.1	Birmingham and its 10 council constituencies and 40 electoral wards.	10
3.1	Matrix frequency heat map of all service agreement records in all postcode districts over the past 15 years	25
3.2	Workflow employed in this research	26
3.3	Top ten service elements in terms of cost, for all age categories for the period 2010-2015	29
3.4	Top ten service elements in terms of commissioning frequency, for all age categories for the period 2010-2015	30
3.5	Examples of anomalies that the exploration of data expose . . .	32
3.6	Geographical dispersal of the OAEHSGCO and HSSU65PL service elements across Birmingham's postcode regions	33
3.7	Ethnicity profile of the recipients of OAEHSGCO and HSSU65PL	34
3.8	Unique registered users for CHIRDRT over the six-year study period	35
3.9	Postcode regions which saw the highest concentration of the three service elements in question in 2010-2015	37
3.10	Density plots comparing the three service elements over the period 2010 to 2015	38
3.11	The location of social care service provision across Birmingham, ages 0-11 (1st column), 11-25 (2nd column), 25-65 (3rd column) and 65-90 (4th column) from 2010-2012 (first two rows) and 2013-2015 (last two rows) both point and density heat maps	40
3.12	Birmingham postcodes at a district level, with three areas of interest; northern, eastern and southern	41

3.13	Cost of top twenty elements for the northern area	42
3.14	Cost of top 20 elements for the eastern area	43
3.15	Cost of top 20 elements for the southern area	44
3.16	Three-dimension geographical dispersal of service agreements for all age groups across three regions, 2010-2012 (left) and 2013-2015 (right)	44
4.1	Number of cases, service users and total cost of transport services over a six-year period.	53
4.2	Spatial-temporal heat map matrix of percentage of provision be- tween internal and external services in district postcode.	56
4.3	Spatial-temporal heat map matrix of aggregated cost and number of service users of internal care services among different service types in district postcode.	57
4.4	Frequency graphs of the three enablement service elements about number of the service users who receive less and more than six weeks by month over six-year period.	60
4.5	Geographical mapping of normalised frequency of the enablement service elements and users who receive more than six weeks of the services per thousand population of district postcode.	61
5.1	High-level assessment process.	67
5.2	Number of frequency of assessment taken by individuals who only appear in CA.	76
5.3	Frequency of length of provision of CA people who receive one assessment and FA as outcome form.	77
5.4	Geographical dispersal of CA people who receive one assessment across Birmingham's ward region (per 1000 population).	78
5.5	Geographical dispersal ratio of CA people who receive one as- sessment of FA but not CL across Birmingham's ward region (per 1000 population).	78

5.6	Matrix of form of outcomes (rows) against the corresponding teams (columns) in assessment process.	80
5.7	Sample (top left) and key findings (the others) within the matrix.	81
7.1	Formalisation of this research workflow.	98

List of Tables

2.1	Budget reduction plan for the top five councils in England in 2016/2017.	17
3.1	Records comprising a Closed Agreement and their description . .	23
3.2	Sample service elements and their descriptions.	23
3.3	Number of service agreement records in respect to the four age bands.	26
3.4	The data attributes utilised in the subsequent case studies	28
3.5	Top ten service elements in terms of cost for the period 2010-2015	29
3.6	Top ten service elements in terms of frequency for the period 2010-2015	30
3.7	OAEHSGCO and HSSU65PL agreements for different postcodes in Birmingham	33
3.8	Comparison of records between Q1_2010 and Q1_2015	36
3.9	Postcodes within the three areas of interest and the estimated population	42
4.1	Net spending, proposed cost saving of MIA3, MIA5 and MIA17 (in £million) and its percentage cost saving.	50
4.2	Number of unique service users and aggregated cost between 2010 and 2015 of transport services.	54
4.3	Predicted number of service users and net spends according to the cost saving plan.	54
4.4	Pattern and change of variation in internal care services provisioning percentage.	57
5.1	Total adult social care net expenditure of 2014/15.	66

5.2	The service assessment and agreement records used in this study.	70
5.3	Number of service records and unique individuals of sub-process in assessment process.	70
5.4	The category of form of outcome and corresponding team and the samples.	71
5.5	Matrix of number of people that appear in a stage but not the proceeding stage.	74
5.6	Number of people involve in other non-core stage within assess- ment process.	74
5.7	Number of people who are filtered from HIR, ENB and excluded list.	74
6.1	Records comprising a childs assessment	88

CHAPTER 1

Introduction

The proportion of the population living in urban areas has been increasing over the past decades. As a result, almost 70 percent of the world population is expected to live in an urban environment by 2050 [116]. A city can be diverse in regard to age, culture and ethnic background. As the world continues to urbanize, sustainable development will become more important and steadily more dependent on the management and governance of central administrative authorities. Advances in technology have resulted in an increase in rural to urban migration, arguably for reasons of gaining a better standard of living and a better quality of life, as well benefitting from increased diversity of populations [43]. However, living in an urban area can be difficult, as a larger population can increase the level of competitiveness in society, resulting on growing unemployment rates and increasing demand upon public services. Therefore, the rise in urbanisation and rapid growth in technology clearly influences the way in which governments provide public services to its citizens - for example, the shift from government-centred to citizen-centred services [106]. In many developed countries, local authorities have become involved in improving the dispersal and control in the quality of service provision to the most needed people at the community level [122].

According to [7], technology is a medium that helps seekers to solve problems: New technology is normally built on-top of the existing technology and innovation is often a result of integrating complementary technologies. The definition of digitisation differs from this with regard to the purpose or perspective of how technology is developed and defined. For example, technology could be represented as an advancement of the internet or of hardware, software, the network

or of data. At the city level, technologies can support the general efficiency and productivity of public services, whilst improving city governance, planning and policy-making process. As such, the establishment of e-government or digital government [109] allows public organisations to make better use of Information Technology (IT). The challenge is not about introducing technologies to public administrations, but the transformative process to apply the applications into tools of digital government [106]. Difficulties arise in the increase in the number of poor quality online platforms [121], failure to deliver cost effective services and the ability to maintain quality standards [54].

There is interest in integrating technology with government owned information to improve public service delivery and to generate tangible benefits to public sector decision-making in the United Kingdom (UK). Recent examples of supporting city governance through the collection of large, heterogeneous data sources (unstructured, semi-structured and structured datasets) and the application of spatial-temporal data analytics include [74, 78]. As councils encounter the challenges of declining budgets and rising demand [107], it is desirable to combine data and technology to improve citizens outcomes, as well as achieving financial savings [74]. Research by Symons [108] has shown that the pool of sensitive and complex data held by local authorities ranges from social care data to that concerning procurement and planning both of which could significantly benefit service provision, by targeting vulnerable groups of individuals and allocating resources to areas in most need.

Social care is a primary and fundamental service provided by local government to support citizens with illness, disability and vulnerability (including the elderly) within their locality. The challenge of delivering social care to children and adults is not new from a public sector perspective. Social care services in many local authorities have been reported to be ineffectively allocated and have failed in performance evaluations, resulting in injury or death of individuals a result of abuse or neglect [20, 91] and inefficiency and poor allocation of safeguarding services [70]. In addition, the concept of centralisation proposed by

the UK central government to control the nature of service provisioning and its sustainability has also been found to be inconsistent and difficult to manage [40].

This research has been undertaken in collaboration with Birmingham City Council (BCC), the largest local authority in Western Europe. The Council recognises, like all local authorities, that it collects and stores a considerable amount of data about its citizens, their circumstances and the services for which they register. For social care services, the Council was rated inadequate in service provision of social care to its citizens by the UK Office for Standards in Education, Children's Services and Skills (Ofsted) [93]. The organisation was cited nationwide for serious failures in protecting and safeguarding of vulnerable people, as a number of high-profile child deaths in Birmingham have been reported in the national press since 2003. Concurrently, in 2010, there was a budgetary reduction scheme the central government required the local authorities to apply. This resulted in the council being unable to provide services to people whose financial resources were less critical [62].

This research was prompted by preliminary work at BCC to apply data analytics and various spatial-temporal techniques to help understand the social care provision. In developing this research, our intentions were to support decision making with regard to resource management and addressing budget challenges in different areas of the city, and to highlight value which could be obtained from data held by the council. Consequently, the derived intelligence can be used internally to reduce the requirements for costly outsourced business analytic consultancy services. This research was predicated on the basis that the council was seeking to better understand the demand for its services and how this demand could be met or managed during periods of austerity. In addition, the research also analysed assessment data and the process by which it was collected.

We note that this research does not seek to identify risk factors that affect specific individuals. Rather it aims at supporting the organisation in understanding patterns, insights and trends, which can impact future government

operations to support service and budgetary planning.

1.1 Thesis Contributions

In this thesis we identify and develop new approaches to data analytics and visualisation for social care data. This includes new methods, management, and qualitative and quantitative studies. Three case studies are developed and explored in detail in each of the three contribution chapters. The main contributions of this thesis are as follows:

1. The novel application of data analytic techniques that allow the past provisioning of social care services provided by the city of Birmingham to be better understood, including an investigation of the trends in the delivery of services and future demand to be forecasted. New spatial-temporal data analysis is presented and is evaluated through three case studies: An evaluation of the impact of a new contractual framework on older adults home support; An investigation of residential respite care for disabled children; and a study of care services for older adults. The research identifies and underpins new ways of integrating data analysis and visualisation with the monitoring and analysis of social care service closed agreements to support the Birmingham City Council's resource and service allocation.
2. New data-led research that connects the data and its analysis with the ongoing business planning and budget setting process at Birmingham City Council. Three case studies are again used to illustrate this research and its value, all three of which are taken from the Councils strategic planning concerning Maximising the Independence of Adults (MIA): An evaluation of proposals to promote independent travel and reduce reliance on Council-funded transport; An investigation into internal care services, with particular reference to younger adult day care; and an inquiry into home enablement services and proposals for cost savings. The analysis demonstrates how insight can be obtained from the data, through a targeted

evaluation of the data alongside historical records of service management frameworks and key council priorities and objectives.

3. The employment of data analytic techniques to examine the flow of information from referral through the assessment process and the resulting service provision. This contribution is again illustrated through illustrative key findings: Qualitative exploration of data-flow in the assessment process; Identifying anomalies in the assessment process; and identifying the key characteristics of stages in the data life-cycle, in order to identify opportunities for service improvement and, as a result, potential resource savings.

This research approached the analysis from a bottom-up perspective meaning that it analysed the social care data from service agreement, which was the actual services receive by the recipients, up to referral, which was when the users request for the service. In the first contribution, we sought to analyse and comprehend the past service provision from the Council's owned data. The second contribution integrated the use of data analytic and visualisation tools with the business and budget reports from the Council, to see how the analysis can contribute more impact directly to the Council by supporting cost-saving plans. The third contribution focused on the flow of users' information from the referral to agreement services - through the assessment process. The bottom-up approach allowed us to better understand the fundamental of social care service provisioning at a city-level to support city governance. This also helped enhance data interpretation and the quality of the research.

To the best of our knowledge, these contributions are unique within this research domain. All provide both in-depth quantitative and qualitative analyses of social care services and have been developed in consultation with domain experts at the council. The results can be used as a fundamental frame-work to support decision-making processes of the City Council for future service planning.

1.2 Thesis Outline

Applying data analytic tools and techniques to social care service data helps categorise this thesis into four parts: (i) A general analysis and longitudinal exploration of social care provisioning in the city of Birmingham; (ii) The study of service agreements in the city, leading to a fundamental understanding the services provided and where people receive these local authority services; (iii) A study of data-flow in the assessment process from initial assessment, through referral, to the allocation of appropriate services; and (iv) An in-depth analysis of service provision from existing data. The following chapters provide details of these contributions:

Chapter 2 reviews previous literature that supports the use of data and technology to improve city social care service provision and its challenges. This includes challenges introduced by financial austerity, and the use of different data analytic techniques, spatial and temporal analysis. Related work concerning the assessment of social care services is also discussed.

Chapter 3 introduces a general analysis and longitudinal exploration of social care provisioning in the city of Birmingham. The research is divided into the analysis derived from temporal and spatial analysis. For the former, the study includes discovering overall trends and patterns of all service users in social care, including cost and frequency in different type of services and the characteristics of the recipients. Furthermore, by applying spatial analysis techniques, the research also provides geographical patterns where there is evidence of high service demand from which more detailed analysis can be derived.

Chapter 4 presents additional analyses from the same service agreements data. However, the research is developed further through three case studies derived from the Council's budget planning proposals. The analysis involves spatial and temporal elements as well as predictive analysis for services relating to transport, care services for younger adults and internal care for home-care-enablement users.

Chapter 5 presents an analyses of personal data and its flow through the social care assessment process. Moreover, it considers how data is stored and manipulated at different stages in the process: From referral to when individuals receive the actual service agreements from the local authority. In-depth analysis identifies the quality of the process and sub-processes and also identifies anomalies and characterisitcs of the stages of the process.

Chapter 6 clarifies the novelty of this research and what makes the contributions distinct from previous research within the same domain. The chapter discusses the application and impact of this research, its contribution to an on-going Children's Trust project, how this research contributes to and is embedded within the Council decision-making structures, and its impact on the planning of social care services and the generalisability of the research to other city councils.

Chapter 7 summarises the conclusion from the work presented in this thesis and offers suggestions for possible future research.

CHAPTER 2

Literature Review

This chapter presents the related literatures or articles that use data analytic technologies to analyse the social care services to support decision-making process and resources management of the local authority. The remaining parts of this chapter follow as identifying the terminology of smart cities and technologies in general, information and facts of the local government, the social care services, the public sector interest on applying technology to gain better insight and understanding of the data, the problem of austerity and financial strain, and the applications of data analytics that have been used in similar or other research domains.

2.1 Smart Cities

There has been an increasing number of interest about smart cities which also influence the future of urban development of many countries around the world [57]. The current scenario of a big city requires the local government to discover solutions to tackle city's problem from transportation to high-quality urban services in the most efficient way in which many approaches related to the services involve technologies or Information and Communications Technology (ICT). Despite a skepticism and unclear on defining the terminology of 'smart cities' since it was first being introduced in the 1990s [5], this term involves an integration of multi-dimension components and systems; such as technologies, economy, people, governance, networks and communication, in order to create smartness to the city and elevate the quality of people and wellness of the communities [52, 23, 67].

In the UK, Southampton claims to be the first region that implement smartness to the cities. The local government has introduced multifunctional smart

cards for accessing different local government services which helped engaging the citizen, local authority and the commercial organisations [30]. The benefit of introducing technology to a city, resulting in a smarter place to live, can be seen in city of Leeds that has transformed the city from manufacturing and industrial-based to the a service-based urban form that eventually increases the number of bar and nightlife places [58]. Whilst, in Birmingham, the city encounters several challenges of urbanisation from socio-economics to health and environments [55]. The Council decides to implement Digital Birmingham, a platform in Information, Technology and Digital Services (ITDS) to operate technology, innovation and digitising services, over the past decade. The platform is managed under four smart city principles - integration, digital, data and citizen engagement. The scheme aims to improve the city's economics and living condition of the citizens, expand connection with external partners, create digitally connected city, develop new framework from an intelligence of data to create new urban applications and work across sectors to exploit opportunity to emerging new technologies in different service departments [37].

Embedding technologies into applications and services of the city can lead to a considerable amount of information being generated. The available technology that can support services in the smart cities is (big) data analytic. There is a potential use of the technology to better develop and understand insight to address problem of the city from another perspective, while controlling cost of the local government. One of many benefit components of smart cities support the smart governance. This help improve opportunity of collaboration between the government and multi-agencies, decision-making support, development of policy making and focus on citizens' services of health and social care, education, and other issues [4].

2.2 Birmingham City Council

Birmingham City Council is the local government body responsible for the governance of Birmingham, the UK's largest and most populous city outside London. It has a population of over 1.1 million people and the population is growing faster than the UK average [95]. Birmingham is a young and diverse city; half of the population are aged 30 or under, and the city benefits from many different nationalities, faiths, languages, ethnicities and cultures. The population of adults and older adults are reported to have increased by more than 10 per cent since 2013 [94] and now account for more than 75 per cent of the total population in the city [94].

The City Council is the local government body responsible for the governance of the city, which is managed through the division of the city into 10 council constituencies and 40 electoral wards, see Figure 2.1. BCC is the largest local authority in Europe. Income and expenditure in 2016/17 was £3.094 billion, of which £782 million was spent on schools, £550 million spent on benefits, £805 million spent on services for people and £287 million spent on housing [17]. The Council is expected to make total savings of £815 million from 2011/12 to 2019/20 and, as a result of this, the authority is reducing staff from 20,000 in 2010 to around 7,000 by the end of 2018 [18].



Figure 2.1: Birmingham and its 10 council constituencies and 40 electoral wards.

Birmingham faces many challenges. The Council is ranked the sixth most deprived local authority in the UK; 40 per cent of the city was identified in the most deprived 10 per cent of areas in England [96]. There are significant levels of child poverty; 30 per cent of the city's children live in a deprived household [18]. Life expectancy, which varies significantly between the most and least deprived areas, is 7.6 years lower for men and 6.2 years lower for women than the average found across the remainder of England.

2.3 Social Care Services

Adult social care refers to 'care and support services to help with personal care and practical tasks to adults who need it due to physical disabilities, learning disabilities, physical or mental ill-health, or old age' [10]. Social care services, provided by the local authority, covers a huge range of activities from child protection to end-of-life care. The Care Act 2014 specifies that it is the responsibility of the local government to ensure that high quality services are being provided, as well as people's desired services are facilitated to improve care and support decision and ability to control the services themselves [24]. The service helps increase independency with providing help, care and protection from harm for people with physical disabilities, learning disabilities, or physical and mental illnesses [6]. At its most basic, this can include help with washing, dressing, getting out of bed in the morning, help taking medicine, and help with the housework. Social care is becoming more and more important as the population gets older, as the number of elderly aged over 65 in England has gone up by over 11 per cent between 2011 and 2016 [97].

Local governments have the main responsibility when it comes to publicly funded social care. The authorities provide information and advice, assess and monitor the recipient's needs and finances, provide short-term support called reablement, safeguard vulnerable people from abuse and neglect, and buy and monitor care from a large range of organisations. With more people living into

older age, this means there will be more frail people and more people living with long-term illnesses. In turn, this means that there will be more people with needs for care and support. However, the number of people receiving formal care from the public sector has actually reduced by 26 per cent over the past six years, despite this increase in need and ageing population [62].

The social care assessment process captures an important interaction between local government and individuals. According to the Care Act [24], a local authority must have regard to an individual's assessment of their needs, an individual's views and beliefs, their well-being and those of friends and relatives who may be caring for them, and must be flexible in terms of individual rights and the participation of recipients in the decision-making process [71]. Milner, Myers and O'Byrne [82] note that the flexibility of assessment is impacted by the fact that assessment is often a continuous process.

The proportion of service recipients who require assessment in the UK remains high, particularly for older adults [86, 87, 88, 89]: 46 per cent of referrals in 2014 received an assessment and in 2015 to 2016 approximately 0.9 million people received state-funded social care services in England. Changes in demographics adds to the complexity of the assessment process [65, 26]. At the same time, changes to social care services, resulting from minor or major care planning reviews, should be seamless from the point of view of the care recipient [119]. This creates significant challenges for local government, because needs and outcomes must be serviced equitably, regardless of the fact that the mechanism for meeting needs will differ, depending on local circumstances and individual preferences [1].

Adult social care in England has seen major restructuring over time and this has led to the introduction of 'personalisation', where an individual is placed at the heart of service provision to maximise accessibility and reinforce personal solutions [72, 76]. Person-centred services assist individuals in retaining more control over services they receive. There is some evidence that this has led to a reduction in spending on services for older adults by local authorities [61].

However, other studies suggest more mixed evidence for personalised services reducing local authority spend [103, 104, 125].

Good-quality assessments are required to support personalisation for the individual. However, it is possible that accessibility to services for people with significant needs might still be limited; social care professionals are still required to make a judgement about eligibility before co-producing a response in accordance with the client concerns and outcomes they are seeking. Data will also be input in concurrent streams, and therefore the decision-making points could also contribute to rate limiting in the process over time [27]. Historically, there has been interest in using case review systems, monitoring tools that support social work service provision to clients, while promoting the use of new technology for digital-based record-keeping [50]. Using data from existing assessment documents provides the basis for identifying requirements and improving decision-making [46].

2.4 Public Sector Interest

There is an increasing body of work in the public sector related to data and, in particular, how these paradigms could assist in transforming public services.

In recent years, there has been growing interest in using social care data to highlight increased requirements, improve decision-making processes and transforming public services [46]. It is argued that data is a powerful raw material necessary for holding governments to account, driving decision-making and improving the transparency of public services. The capture, curation, search, analysis, visualization and storage of large and complex datasets will generate value across stakeholders in five key domains: healthcare, public sector administration, retail, global manufacturing and personal data [80]. This said, combining data analytics with policymaking and the design of public service within the public sector have been shown to improve service delivery [115]. The HM Government [83] described the UK as a world leader in the public dissemination of

data, citing more than 9,000 datasets that were already available through public portals. However, a report by Yiu [123] argued that applying technologies alone was insufficient for city transformation and that, as a minimum, data quality and standards needed to be addressed. Yiu's report estimates that performance improvements could result in public sector savings of between £16 billion and £33 billion per annum.

Whilst the benefits of data are apparent, there is widespread recognition that in exploiting data, organisations may leave themselves vulnerable to breaches in privacy or data exploitation. The issue of realising the benefits of data, whilst preventing privacy abuses, has been the subject of two reports published by the White House and analysed by PwC [3]. In these reports it was suggested that in order to manage expectations, changes were needed in legislation and a wider recognition of issues was needed within organisations; thus, the use of data and corresponding issues of privacy need to be integrated into the business strategy of local governments to enable ownership, oversight and benefit, whilst ensuring individuals retain protection to prevent abuse and discrimination.

Moreover, the use of personal information owned by the local government could create several challenges around applying comparative methods or analytics. For example, the issue of data uncertainty was introduced in Child Service Planning in Sheffield, as only half of the datasets supplied by partner organisations met the granularity requirements needed for their analysis [32]. It has also been identified that the difference in characteristics of children registered for children's social care across the UK could cause difficulties when analysing and interpreting published statistics [84].

Matters of privacy and organisational responsibility also feature in work by David Rhind [100], who cites five data protection categories in this context: personal privacy - in which citizen's information must be concealed; the appropriate role of the state - in disseminating findings appropriately and avoiding misuse; the cause and effect of technology - including risk of data transfer and processing; the lack of quantitative skills - which may impact analysis and, the

misrepresentation of scientific findings.

The work by the public sector has been increasing not only the use of data, but also in improving the actual social care services, for example how strengths-based approaches can be applied before individuals start receiving service agreements. Provision of high quality assessment and care management has been a key concern for the Department of Health [35] and it is claimed that Councils have encountered such challenges for at least the past seven years. Local authorities have had to consider cost reduction and process efficiency, whilst conserving the quality of services [8]; improving outcomes and supporting independence may also result in better value for money. Efficiency could be elevated by reviewing and improving assessment and care management processes, including ensuring consistency of eligibility criteria and reducing assessments not leading to services. However, the Department of Health [36] has argued that ‘living with independence’ may relate to particular groups of users only and may be overstated for others. Furthermore, authorities under financial strain had greater difficulty achieving budget saving plans using this approach. In 2012, evidence was presented of increasing spending in assessments and reviews in 12 of the last 14 years [9]. This was largely caused by the cost and number of professionally qualified employees carrying out assessments; it was stated that savings could be made by altering the mix of employed staff grades and skills, and redesigning the care pathway. To enhance the quality of life for people with care and support needs, the Councils have proposed methods to embed new ‘customer journeys’ into the care system [16].

2.5 Austerity

The demands on social care in the UK are increasing, while austerity policies across the UK have seen a reduction in funding and services available to meet the needs of the growing population. The financial cuts to social services experienced by local authorities in England [92, 112, 60, 2, 21, 53] and changes in the

number of people receiving services [41], has resulted in difficulties in supply and eligibility [48], a reduction in service quality [73] and an incremental increase in the number of self-funded recipients [92]. The problem of identifying and examining care quality [77] has been limited by the inaccessibility of good data sources [114], insufficient high-quality care [118] and an increase in deprivation rates [59, 22].

Budgetary challenges in England since 2010 have resulted in a 26 per cent reduction in financial resources since 2014/15 [56], and it has been forecast that this will significantly impact adult social care service provision [47, 61]. The Local Government Association (LGA) [75] estimated that taking account of future funding and the range of pressures facing councils, local government could face an overall funding gap of £5.8 billion by 2019/20. Expenditure on social care assessment and commissioning service delivery, including long- and short-term care plans, totalled £13.62 billion in 2016 across five different areas of support; physical, sensory, memory and cognition, learning disability and mental health [89]. Alongside the funding gap, councils with social care responsibilities spend roughly 30-35 per cent of their total budget on adult social care [75]. The Association of Directors of Adult Social Services (ADASS) [2] suggest that necessary savings to adult social care budgets by local authorities - approximately £940 million - could not be reached without serious consequences for front line services. However, a statistical analysis study from Iparraguirre suggested that the fall in expenditure of adult social care leads to an increases in proportion of elderly with unmet social care needs [64].

In order to illustrate the financial pressures on the Council, which compound the operational issues described, Table 2.1 illustrates the plan for budget reduction for Birmingham City Council compared to other local governments in England in 2016/2017 [28, 31, 29].

City Council Name	Budget Reduction Plan
Birmingham City Council	£88.2 million
Bristol City Council	£52 million
Sheffield City Council	£51 million
Newcastle City Council	£32 million
Liverpool City Council	£28 million

Table 2.1: Budget reduction plan for the top five councils in England in 2016/2017.

BCC, like many other local authorities, has sought to make better use of the data that it holds to enhance city governance and use it in different contexts, such as in financial planning and street cleaning optimisation. It is also making aspects of the data ‘open’ as part of its transparency agenda.

2.6 Data Analytics and Spatial-Temporal Analysis

In this digital age, when large volumes of data are produced and stored in local authority systems daily, the advance of data analytics tools and techniques play an important role in supporting the use of in-house, multi-dimensional data in the most efficient way [42, 25]. Analysis is usually implemented using programming languages such as R [63, 110] and Python [85, 99] and relational database query languages including Structured Query Language (SQL) to manipulate the data and structures [34]. These analytic tools can also be used to visualise data from various perspectives to gain added value and obtain new insights [68].

There is evidence of the use of personal data held by the government to support service delivery and planning, particularly in relation to vulnerable children [49, 105, 102]. Guralnick [51] stated that a well-organised system of early intervention could prevent cognitive impairment in children up to the age of five. The characteristics of children registered for social care across the country showed variation in age, ethnicity and requirements, based on published statistics from different areas of the UK [84]. In New Zealand, research has

been carried out on the use of administrative data in identifying children at risk, supporting predictive risk modelling as a means of tackling issues of child protection and maltreatment [117]. This study highlighted that whilst modelling could identify instances of abuse and neglect, the approach was not without risk of stigmatising and discriminating against certain individuals and families. Thomas and Percy-Smith [113] take a different approach, citing the effective participation of children and social workers in service planning and provision. They note that the voice of young people who were recipients of these services can be very important and can help shape the overall strategy of services within local areas.

Many studies have used spatial analysis, most notably Geographical Information Systems (GIS), to analyse issues related to children in social and health care. The research of Susan [33] shows biophysical and social vulnerabilities of Georgetown County using methods to calculate an index score with several indicators such as census, demographics and housing status, before applying GIS mapping to create a better understanding of vulnerable areas. In research by Ernst [39], the rates and distributions of three types of child maltreatment (physical, sexual abuse and neglect) in areas as small as neighbourhoods are identified to highlight at-risk communities. The approach adopts least squares multiple regression analysis and GIS to gain a deeper detail understanding of the child welfare system under investigation. Child service provision plans, including for interventions and funding, has been analysed by Besag and Newell [12] using a novel scoring and clustering technique. Their work supports the detection of rare events, by computing the probability of the number of observed cases given the population at risk. Dasymetric distribution techniques have been used to spatially represent healthcare outcomes. This research highlights significant differences between rural and urban areas [69]. While research from Yu [124] highlights substantial respiratory health problems from child residents near Asian dust storms. The risk is specified using structured additive regression on demographic data and data including air pollutant parameters. The

vulnerability of regions to increased infant mortality has previously been identified using Thiessen (Voronoi) polygons, the use of the Moran index and the G-test [101].

The data analysis documented in this research is a result of a two-year study commissioned by BCC, as part of an agreed ‘case for change’ following several poor Ofsted reports. The commission is to understand what can be ascertained from a data-led investigation, independent of the context of how the data was collected and used. Process assessment proceeds in a similar manner to the Assessments and Packages of Care Return (RAP) and the Adult Social Care Combined Activity Return (ASC-CAR) in [87]. Related studies have explored the relationship and proportion of service provision for children under the age of five and their safeguarding systems [13]. Other studies have used data analytics techniques on different applications in the social care domain: For example, decision trees have been employed to improve the decision-making options of social workers in order to improve service outcomes [98]; Correlational analysis has been applied to explore the relationship of service demand, failure demand and workforce stability [59].

2.7 Challenges of Analysing Social Care Data

There are numerous challenges with the analysis of social care data, which presents significant difficulties when deriving reliable and transferable information and methods from it. Most notably, in the UK social care is not managed by central government, but by 152 local authorities and thousands of domestic service providers [66]. As such, data is not uniform, is subject to regional difference in practice and is stored in a variety of different supporting IT systems. A compounding factor has been financial austerity, which has had acute impact on front-line social care services. It is reported that this has led to very few agencies holding adequate administrative data for all social care in England, and has resulted in datasets which are insufficient to identify why

some recipients receive services while others do not [11]. One might contrast this with investment in National Health Service IT and data infrastructure, including NHS Connecting for Health, established in 2005 at a cost of over £12 billion to provide a national IT infrastructure for 300,000 general practitioners and 300 hospitals, and also NHS Digital providing digital services to the NHS alongside large health informatic programmes.

There is a long tradition of data-led statistical studies in healthcare, from randomized control trials to assess the effectiveness of new treatments or drugs, to longitudinal studies of lifestyle and its impact on health. Such studies are not common in the social care domain and it is argued that given the complex and interacting needs of individuals, and the fact that service needs and recipients change over time, such approaches are impossible to implement in a social care domain [44, 45]. Whether one subscribes to this argument or not, this field of research is clearly under-developed compared with other areas of healthcare and this thesis goes some way to laying the foundation for further social care data-led research.

CHAPTER 3

Exploring the Variation in Social Care Agreement Services

The social care service is a complicated process which is difficult to manage across the city. One way to understand service provision is to study and analyse it from the available information collected from multiple sources, in consultation with experts. The study documented in this chapter employs spatial and temporal analysis which, to the best of our knowledge, has not previously been applied to social care data in the manner intended by this research. Although some approaches had been applied by the local authority to analyse the local government in-house information, these were reported to be less effective than hoped and time consuming in nature. This chapter provides an understanding of the principles of social care services and proposes alternative channels to integrate the data retrieved from social care service users and technology in the form of data analytics. To undertake the process of accessing the data, the researcher was required to follow the Council's internal governance processes to ensure full compliance with relevant data protection and ethical obligations. The aim of this research - conducted as part of BCC's Future Council Programme - was to investigate:

1. How data held in local authority systems can be analysed to provide significant value and insight to the local government and community;
2. The extent to which data value is impacted when personally identifiable attributes are retained at the most fine-grained level of analysis;
3. How the use of local authority data can inform future services planning and delivery in Birmingham, as part of the authority's business planning and budget setting processes.

3.1 Care Service Agreements

The data used in this study were provided in structured form. All data derived as closed agreements (care services which have been agreed upon, commissioned and delivered by BCC or a third party) were extracted from the BCC's CareFirst System, the primary information system for recording social care provision for all vulnerable children and adults over the past 15 years. An agreement refers to the commissioned delivery of a social service following an assessment of need.

The data were extracted using the data extraction technique from the Council's database that consist of more than 100 tables. An initial analysis of CareFirst showed that the total number of client records exceeded 560,000. The data for this study was extracted from more than 100 tables; this comprised of developing a series of queries to extract data directly from the CareFirst database. The data generated was then joined to produce the final extract of information. The information generated was validated throughout and checked against the live application within the Council using Crystal Report and the experts knowledge to ensure its integrity. In identifying the potential data held by the local authority, it was necessary for the researchers to meet with council staff who were cognisant of the technical capabilities of the system as well as with the structure and format of the data that was held.

The results presented here include closed agreements for the period 2001 to 2015, inclusive, in which this research extracted and utilised only six years of data from 2010 to 2015. This is because the research intended to understand the variation of service provision during austerity that began after 2010 and led to social care funding challenges. The extracted data comprised around 260,000 client records. The extracted dataset included 31,610 distinct people, registered for a total of 119 unique *council services* and 360 unique *elements* (a service is comprised of many different elements, which may or may not be enacted as part of a delivered service agreement). Each closed agreement consisted of 18 attributes, see Table 3.1; note that only 14 of these attributes are used in this

study. The other 4 attributes such as religion, category description, category sub-description and gender ID were not included in the research due to i) the attribute is unnecessary to the analysis or redundant to the included variables and ii) the attribute might prone to ethical issues.

Attributes	Description
ADE_ID	Agreement ID
PERID	Person ID
DOB	Date of birth
Agreement Start	Start date of the agreement
Agreement End	End date of the agreement
Service	Alphanumeric coding of the service
Service Description	Description of the service
Element	Alphanumeric coding of the element
Element Description	Description of the element
Postcode	Postcode at unit level
Gender	None
Ethnicity	Ethnic classification (using census categories)
Disability	Disability status
Weekly Cost	Weekly cost per one agreement element

Table 3.1: Records comprising a Closed Agreement and their description

ADE_ID and PERID normally appear in integer form. A person ID can be duplicated and can include one or more ADEID (agreement records in the Care-First system) attach to the individual, but not vice versa. The Element name is typically stored as a string comprising five or more characters characterizing a short version of the full element description. Table 3.2 provides example service elements and their description from Table 3.1.

Element Name	Element Description
CHEFODIS	Children, External, Fostering, Disabled
DIRCWD	Direct Payments, Children with Disabilities
HSSU65PL	Home Support, 65 Plus, External Community Based
LDEHSQDS	Learning Disability, External, Quick Discharge Service
MHEBLACT	Mental Health, External, Block Activity
OAICINT	Older Adults, Interim Care, Internal
PDEHSUPP	Physical Disabilities, External, Supported Living

Table 3.2: Sample service elements and their descriptions.

A simple coding strategy is employed: An element name that begins with CH is related to children; DIR represents a direct payment; HSSU represents home support; LD is related to learning disabilities; MH is related to mental health;

OA refers to a service element for an older adult; PD represents a service for people with physical disabilities and, SM represents a service connected to substance misuse.

Postcode details are configured to allow the study to preserve the anonymity of individuals but, at the same time, fine-grain enough to provide meaningful spatial analysis. Each postcode can be divided into three levels: district, sector and unit. An example of a relevant unit postcode is ‘B1 1AA’. The district postcode accounts for those letters and numerals before the space, representing part of the city, in this case ‘B1’. While the sector code includes one more numeral after the space to display a deeper level sub-area of that district, in this case ‘B1 1’.

The total value of the expenditure of service agreements extracted from the system was estimated at £670 million for the sample period in question.

3.1.1 Data Cleansing and Data-Processing

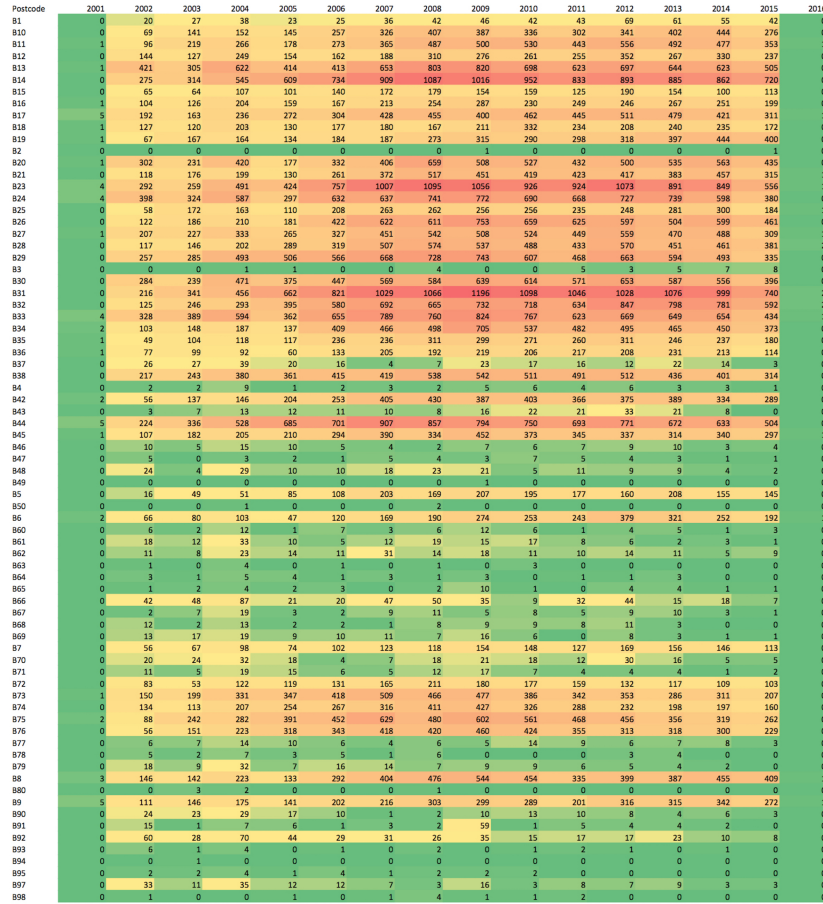


Figure 3.1: Matrix frequency heat map of all service agreement records in all postcode districts over the past 15 years

The matrix heat map highlighted data quality and allowed the research to conduct anomaly detection. The heat map in Figure 3.1 displays the frequency of registered agreements for all registered recipients over 75 (of the 79) postcode districts.

The data are further categorised into four age groups according to council norms: Children aged 0 to 11; Young People and Adults aged 11 to 25; Adults aged 25 to 65 and Older People aged 65 to 90. Records are retrieved for these age ranges, see Table 3.3; note that there are some duplications of individuals, as a person may be registered for more than one service within a year.

3. Exploring the Variation in Social Care Agreement Services

Age Category	Number of Records (approx.)
0-11	7,308
11-25	26,142
25-65	47,247
65-90	133,599

Table 3.3: Number of service agreement records in respect to the four age bands.

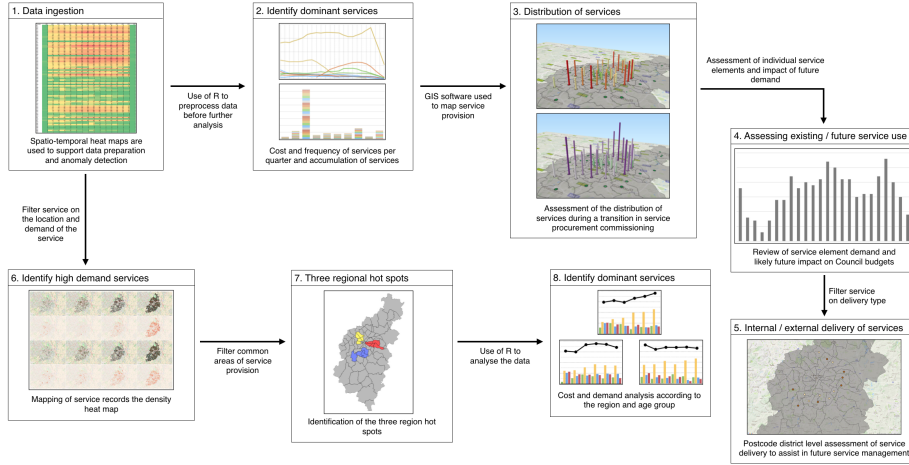


Figure 3.2: Workflow employed in this research

The data-processing workflow used in this research is shown in Figure 3.2. Data ingestion, cleansing and anomaly detection are depicted in Stage 1. Pre-processing scripts and the statistical tool R are used, removing math symbols, conducting age range checks, misspell or typos and identifying missing values. Of the 258,673 closed agreements study, 18,872 (7.3 per cent) are removed because of ‘bad data’; the majority of cases involve (i) missing values, (ii) unreadable or invalid data records during data collection or extraction process, and/or (iii) entries with value specified as unknown, invalid postcodes or out-of-range age entries. The reason for bad data may happen during data collection and/or data extraction processes. This stage is splitted into two paths: the analysis derived from temporal analysis (cover Stage 2 to 5) and the analysis derived from spatial pattern (cover Stage 6 to 8). The Stage 2 focuses analysis of all 119 services and 360 service elements to understand the dominant services in either cost or frequency. The analysis is presented per quarter and accumu-

lated cost and frequency per service element. Stage 3 employs the open-source geographical information systems Quantum GIS (QGIS) to perform spatial-temporal mapping using postcodes in the closed agreement services. As the data contain postcodes, exploration is possible at the sector level analysis, at which point the data are spatially joined with a geographic shapefile (in the Environmental Systems Research Institute (ESRI) vector data storage format) representing the location, shape and attributes of the corresponding geographic unit. Coordinates are plotted using the Ordnance Survey National Grid reference system of British National Grid (BNG) with the European Petroleum Survey Group (EPSG) Code EPSG:27700. The plugin for OpenStreetMap is employed from the QGIS OpenLayers Plugin ¹. Stage 4 corresponds to the second case study where the frequency of service elements is analysed and, with population data, predictions are explored as to the likely increase in demand (and cost). Postcode-level assessments are conducted to assist the Council in business planning and budgetary objectives in relation to the policy of internal care services presents in Stage 5. Stage 6 highlights where spatial analysis plays an important part to help filtering data for the analysis. The study identifies several hot spot regions in regards to the location and demand of the service provisions. Involving input from the Council's in-house team, those regions proceed to Stage 8 for cost and service comparison over different age categories.

3.2 Analysis derived from Temporal Analysis

Temporal analysis of the data was performed: (i) as a single sample period 2010 to 2015 (six years in total); (ii) in two three-year sample blocks - 2010 to 2012 and 2013 to 2015; and (iii) quarterly, resulting in 24 consecutive time-series period. Analysis of services and service elements included seven of the CareFirst data attributes. Whereas, the analysis of service users involves nine of the data records, see Table 3.4. The analysis focused on the top ten service elements, the

¹Polygons of the UK boundaries could be obtained from the UK Data Service.

top three, accounted for about 12 per cent of the total expenditure, of which were explored further in the subsequent case studies.

Variable Name	Variable Type
Postcode	Spatial
Coordinates	Spatial
Agreement Start Date	Temporal
Agreement End Date	Temporal
Element Name	Temporal
Element Description	Temporal
Weekly Cost	Temporal
Age	Spatial and Temporal
Ethnicity	Spatial and Temporal

Table 3.4: The data attributes utilised in the subsequent case studies

3.2.1 Identifying the Top Ten Service Elements over time

The Council sought to identify the top ten service elements over a six-year period, to identify the service elements with the greatest aggregated cost and consistency of spending over the six-year period, and the service elements with greatest aggregated frequency and impact of services with high provisioning. Both would be fed into future analysis and modelling of social service care provision.

Figure 3.3 shows the top ten service elements in terms of quarterly aggregated cost and the fluctuation in this cost over six years. The service element CHIRDRT dominates and shows a steady increase in spending between Q1.2010 and Q1.2015; Figure 3.3b reports that this service element accounts for £54,964,000 over the six years period. Table 3.5 documents the cost of top ten service elements for the period between 2010 and 2015; of these, more than half are delivered by external providers.

3. Exploring the Variation in Social Care Agreement Services

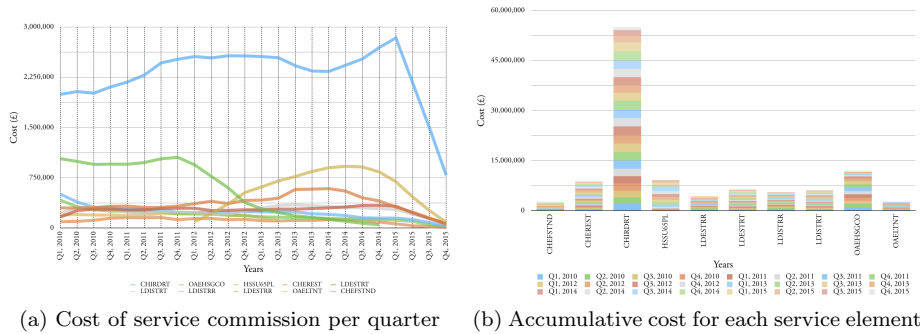


Figure 3.3: Top ten service elements in terms of cost, for all age categories for the period 2010-2015

Service element	Description	Cost
CHIRDRD	Children Internal Residential Disabled Respite	£54,964,000
OAEHSGCO	Older Adults External General Contracted	£11,864,117
HSSU65PL	Home Support 65 Plus External Community Based	£9,206,837
CHEREST	Children External Residential Home	£8,823,100
LDESTRT	Learning Disability External Short Term Residential	£6,407,018
LDISTR	Learning Disability Internal Short Term Residential	£6,172,000
LDISTR	Learning Disability Internal Short Term Residential	£5,561,040
LDESTRT	Learning Disability External Short Term Residential	£4,453,364
OAEHSGCO	Older Adults External Long Term Nursing	£2,697,419
CHEFSTND	Children External Fostering Standard Fee	£2,609,469
Total		£112,758,364

Table 3.5: Top ten service elements in terms of cost for the period 2010-2015

In addition to cost, BCC also interested in the commissioning frequency of the service elements, as each commission required associated administrative overhead. Figure 3.4a documents the top ten service elements in terms of quarterly frequency and the fluctuation in this commissioning volume over six years. Table 3.6 reports that the amount of care services are provided to older adults more than the younger groups over time.

3. Exploring the Variation in Social Care Agreement Services

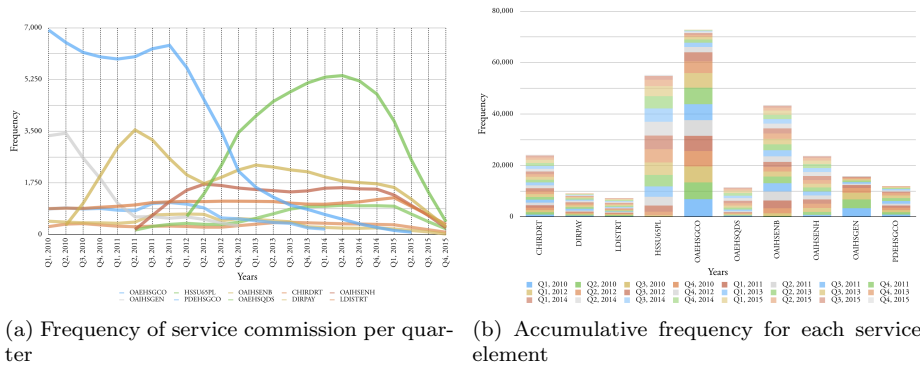


Figure 3.4: Top ten service elements in terms of commissioning frequency, for all age categories for the period 2010-2015

Service element	Description	Frequency
OAEHSGCO	Older Adults External General Contracted	72,860
HSSU65PL	Home Support 65 Plus External Community Based	55,199
OAIHSENB	Older Adults Internal Home Support Enablement	43,524
CHIRDRT	Children Internal Residential Disabled Respite	24,160
OAIHSENH	Older Adults Internal Home Support Enhanced Assessment	23,743
OAIHSGEN	Older Adults Internal Home Support General	15,875
PDEHSGCO	Physical Disability External General Contracted	11,984
OAEHSQDS	Older Adults External Quick Discharge Service	11,500
DIRPAY	Direct Payments	9,217
LDISTRTR	Learning Disability Internal Short Term Residential	7,348
Total		275,410

Table 3.6: Top ten service elements in terms of frequency for the period 2010-2015

3.2.2 Choosing the Case Studies

The analyses raised a number of questions, but this reserach restricted the discussion to four high cost and/or frequency contributed services in particular:

1. OAEHSGCO and HSSU65PL, represents as older adults care and rank top in terms of frequency and in the top three services in terms of cost. There is an interesting connection between these service elements, due to the introduction of a new contractual framework for the procurement of home support services. The first case study exploits a reporting limitation to highlight this pre and post contractual change and its impact on the

city;

2. CHIRDRT, Children's Internal Residential Disabled Respite, is the most costly service to the Council, accounting for £55 million over the six-year period. Despite the high cost, this service has received by a relatively small number of individuals. This will be presented and explored in the second case study;
3. OAIHSENB, is an internal service delivered directly by the Council to support the care of older adults. Although this service has not featured in an expensive cost, it is however belonged to an internally managed service that commissioned over 43,000 times during the period in question. The last case study will investigate the geographical areas within the city in which this service element is most used.

Prior to the analysis of the proposed three case studies proposed above, two (of many) anomalies are exposed from this data exploration, see Figure 3.5. Two service elements are chosen to illustrate the findings: (i) CHERSET - denoting that a child is/was placed at an external residential setting as a result of their assessment needs (in Figure 3.5a); and (ii) LDELVRT - denoting a variation in contract, possibly following a review, of a long-term residential placement to support the learning disabilities of a child (in Figure 3.5b). The results provide quarterly aggregated cost for the period of 2010 to 2015. The predictability of the provision of these two service elements is highly variable: The cost per quarter ranges from £0 to approximately £180,000; There are extended periods when these service element codes are not used or paid at all such as Q3.2011 and Q1 to Q2.2012 in CHERSET and Q3.2013 in LDELVRT; There are periods when the service element codes are overly used such as Q1.2010 in LDELVRT; There are outliers which make the financial management of these service elements difficult; There are features in the data which echo responses to priorities, care service management and financial pressures; These outcomes reflect poor quality and inconsistency of service provision in specific services.

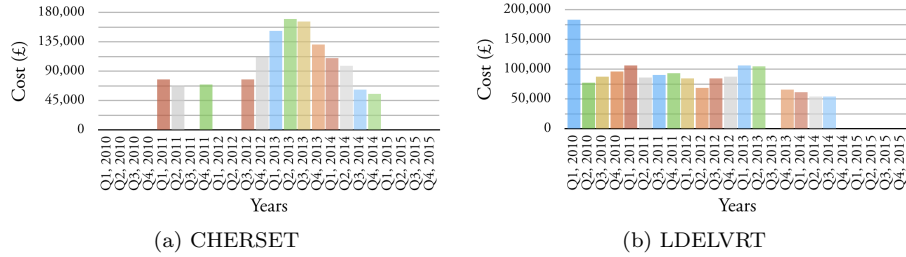


Figure 3.5: Examples of anomalies that the exploration of data expose

3.2.3 Case Study 1 - The Impact of a New Contractual Framework

The first case study sought to understand transition of the services delivery following an implementation of a new contractual framework. In particular, this case study interested in understanding whether this service transition impacted some of Birmingham residents more than others.

The change in contractual management of the agreement which was highlighted came about as a result of The Adults and Communities Transformation Programme Future Operating Model, identifying the need for a different approach to block contract purchasing of adult social care provision. Following a tender in 2011, the People Directorate commissioned a micro-procurement system (Sproc.net) to procure individual home support and bed-based care packages for Birmingham citizens with eligible needs. A further contract to use the Sproc.net system to provide the contract management function was subsequently entered into, following the original contract award provider failing to be able to progress and provide this function within a reasonable timescale. In 2012, Sproc.net became the procurement system of choice for home support commissioning and, in October 2013, the system was extended for older adults' nursing and residential care.

The analysis focused on the service elements OAEHSGCO and HSSU65PL, both of which related to older adults care and fell under the 2011/12 transformation programme. This study shows the geographical dispersal of the service

elements and the recipients, see Figure 3.6. Data was aggregated over a six-year period and two colour ramps were used for each graphical cylinder - purple to green for the service element OAEHSGCO (Figure 3.6a); red to green for the service element HSSU65PL (Figure 3.6b). The height of each cylindrical bar in the figures is determined by the number of unique service agreements registered within the specific postcode; a higher bar indicates that more recipients have been received the service. Note that multiple agreements for the same service, for a unique individual, would only be registered once.

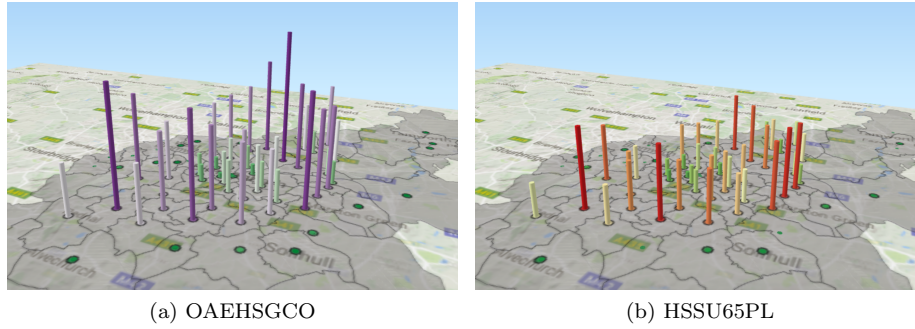


Figure 3.6: Geographical dispersal of the OAEHSGCO and HSSU65PL service elements across Birmingham's postcode regions

Postcode	OAEHSGCO	HSSU65PL	Total	Difference
B23	1,254	564	1,818	-690
B24	816	426	1,242	-390
B75	645	261	906	-384
B26	952	569	1,521	-383
B42	690	332	1,022	-358
B1	37	47	84	10
B3	0	11	11	11
B7	97	109	206	12
B18	113	135	248	22
B9	232	276	508	44

Table 3.7: OAEHSGCO and HSSU65PL agreements for different postcodes in Birmingham

Table 3.7 highlights the five postcodes where the difference between these two delivered services was the greatest (note that one might expect the frequency of OAEHSGCO and HSSU65PL to remain consistent as the Council transitioned from one service delivery framework to the other). The areas with the largest

drop in unique service delivery (before and after the Sproc.net services delivery transition) cluster in the northern part of the city (postcodes B23, B24, B26, B42 and B75); conversely, the areas with the greatest increase in the number of service agreements is in central Birmingham (postcodes B1, B3, B7, B9 and B18).

According to the 2011 census, the distribution of ethnic groups in Birmingham is mixed. Postcodes B23 and B24, for example, have a population which is almost 78 per cent white; B9 on the other hand has a white population of just above 27 per cent. The research subsequently tried to discover whether certain ethnic communities were impacted more by the transition of older adult care services than others, as the population demographics of the most affected regions might suggest.

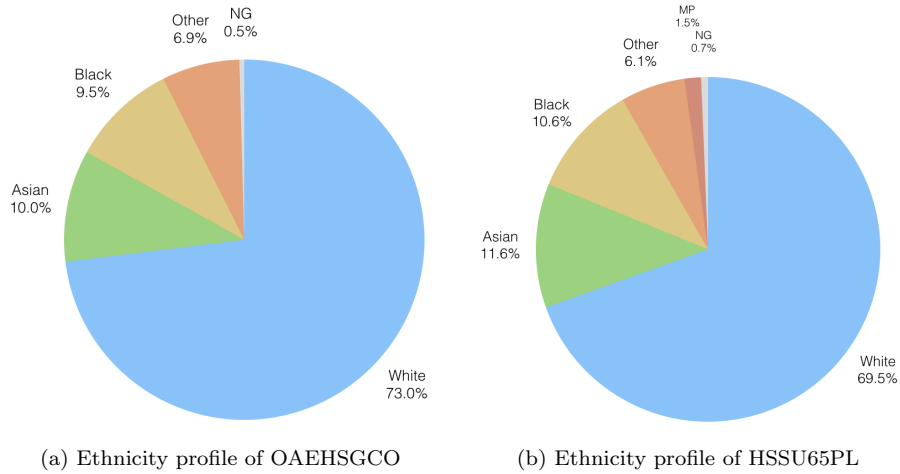


Figure 3.7: Ethnicity profile of the recipients of OAEHSGCO and HSSU65PL

Figure 3.7 displays the distribution of ethnicity for the recipients of OAEHSGCO and HSSU65PL as pie-charts. There were six out of a potential twenty ethnicity groups included within the agreements data. Majority of the service users are White, followed by Asian, Black, Others, Mixed Parentage and Not Given (information could not be obtained). This data were somewhat reassuring: Whilst it was clear that the service framework transition had impacted

the establishment of new agreements, particularly in the northern region of the city, this impact was not however limited to one specific ethnicity group than others. This study suggested that the local authority would require additional work to understand rational of such effect caused by transition of the service framework and supporting research will be needed to establish procedures to mitigate similar issues in the future.

3.2.4 Case Study 2 - Residential Respite Care for Disabled Children

Residential respite care for disabled children (CHIRDRT) accounts for approximately £55 million of Council spend on care services over the six-year period. This service element dominates the spend profile (Figure 3.3) and shows a steady increase in cost between Q1_2010 and Q1_2014. Despite this constant rise in cost, the number of unique individuals for CHIRDRT varies significantly over the period, as shown in Figure 3.8.

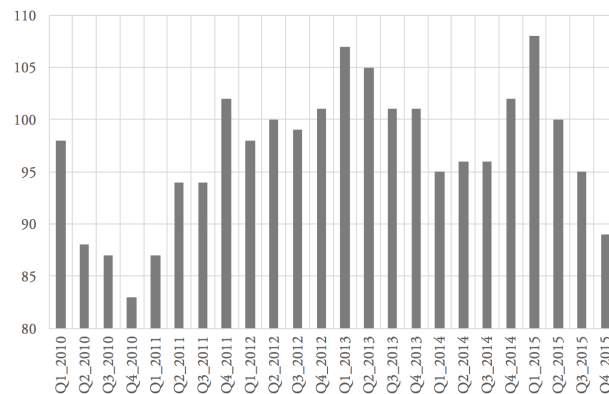


Figure 3.8: Unique registered users for CHIRDRT over the six-year study period

The number of unique registered users in each quarter varies by as much as 20 per cent. Unlike the first case study, in which service elements had a significant cost and frequency, this case study highlights that although the cost and frequency of service agreements are also high, the number of service users

is comparatively small, see Table 3.8.

Interestingly, this also reports that a high proportion of the users in Q1_2010 are not found in Q1_2015: There are several explanations for this, including that (i) the user drops out of the 5 to 18 age bracket caught by this service element code (the result shows around 22 per cent of users transition to the adult age category in the dataset) and (ii) users no longer live in the area.

Condition	Q1_2010	Q1_2015
Number of unique registered users	98	108
Number of unique users between Q1_2010 and Q1_2015	76	86

Table 3.8: Comparison of records between Q1_2010 and Q1_2015

It is clearly advantageous to attempt to predict this population in Birmingham when modelling service expenditure in future years. Birmingham has the youngest population of any European city and, according to population estimates and census data, more than 28 per cent of its population aged under 19. The Birmingham City Budget Plan 2016 [18] provides more detailed population statistics: Between 2001 and 2011, the 0 to 4 age group grew by 17 per cent and now accounts for 7.8 per cent of Birmingham’s population. This growth is set to slow to 1.1 per cent between now and 2021; the largest growth will be the 10 to 14 age group, which will see its population increase by 7.7 per cent.

This presents several challenges to the Council, as the number of people in Birmingham eligible for care services such as CHIRDRT grows. The current population projections point to an increase in demand for residential respite care for disabled children and the cost of this service element expects to increase by around 15 per cent between now and 2021, assuming that both factors remain static.

3.2.5 Case Study 3 - Care Services for Older Adults

The third case study, in contrast to the previous two, focused on the delivery of older adult internal care. The Council provided housing support and en-

ablement for older adults both through a commissioned service from external providers (a) OAEHSCGO (Older Adults External General Contracted) and (b) HSSU65PL (Home Support 65 Plus External Community Based) and as a provider of the service itself (c) OAIHSENB (Older Adults Internal Home Support Enablement).

As a result of budget setting proposals for 2015/16, which considered externalisation of existing internally provided services, the Council wanted to understand if the provisioning patterns were similar for the internal and external services or, if there was significant deviation between these, where and to what extent this manifested itself in the city.

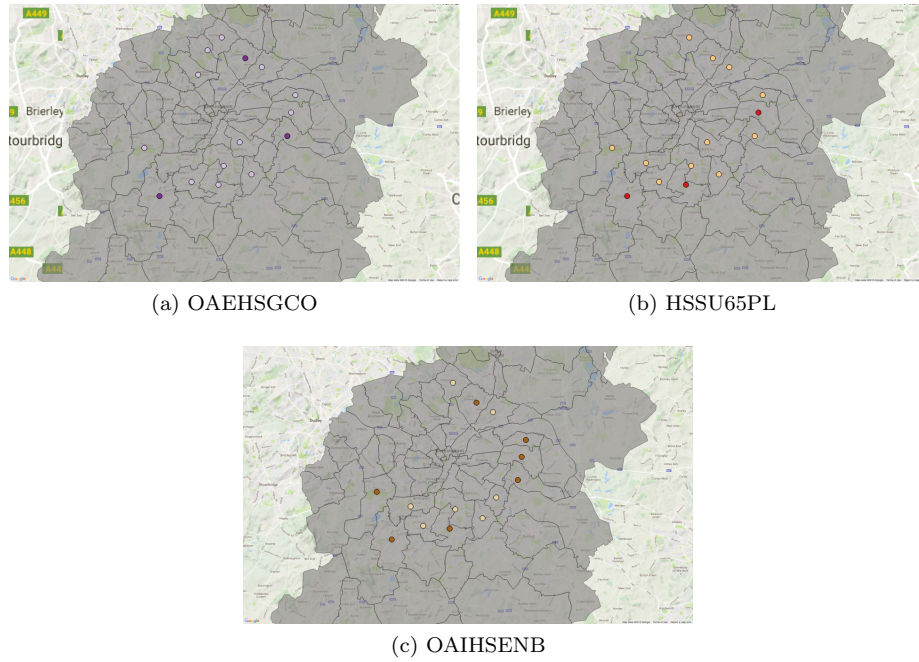


Figure 3.9: Postcode regions which saw the highest concentration of the three service elements in question in 2010-2015

Figure 3.9 shows the concentration of the three service elements in question between 2010 and 2015. Darker spots present a two standard deviations above the mean and lighter spots present a standard deviation above the mean. The 'outer ring' pattern is clear for all three service elements and indeed there

appears little difference in the externally provided service HSSU65PL and the internally provided service OAIHSENB. In order to verify these findings, the method to calculate the distribution frequencies for all three service elements for all 75 postcode regions were used. The analysis takes into account all calendar quarters of a six-year period. Figure 3.10 shows the distribution of frequencies within the three service elements over a continuous interval in density format.

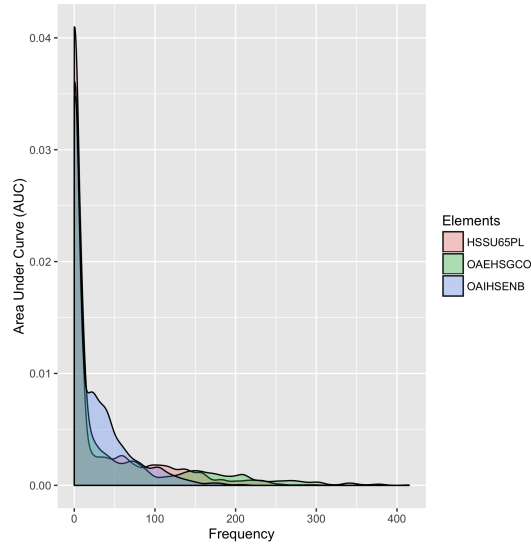


Figure 3.10: Density plots comparing the three service elements over the period 2010 to 2015

Figure 3.10 highlights that the two external elements (OAEHSGCO and HSSU65PL) show similar trends, with a sharp descent and a narrow tail, indicating that few postcode regions have a large number of registered agreements. The peak of the curve helps identify where services are concentrated and at what frequency. The area under the curve for the internal element shows a higher density of service provision in some postcode areas, typically where between 20 and 70 service agreements are delivered. This confirms the findings in Figure 3.9, but allows this analysis to tune the conclusions accordingly.

With such analysis, it is possible to be very accurate in calculating the similarities (and differences) in service element delivery. This pattern identification will be used to support the development of commissioning strategies for exter-

nalising internal services.

3.3 Analysis derived from Spatial Analysis

This research used start and end dates of service agreements and the full postcodes for spatial-temporal analysis, which could be applied when data were collected in time (interval) as well as space (location and geometry). The analysis excluded any possible outliers from the data, including those who receive the services from the authority outside the Birmingham postcode region which could otherwise distort the overall results. The research was structured using a number of different methods. Firstly, the research focused on the top twenty service elements, having determined through analysis they accounted for approximately 80 per cent of the total cost of all service elements. The annual cost analysis of the top twenty elements highlighted that the cost of these services had fallen by about £1 million over the study period. Given the Council's budget reduction plan, this trend was likely to continue. Secondly, the data with postcodes were analysed to highlight geographical areas across the city with the highest cost and demand, and a matrix heat map was used to identify hot spots for further analysis. Thirdly, spatial density heat maps were then generated for different age groups and services, which themselves can be animated to show the demand for services in the city over time. Finally, the geographical demand was assessed, to help understand those services where historical demand has been high by location and what conclusions can be drawn from this to inform future service provision.

3.3.1 Identification of Three Regional Hot Spots

In order to better understand the provision of services and their cost, the focus of the analysis was conducted at the district level to retain privacy of the individuals. Two methods were required to choose the candidate areas, so that (i) the areas showed the highest density of recipients across all age groups and (ii)

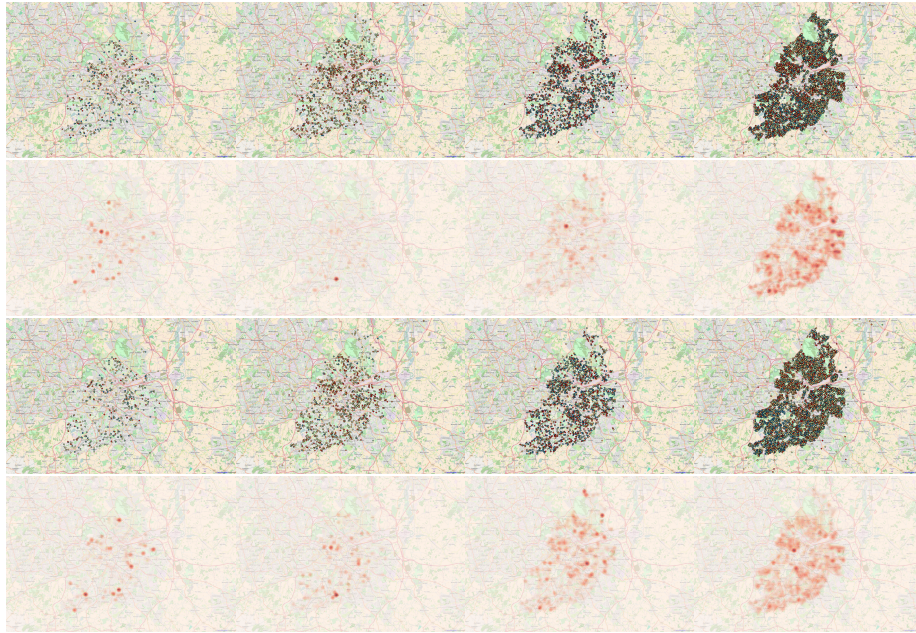


Figure 3.11: The location of social care service provision across Birmingham, ages 0-11 (1st column), 11-25 (2nd column), 25-65 (3rd column) and 65-90 (4th column) from 2010-2012 (first two rows) and 2013-2015 (last two rows) both point and density heat maps

areas had a population of approximately 50,000 people.

Figure 3.11 displays the point and density heat map of the entire social care client records in the extracted dataset. Each density heat map is plotted by the four different age groups (columns) and represents the service provision over two three-year periods (rows) to enable comparison over time: Dark color shows occurrence and represents density. This helped identify potential locations with high demand (darker spots indicate higher density of service provisions). For example, the service provision for children aged 0 to 11 (the first column), even though number of agreement records is far fewer than other age bands, the provision tends to cluster at some parts of the city and those differ over the two three-year periods. Whereas, the maps representing the 11 to 25 age group (the second column) demonstrate a good dispersal of service agreements over the periods as the services distribute quite evenly throughout the city (fewer hot spots), though some are concentrated around the southern region. However, for

registered individuals aged 25 and over (the last two columns), there is a greater diversity in clients receiving different service elements from the authority.

Consequently, a second method was applied to help identify the areas of interest that may contain multiple district-level postcodes. Estimating the population per postcode was calculated by aggregating the number of citizens within a particular district from the 2011 Census of Postcode Headcounts and Household Estimates, before retrieving an approximate number of people per postcode. Regions that displayed the highest density of registered service users and where the residents totalled approximately 50,000 were located in the eastern, northern and southern parts of central Birmingham, see Figure 3.12. In addition, Table 3.9 shows the postcodes involved and the approximate aggregated population from each chosen region. Note that, the final decision when choosing the candidate area also considered the number of adjacent postcodes as well as the size of the corresponding focused region.

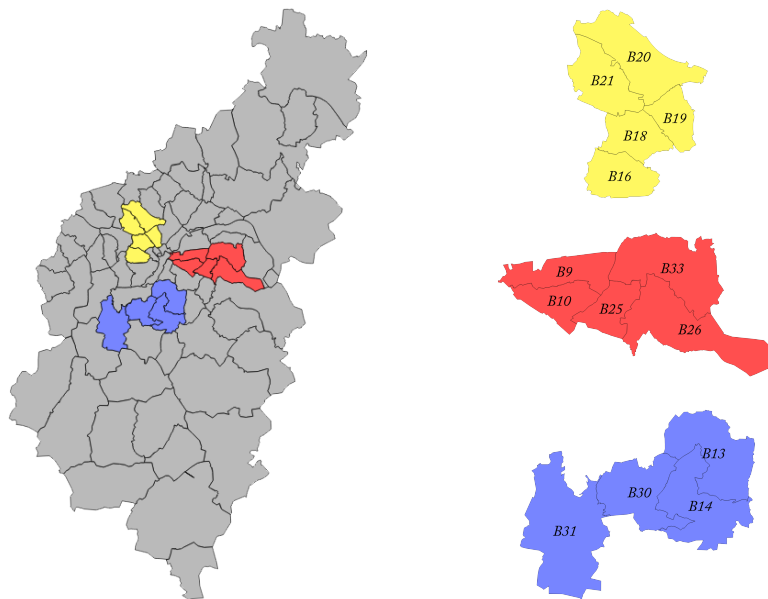


Figure 3.12: Birmingham postcodes at a district level, with three areas of interest; northern, eastern and southern

Regions	Postcodes	Population (approx.)
Northern	B16, B18, B19, B20, B21	45,000
Eastern	B9, B10, B25, B26, B33	45,000
Southern	B13, B14, B30, B31	65,000

Table 3.9: Postcodes within the three areas of interest and the estimated population

The study applied further analysis of the three regions by examining the annual cost of the top twenty service elements in all age groups over the six-year period.

Northern

The northern part of the city was smaller by size but was included as it represents a higher density of population per district. Figure 3.13 shows the annual cost of service provision for the top twenty social care elements for the northern region. Other than a small decrease in cost in 2012, the overall spending by the local government increases by almost 30 per cent between 2010 and 2015. Moreover, the pattern emphasises registered clients aged 11 to 25, which after 2010 grow by more than 120 per cent to the end of 2015.

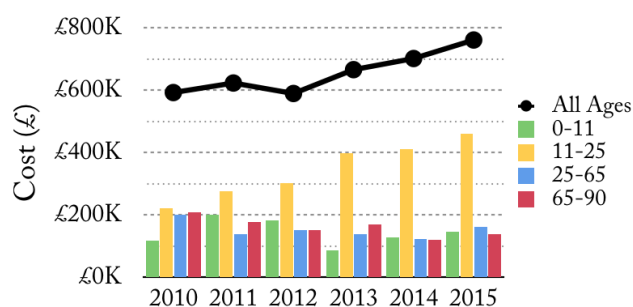


Figure 3.13: Cost of top twenty elements for the northern area

Eastern

In the eastern part of the city, service element provision is dispersed evenly across the region over time. Figure 3.14 indicates an increasing pattern of overall cost starting from an initial increase in 2011 to 2012 of approximately 24

per cent before gradually diminished to less than £750,000 in 2015. The 11 to 25 age group, as in the northern region, dominates from the start of the period (with costs in excess of £250,000) and continues to increase to more than 50 per cent of the overall cost by 2015.

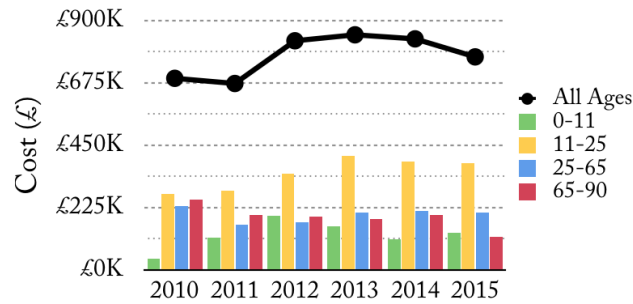


Figure 3.14: Cost of top 20 elements for the eastern area

Southern

In the southern part of the city, fewer postcodes were selected for analysis. However, the region contained more unique recipients of services as well as greater overall population. The cost of service element provision, found in Figure 3.15, is therefore higher than the other two regions. The data shows a slow reduction in the accumulated cost from above £1.4 million at the beginning of the period to around £1.35 million by the end of the period. Despite a decreasing trend in the annual cost for the top twenty service elements, the cost for clients who are aged 11 to 25 has increased by approximately 30 per cent from 2010 and dominates other age groups. The cost profile for other age groups shows fluctuating yet diminishing costs over the six-year period.

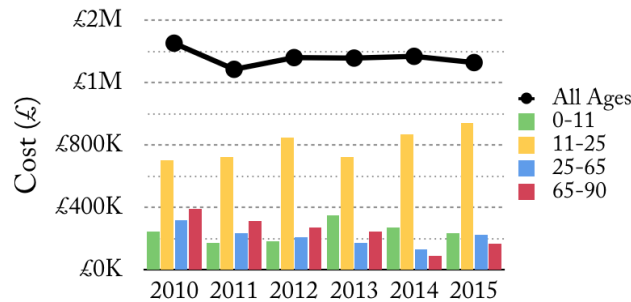


Figure 3.15: Cost of top 20 elements for the southern area

The total cost of services for each region over the six years period is: northern region £3.9 million; eastern region £4.6 million and southern region 8.1 million.

The analysis subsequently investigated the geographical dispersal of the top 20 per cent of recipients who receive the largest number of service agreements over two three-year periods, see Figure 3.16. A threshold percentage was used to highlight the top quartile of data and techniques were employed to ensure individual privacy. The data were overlaid over the district postcode boundaries of the three regions as shown in Figure 3.12. The height and colour intensity of each cylindrical bar are determined by the number of unique agreements registered within the postcode region; the higher and darker bar indicates the higher number of agreements involved. The change of service provision between two periods is apparent.

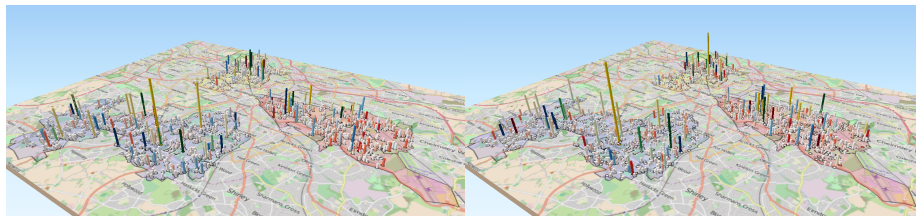


Figure 3.16: Three-dimension geographical dispersal of service agreements for all age groups across three regions, 2010-2012 (left) and 2013-2015 (right)

The use of the three-dimensional map had helped the study to identify not only the location of service users, but also the frequency of services within those regions and, in particular, the temporal demand.

3.3.2 Discussion

The research presented in this first contribution chapter considers how social care data already held by Birmingham City Council could be extracted, analysed and used to support decision-making in light of the financial challenges facing the local authority. This study focuses on the authority's social care system, CareFirst, although other similar data exist in the Council and many other opportunities exist in this regard. To begin the process of accessing the data, the researchers followed and gained approval for the research through the Council's internal governance processes to ensure compliance with relevant data protection and ethical obligations. All data were deidentified before receipt (all identifiable attributes were removed), so that it was not possible for the researchers to identify individuals or groups of individuals.

CareFirst is the Council's primary case management system used for social care referrals, assessments and the recording of service agreements. The workflow began with data extraction, ingestion, cleansing and spatial-temporal analysis to derive a potential data model suitable for further analysis and manipulation.

The primary purpose of data collection within the CareFirst system is the delivery of services and the management of caseloads, as opposed to supporting analysis and research, and making use of the data beyond its original purpose is challenging. However, as this research shows, with the support of suitable anonymisation and data analytics techniques, data are assets that local authorities may increasingly look towards to support budget reduction challenges whilst supporting and maintaining levels of service to a diverse population.

The use of postcode sector data and individual attributes raises questions of data protection and privacy. As described earlier, the data are extracted from the Council's social care system, and in order to comply with the provisions of the Data Protection Act 1998 (the Act), the data are deidentified at source (i.e. before being made available for research) to prevent the identification of any individuals or groups. This allows the researchers (and the Council)

to demonstrate compliance with Section 33 of the Act ² provided that: “(a) the data are not processed to support measures or decisions with respect to particular individuals, and (b) the data are not processed in such a way that substantial damage or substantial distress is, or is likely to be, caused to any data subject”. Furthermore, the Act states that: “the further processing of personal data for research purposes (in compliance with conditions, (a) and (b) above), is not to be regarded as incompatible with the purposes for which it was obtained.”. It is within the parameters of these conditions, and under the jurisdiction of the Council ethics and governance procedures, that this research is conducted.

Whilst the Act clearly defines parameters for the research, the study falls into a common class of problem - the desire to understand aggregate information about data, without exposing data about individuals themselves. This problem is well understood in the context of population census studies (the 2016 Australian census was criticised for this very reason [111]) and as a result, an emerging collection of methods, including differential privacy [38], have been developed to ensure anonymisation in large sparse datasets.

Despite there are risks associated with the use of even deidentified data, it should be recognised that, if appropriately utilised and by following relevant legal, ethical and organisational requirements, the data can provide evidence of continuity of service and public good, and improve the operations of public services in the UK and beyond [46, 115]. The retention and use of data in the Case Study 1 are used to demonstrate that following the implementation of a new contractual framework, the ethnic mix of recipients of this service remained largely consistent, even if the delivery of services in some areas did drop.

In the analysis derived from temporal analysis, three case studies are selected to demonstrate how research and insight can be obtained from the data, through a targeted evaluation of the data alongside historical records of service management frameworks and key council priorities and objectives. Record

²Section 33 of the Data Protection Act (1998) has been repealed and replaced by Section 19 of the Data Protection Act (2018)

attributes, including user identifiers, commissioning dates, location details and service costs, are critical to understanding the provisioning of social care services and the trends and demands that these services are subjected to over time.

As each of the three case studies highlights, the analysis allows past provisioning of services to be better understood, trends in the delivery of services to be identified and future demand to be forecasted. The first case study investigates the impact on older adult care of transitioning from one contractual framework to another, identifying those postcodes which may have been impacted by this transition. The second case study considers services provided to disabled children, a small pool of recipients aged between 5 and 18. Respite services are costly, and the analysis shows how it is possible to model the likely increase in these costs in future years. The third case study explores how Care-First data can be used to understand the relationship between the provision of services provided by an external provider and those provided directly by the Council. This work will also support the local authority to save around £9 million on Home Care Enablement between now and 2020.

On the other hand, the research derived from spatial analysis seeks to identify new ways of integrating data analysis and visualisation with the monitoring and analysis of social care service closed agreements. This work is being used to support Birmingham City Council in resource and service allocation, a task which is particularly challenging in times of financial austerity. There was a desire to make use of this data to better understand service provision at different levels of granularity, develop new analysis to predict future demand and, improve the strength of data interpretation to identify risk.

The research focuses on applying spatial analysis to the three geographical areas of interest, which provide an overall picture of where Council spend on these services has taken place, and the age groups of registered users. The researcher can identify the distribution of services over time and, in the example, the uptake of these services by people who are aged 11 to 25 across the city. Child care services (for those aged below 18) are notable, as they dominate all

other groups in the cost of social care services.

The analysis of the three city regions demonstrates that in the southern part of the city, service payment per year was approximately 25 per cent more than in the northern and eastern parts of Birmingham. Despite a higher number of agreement records, services for older adults (aged over 25) were less costly than those of the younger age group. The cost patterns and three-dimensional dispersal map emphasise the impact of clients aged 11 to 25 in the number of recipients and agreement records received from different locations across the three city regions. The research found that this age band also shows that Council spend is highly correlated to the region's total service provisioning cost.

These results provide detailed analysis of the financial commitment that the local authority is required to make in specific regions in the city. Despite the overall annual spend declining over the past six-years, support within the northern region has increased by 33 per cent. These remain a topic of further investigation by the Council. In presenting the service provisioning at the district postcode, a more fine-grained analysis is possible, while avoiding disclosure of recipient's identity and data. It is possible to re-apply the techniques used in this research and repeat the analysis with different parameters, for example, analysing other age ranges (0 to 5, 6 to 11, 11 to 16, etc.), changing the population size or identifying the most costly services, in order to provide an alternative view of the data for the Council to consider.

CHAPTER 4

Assessing the viability of budget saving proposals for social care delivery

In this chapter we relate further analysis to the Council’s Business Plan and Budget 2016+ [18] and the associated consultation factsheets [15]. The aim of this research is to demonstrate how data analytics, such as that shown in Chapter 3, can be used to develop (and critique) the Council’s vision. In order to aid uptake of the research, we present the research in the context of services aimed at increasing the opportunity for younger and older adults to live as independent as possible. The aim of this research is therefore to:

1. Demonstrate how data analytics tools can be applied to the administrative data held within local government with focus on Maximising the Independence of Adults;
2. Connect the data and its analysis with the ongoing business planning and budget setting process;
3. Highlight how this data could be used to gain insight into proposed service planning changes.

4.1 Care Service Agreements

This research used the same agreement dataset as the studies in Chapter 3, including the data extraction process, the number of attributes and, the meaning of each attribute.

4.2 The Choice of Case Studies

The Council’s 2016 budget plan sets out six themes as follows: Planning and budgeting; Preventing family breakdown; Maximising the independence of adults; Sustainable neighbourhoods; Economic growth and jobs; The changing work-force; and Council-wide.

The specific case studies presented here are taken from the Maximising the Independence of Adults (MIA) theme, which included current service delivery to children and adults. The theme aims to support both younger and older adults to live as independently as possible, connecting adults with local community services, and providing services at the right time. There are 16 MIA areas, but this research focuses on three: (i) MIA3: Promoting independent travel and reducing reliance on Council funded transport underpinned by clear policy; (ii) MIA5: Internal Care Services - Younger adults day care and, (iii) MIA17: Internal Care Review - Home care enablement. These three themes were chosen as (a) the Council proposed to implement a high proportion of cost saving in relation to these MIAs (see Table 4.1), and (b) there was good compatibility between the themes and the attributes and service elements within the dataset provided.

MIAs	Net Spend 2015/16	Saving 2016/17	Saving 2017/18	Saving 2018/19	Saving 2019/20	Cost Saving Percentage
MIA3	£15.711	£2.463	£2.634	£2.634	£2.854	16.84%
MIA5	£7.693	£0.702	£1.113	£1.288	£1.288	14.26%
MIA17	£13.707	£1.5	£1.5	£1.5	£3.7	14.96%

Table 4.1: Net spending, proposed cost saving of MIA3, MIA5 and MIA17 (in £million) and its percentage cost saving.

4.3 Data Analysis Strategies

The frequency of service delivery in a district of the city was first normalised based on the population per postcode. Estimating the population per postcode was itself calculated from the 2011 Census of Postcode Headcounts and

Household Estimates.

Other methodologies employed included trend analysis and geographical mapping analysis. Trend analysis allowed us to investigate changes in relation to the three MIAs and identify relationships occurring among supporting service elements, including: temporal analysis of service provision (i) as a single period 2010 to 2015 (6 years in total), and (ii) in two three-year blocks, 2010 to 2012 and 2013 to 2015. Geographical mapping using Geographical Information System (GIS) software supported spatial understanding, data interpretation and visualisation of the results. Postcodes in the closed agreements (alphanumeric identifiers of six to eight characters, which designate an area with a number of distinct addresses) comprise a postcode area and postcode district (the outward code) and a postcode sector and a postcode unit (the inward code). As the data contained full postcodes, exploration was possible at the sector level, at which point the data was spatially joined with a geographic shapefile (in the ESRI vector data storage format) representing the location, shape and attributes of the corresponding geographic unit. Coordinates are plotted using the Ordnance Survey National Grid reference system (BNG) with the European Petroleum Survey Group (EPSG) Code EPSG:27700 ¹. Note that the postcodes were filtered so that they only covered BCC governed areas.

4.4 Data Cleansing and Pre-Processing

Pre-processing scripts and the statistical tool R were used, removing erroneous characters, conducting range checks and identifying missing values. As described in Chapter 3, of the 258,673 closed agreements studied, 18,872 (7.3 per cent) were removed because of ‘bad data’. In most cases these involved: (i) missing values, (ii) unreadable data records and, (iii) unknown or invalid entries. In order to ensure consistency of data and taking account of the upgrade to the CareFirst system in March 2010, six of the fifteen years of available data was

¹Polygons of the UK’s boundaries can be obtained via UK Data Service.

selected for this investigation.

During the pre-processing activity we defined standards as to how to manage or remove missing values from the respective attributes. Missing values might, for example, occur within attributes such as date of birth, agreement start and end dates, service and element codes, postcodes and weekly cost per agreement element. These attributes all have a significant impact on the recipient's data record, its meaning and the potential to distort the overall results of analysis. For example, missing date of birth or agreement dates, will affect understanding of the age of recipients and the length of time they were in receipt of services. Similarly, service and element codes specify what services were provided by the authority and are clearly important in understanding which services are being provided and to whom. Finally, the absence of postcodes and cost data would impact on spatial analysis and overall analysis of the costs of services.

4.5 Key Findings

4.5.1 Case Study 1 - MIA3: Promote Independent Travel and Reduce Reliance on Council Funded Transport

The Council's stated aim for this theme proposed to work with families to create travel solutions that decreased the number of council-run transport to school services. Therefore, we were interested in analysing the change in demand in related services over time and the potential impact of this change on Council spending and the number of service users.

The approach focused on individuals aged under 20, to capture those who were attending educational settings and were eligible for the service. Analysis of the data showed that 661 unique individuals received a total of 6,947 related social care services over the six-year period in question. The dataset highlighted four transport service elements that could be categorised into two type of support: (i) a taxi service for child and an accompanying adult and (ii) a taxi service for a child who travelled independently. Each comprised either outward

(home to educational establishment) or inward (educational establishment to home) direction of travel. The total aggregated cost to the Council of these service elements was £3,088,553. Note that the transport service data used in this case study is provided from social care data alone and does not include additional data from the Home to School Transport Team.

To illustrate the demand and spending on transport services, we use temporal analysis to interpret the data across the six-year period, see Figure 4.1. The analysis reveals the number of services provided (the grey bar chart), the number of recipients (the black trend line) and the total cost of the services to the Council (the blue trend line); each gradually decreases over time. The decrease displays reduction of more than 50 per cent in all three variables by the end of 2015. Vertical red lines highlight January of each year; it can be seen that the fluctuation reflects the UK's school year.

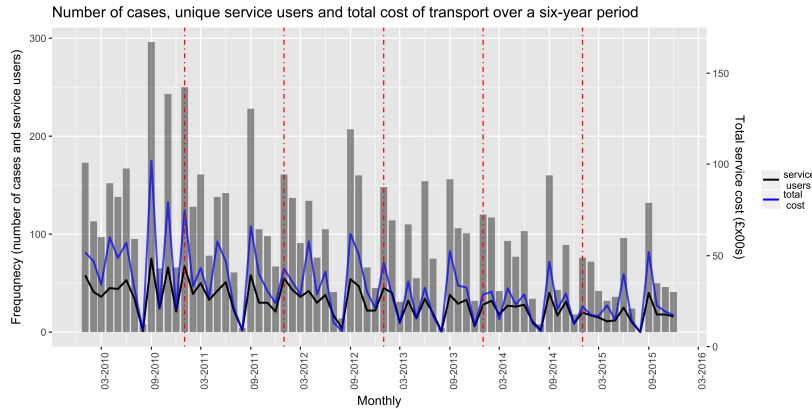


Figure 4.1: Number of cases, service users and total cost of transport services over a six-year period.

The results in Table 4.2 show the number of service users and the aggregated cost of the transport services between 2010 and 2015. The number of unique recipients during this period drops by 117 users (about 54.17 per cent). Likewise, there is also a decline in annual cost of £477,840 (about 60.28 per cent) over the five-year period. We calculate the ratio of the percentage change between the unique number of individuals and total cost as 1:1.113. This means that

whenever the number of users decreases by 1 per cent, the cost is reduced by roughly 1.113 per cent. Based on this, and given that the service costs are likely to be similar for both directions of travel, we sought to carry out similar analysis on a larger group of service users.

Year	Number of Service Users	Aggregated Weekly Cost
2010	216	£792,759.5
2015	99	£314,919.5

Table 4.2: Number of unique service users and aggregated cost between 2010 and 2015 of transport services.

According to the Council’s business budget plan document and the consultation factsheet, there were over 6,000 pupils who received transport services; accounting for £15.711 million of the Council’s net spend in 2015/16, see Table 4.1, with targets for cost reduction identified until 2019/20. By utilising the ratio calculated from the analysis of past transport services, it is possible to assess the percentage change the authority needs to achieve annually in order to meet its cost saving aim, see Table 4.3. For example, to achieve a cost saving of £2.463 million (15.68 per cent) in 2016/17, with 6,000 service users, the Council would be required to reduce the number of recipients to 5,155 people (a 14.09 per cent reduction).

Year	Number of Service Users	Expected Percentage change in Users	Net Spend (million)	Planned Percentage change in Spend	Cost Saving Plan (million)
2015/16	6,000	14.09%	£15.711	15.68%	£2.463
2016/17	5,155	1.16%	£13.428	1.27%	£0.171
2017/18	5,095	0%	£13.257	0%	£0
2018/19	5,095	1.51%	£13.257	1.66%	£0.220
2019/20	5,018	-	£13.037	-	-

Table 4.3: Predicted number of service users and net spends according to the cost saving plan.

Extrapolating this across the four years in the saving plan would suggest a reduction of around 16.8 per cent in service users to achieve an 18 per cent saving on the net spend. These predictions rely on several assumptions; that (i) the cost of services remain static over time, (ii) that service demand remains

the same, and (iii) that the future budget between 2016 and 2020 includes inflationary considerations. Given price rises and a growing population, one might consider these findings to be too conservative: To achieve the budgetary savings proposed in MIA3, 982 fewer individuals will be supported if there are no changes in cost or types of provision.

4.5.2 Case Study 2 - MIA5: Internal Care Services - Younger Adults Day Care

The Council's stated aim for this theme proposed to reorganise its internally provided services so that people could choose to purchase these services, or different community based services, thus allowing recipients greater control of the services for their assessed needs. Analysis presented here features levels of internal and external provision during 2010 and 2015, the service user types, as well as the aggregate costs and the geographical dispersal of the services. We were interested in understanding what impact service demand over a given period would have on the viability of the savings proposals for this theme.

The case study focused on the provision of internal care versus external care, and sought to identify change in demand over time. The internal services delivered by the Council in 2016 included, enablement/home care, extra care, internal day centres for older adults, internal day centres for younger adults, residential respite services and residential care centres. Similar external services are operated by private and 'not for profit' organisations across Birmingham.

The analysis was restricted to service recipients between the ages of 18 and 64 and to service elements that concerned internal care only. Of the 360 service elements, 183 were extracted and analysed in this study. This resulted in a sample of 22,105 data records of 4,864 external and internal individual service users. The aggregated cost of the internal care services from 2010 to 2015 was more than £18 million.

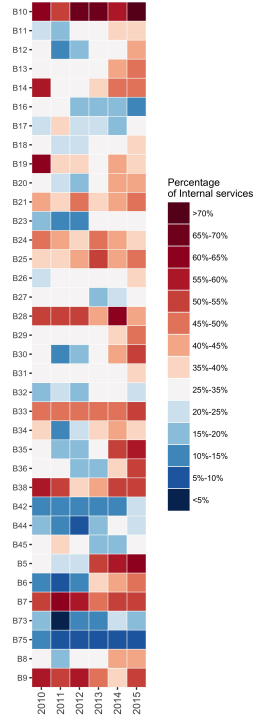


Figure 4.2: Spatial-temporal heat map matrix of percentage of provision between internal and external services in district postcode.

The aggregated proportion of internal and external services provided over the six-year period in question is 31:69. Using the data, we analysed the percentage of the two service types at the district postcode level, see Figure 4.2. This study focuses on postcode areas where more than 50 service users have received services over the six-year period to avoid bias in the outcome; this provided 36 postcode areas for analysis. Results are shown as a three-colour discrete interval gradient, indicating the proportion of internal care services against the 31:69 ratio: White represents a similar proportion of care provision over the six-year period; Dark red represents a high portion of internal care; Dark blue shows a high proportion of external care. The results highlight that a higher provision of internal care services were delivered in 2015 (about 72 per cent of the included postcodes) than in 2010. Three patterns can be discerned from Table 4.4: (i) There are consistent changes in variation of the provision (either

an increased or decreased trend) in 7 postcode regions, (ii) inconsistent changes in the variation of provision (representing a dramatic shift between internal and external care) can be seen in 14 postcode regions, and (iii) there are very few changes in internal services in 15 postcode regions.

Pattern	Postcodes
Consistent changes in provision variation	B8, B11, B13, B16, B26, B29, and B30
Inconsistent changes in provision variation	B5, B6, B12, B14, B17, B19, B20, B23, B28, B34, B35, B36, B44, and B73
Consistent unchanges in provision variation	B7, B9, B10, B18, B21, B24, B25, B27, B31, B32, B33, B38, B42, B45, and B75

Table 4.4: Pattern and change of variation in internal care services provisioning percentage.

The study widened to include an investigation of the 2,210 service users who received one of 49 internal service care elements (from a possible 183), to understand the demand of different types of internal services. The recipients were categorised into four distinct service groups: Learning Disability; Older Adults; Physical Disability and Others (mental health and residential care).

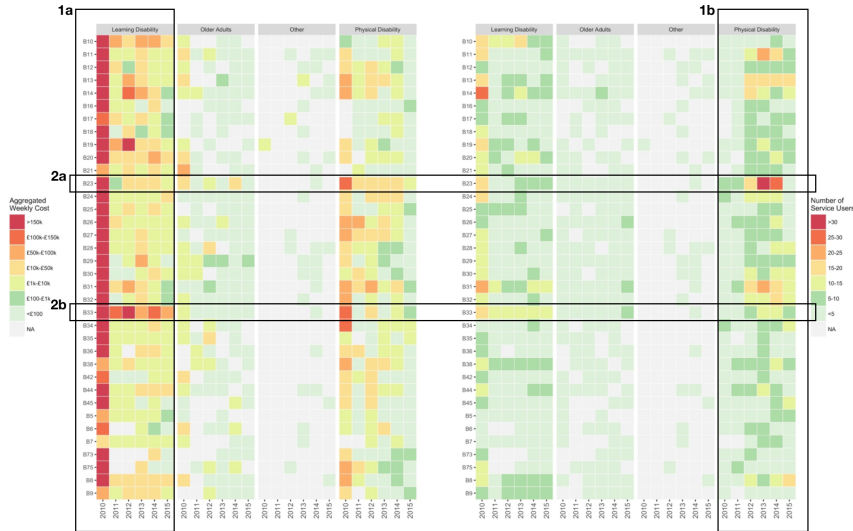


Figure 4.3: Spatial-temporal heat map matrix of aggregated cost and number of service users of internal care services among different service types in district postcode.

Figure 4.3 shows a matrix of aggregated cost (left) and number of service users (right) per district postcode across six years. The figure reports the higher cost of Learning and Physical Disability services compared with Older Adult services. There was high spending over most of the service groups (especially Learning Disability services) for all postcodes, despite the service being provided to a low number of service users over the six-year period.

The research highlights two key findings that emerge from this analysis. Firstly, the aggregated cost of Learning Disability services in 2010 alone accounts for £11.5 million (more than 60 per cent of the total spend over all years). There is a marked decrease in the aggregated costs of Learning Disability services from 2011, with a similar decrease in the number of service users receiving this service, see box 1a. Conversely, the number of recipients receiving Physical Disability services sees a year on year increase from 2010 to 2015, despite the aggregated costs of these services declining during the same period, see box 1b. We speculate that those individuals receiving Learning Disability services in 2010 are transferred to less-costly Physical Disability services thereafter. This could be due to two possible reasons: (i) the Council has decreased the number of Learning Disability services due to the high cost and (ii) in the absence of appropriate Learning Disability services, users are turning to Physical Disability services to supplement their service needs. The second key finding relates to postcode areas B23 and B33, which show patterns of costs and service user numbers that are significantly different from the remaining postcode areas. In B23, costs of Physical Disability services decrease, but with higher numbers of service users being supported before a substantial drop in the final year, see box 2a. In B33, we see a consistent pattern of high spend after an initial decrease, then a stable number of service users being supported, see box 2b. To better understand these anomalous patterns, further data are needed at the postcode level to identify any specific local issues that may impact the findings.

This MIA aimed to reorganise the provision of internal care services provided by the Council that were more expensive to deliver than equivalent external ser-

vices. In doing so, however, the analysis shows that the impact of these savings would most likely to be felt by service users accessing Learning Disabilities. If the Council wishes to enable service choice and control, external services for this group appear highly sensitive to the proposed change.

4.5.3 Case Study 3 - MIA17: Internal Care Review - Home Care Enablement

The Council's stated aim for this theme proposed to operate and develop future enablement services closely aligned with NHS partners and find alternative ways to deliver the services through different providers. The researcher interested in studying consistency and performance of existing provision and how this could affect future service deployment.

Of the 360 service elements, only three were described as enablement services, providing home support care including services for older adults, physically disabled and those with learning disabilities. The data contained 8,062 unique service users and 11,002 agreement records.

The Council stated policy is to provide enablement services to people for up to six weeks with no charge, after which a charge may be applied depending on the users' financial means. This case study focuses on the six-week threshold and the total number of people receiving the service.

The study began by comparing the number of individuals who received the following three service elements: LDIHSENB -Learning Disability Enablement; OAIHSENB - Older Adults Enablement; PDIHSENB - Physical Disability Enablement, over the six-year period, see Figure 4.4.

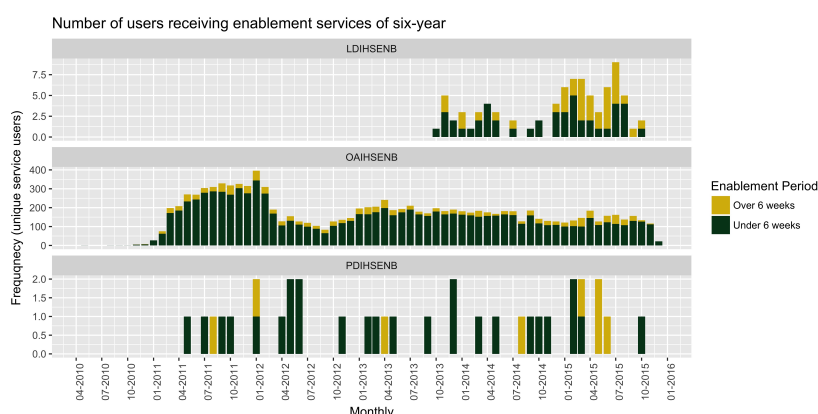


Figure 4.4: Frequency graphs of the three enablement service elements about number of the service users who receive less and more than six weeks by month over six-year period.

The results of this analysis showed that for learning disability enablement, data for the provision of these services only begins in late 2013 and 44 per cent of recipients receive enablement for more than six weeks. For older adult enablement, we see a consistent pattern over the six-year period of service, with many users receiving more than six weeks of enablement care. For physical disability enablement, the pattern is more sporadic and represents a much smaller cohort.

In addition, the data revealed that 1,442 unique individuals (almost 18 per cent of those in receipt of enablement services) received services without incurring further charges after exceeding the six-week threshold. This may be because an assessment of the individuals' financial needs means that they cannot contribute.

The study also examined the geographical dispersal of aggregated and normalised unique enablement service users per thousand of the population, including those that have been in receipt of services for more than six weeks, see Figure 4.5.

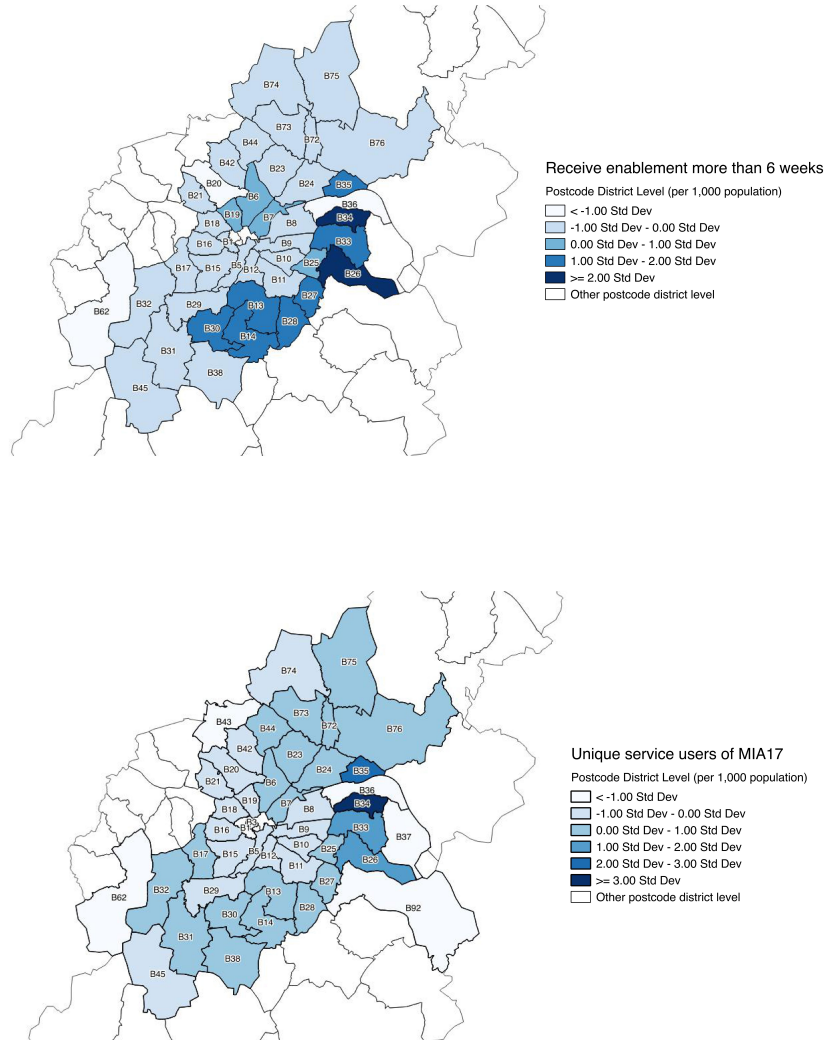


Figure 4.5: Geographical mapping of normalised frequency of the enablement service elements and users who receive more than six weeks of the services per thousand population of district postcode.

The map highlights areas around the eastern, south-eastern and southern regions of the city and highlights the overlapping areas between the two maps. Note in particular the B34 postcode, where there is a high density of recipients who receive enablement services for more than the six-week threshold and which also contains a high number of service users. Note that, as in the first two case

studies, an individual with multiple agreements for the same service would only be counted once.

This study highlights that (i) approximately 1 in 5 service users receive free care beyond the six-week window and this may influence discussions with external partners on the future delivery of these services and (ii) some postcode regions are likely to exceed this 20 per cent and some are not.

The study also explored the potential impact on the Council's planned savings targets, by considering the resource implications of the additional weeks of enablement that were not charged for (in line with Council's policy). To identify an appropriate cost for the additional weeks, we used the cost of the most common service, that is Older Adults External - General Contract (OAEHS-GCO). The average weekly cost per individual of this service was £161.51 over the six-year period. Of the 1,442 enablement recipients, a total of 6,423 extra weeks had been received. Therefore, given the cost assumptions, the estimated total cost of additional weeks of enablement services costs the Council in excess £1,000,000 per year.

4.6 Discussion

In this chapter we have shown further data analysis with particular reference to the Council's Business Plan and Budget 2016+ [18] and the associated consultation factsheets [15]. Our aim was to show how analytics on Council-held in-house data could be used to inform (and critique) the Council's vision. In order to aid uptake of the research, we presented the research in the context of services concerned with Maximising the Independence of Adults.

The findings in this chapter suggest that integrating data analytics with social care data held by BCC are possible, but are complex. This research considers how the information can be extracted, analysed and interpreted to support the assessment of the viability of budget saving proposals in light of the financial challenges faced by the local authority. The study begins with data extraction

from the authority's social care system, CareFirst. Data ingestion, cleansing and spatial-temporal analysis are used to derive a data model suitable for further analysis and manipulation. Three case studies are selected to demonstrate how insight can be obtained from the data, through a targeted evaluation of the data alongside historical records of service management frameworks and key council priorities and objectives. Record attributes, including user identifiers, commissioning dates, location details and service costs, are critical to understand the provisioning of social care services and demands that these services are subjected to over time.

Each case study has a different focus, demonstrating varied analytical capability. The first case study highlights the provision of transport services, supporting a child travelling with guardians or on their own. The total cost of these service elements decreases over the six years of the investigation. The case study shows that decreasing these costs further, as is the Council's aim, will require a reduction of over 16 per cent in both service demand and expenditure if the Council wishes to achieve its target by 2019/20. The analysis shows that this will require almost 1,000 fewer service users than current levels of provision.

The second case study analyses internal care service provision. In the context of proposed savings through externalising services, the study provides two supporting analyses: (i) geographical provision of services with aggregated cost and (ii) service user types across different regions. The study highlights an increase in the number of postcodes that provide a higher proportion of internal care services than external care services. However, this increase in demand only occurs in specific groups of recipients. The results show that number of service users has no relation to the total spending at the postcode level. Moreover, the study highlights the impact of changes on service users receiving Learning Disability services and the importance of this user group as part of any future service reorganisation.

The third case study highlights the demand on enablement services beyond the six consecutive weeks threshold. Although the service is most common for

older adults, learning disability enablement recipients are most likely to require more than six weeks of enablement support. This study seeks to discover the characteristics of the areas and services that are most likely to exceed the six-week threshold. The case study tells us that the value of enablement services provided beyond the stated policy threshold equates to around £1,000,000 a year, and represents over 60 per cent of the following year proposed savings target. The geographical differences observed will also impact on how proposed changes to the six-week threshold are delivered.

This research is complex in that it uses several different analytical methods, combining spatial-temporal techniques, predictive analyses and domain knowledge of local government. All three studies are only possible because of the individual-level data retained at the Council.

It is also important to acknowledge that the techniques that we apply can help clarify the rationale behind existing procedures utilised by the authority and as a result indicate areas for further analysis. As the three case studies highlight, this research allows past service provisioning to be better understood, trends in the delivery of services to be identified and, future demand to be forecasted.

There are number of other MIA themes and over 80 different budget saving proposals within the Council's budget plan 2016. It is equally possible to apply these analytic techniques to these proposals, particularly where they include service user numbers, service types and descriptions, location data, and date and time parameters. Whilst there are risks associated with the use of administrative data, it is recognised that if appropriately utilised the data can provide evidence in support of budget setting and social care service provisioning. Such approaches can also support decision-making, initiating new policies and improving existing service support to current recipients.

CHAPTER 5

Data Continuity and the Assessment Process

In order to develop better recommendations of social care service provision, an important stage prior to obtaining the services is for every recipient to go through a so-called ‘assessment process’. In this research, we use data analytic methods to examine the flow and continuity of the data from referral, through the assessment process, to the resulting service provision and, identify the decision-making points and the data recorded about service users throughout the workflow. This chapter, unlike Chapter 3 and Chapter 4, focuses specifically on adult social care from the initiation of the request of the service. In particular this chapter seeks to:

1. Understand the data-creation and -collection process and the structure of social care data, including different phases of the assessment process;
2. Understand the data flow of the process for adult social care service users;
3. Identify possible areas for further investigation, with a particular focus on underpinning future processes that would allow the Council to meet its savings targets.

The research reveals significant challenges with the assessment data, highlighting issues in data capture between referral and service delivery. Given that this data underpin future strategic decision-making, these findings are considered to offer substantial new insight.

5.1 Performance of Social Care Assessments

This research has been established in the context of understanding the assessments and care paths of adult social care recipients in Birmingham. BCC com-

missioned this research to build evidence that would assist with assessment of demand, analysis of process and identifying opportunities for service improvement and budget reductions. The Council Business Plan 2016 [18] provides the context for this research, identifying: (i) seamless health and social care provision, so people can get the service they require or the correct information and advice in one place, with people who need services able to access these irrespective of who the provider is and (ii) citizens having greater control and independence and making informed choices about care providers, support they require and place of delivery, with all citizens with an eligible care having access to either a Direct Payment or individual budget.

Net expenditure on adult social care for Birmingham in 2014/15 was £272.5 million, from which £202.8 million (74.4 per cent), was spent directly on providing care to citizens, buying care from other organisations and providing Direct Payments (money paid by the Council to independently meet assessed care needs). Table 5.1 shows that the largest contributions from the £202.8 million 2014/15 budget-funded services for people aged 65 and over (44.2 per cent) and for those aged between 18 and 64 with learning disabilities (33.7 per cent).

Category	Cost
Older Peoples' services	£89.7 million
Adults with Learning Disabilities	£68.4 million
Adults with Physical Disabilities	£20.7 million
Older Adult services	£15.2 million
Adults with Mental Health needs	£8.8 million

Table 5.1: Total adult social care net expenditure of 2014/15.

BCC has continued to face cuts in its grants from central government. In 2014/15, Birmingham's adult social care services needed to make net savings of over £32 million - approximately 16 per cent of its annual spend [18].

5.2 Assessment Process

To understand the assessment processes, we study the data flow as it is captured for a client from the initial request for social care support to the Council. There

are two principal routes into social care in Birmingham: (i) community referrals and (ii) hospital referrals. The data in this research showed a 65:35 ratio of people receiving care through the community against hospital referrals. The referral process is then supported by a number of linked processes, as seen in Figure 5.1.

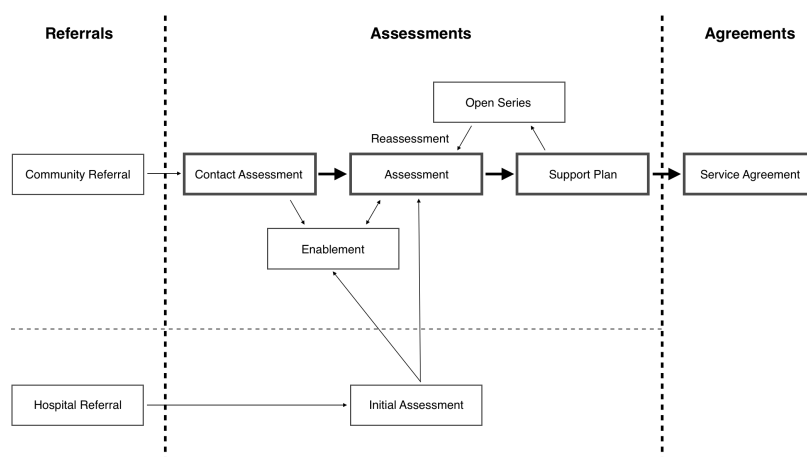


Figure 5.1: High-level assessment process.

5.2.1 Referrals

A community referral can be generated by the service users themselves, a family member, general practitioner or others with concerns for the welfare of an individual. A hospital referral, on the other hand, will require input from a relevant social care assessor employed by the authority to make a primary social care need decision for that individual. Additional information from the social worker may be added to complete the referral process:

1. **Community Referral (CR):** referrers have an opportunity to discuss the referral with a qualified social worker to determine the next step;
2. **Hospital Referral (HR):** referral is created as part of the discharge plan for an inpatient, categorised as (i) a hospital referral for a new client or (ii) a hospital referral for an existing client who is currently receiving a service but has now been admitted to hospital.

5.2.2 Assessments

The recording of the assessment process in BCC's CareFirst system consists of six sub-processes.

1. Contact Assessment (CA): a screening-level assessment to provide information and record clients' basic information before transferring the case for further consideration;
2. Initial Assessment (IA): creating a concise assessment, carried out 24 to 48 hours after receipt of the referral;
3. Assessment (AS): a record of the discussion between the eligible client and the social worker to determine the level of the individuals' needs; the focus will include the eligibility of the client and the options available to meet their needs;
4. Support Plan (SP): details the services that the client is eligible for, including their duration and location, based on the outcome of the assessment;
5. Enablement (ENB): a short-term support option with no charge, normally consisting of an intense six-week period of home support and homecare to help a client regain their independence;
6. Open Services (OS) / Reassessment (RE): where changing circumstances and level of need are reassessed in the support plan or assessment.

5.2.3 Agreements

The service agreement refers to the contract between the Council and the commissioned service provider to deliver the support plan.

5.3 Adult Social Care Eligibility

An assessment was carried out to establish whether a citizen may be eligible for social care services. During the period covered by the data, prior to April 2015, the eligibility threshold was set locally, based on the Fair Access to Care directive. New criteria came into effect in April 2015, as set out in the Care Act and its statutory guidance [71]. The Care Act needs assessment employed a three-stage test which establishes: (i) whether needs are connected with disability or illness; (ii) whether those needs prevent an individual achieving two or more outcomes, from a list that includes criteria such as managing and maintaining nutrition, being appropriately clothed and being able to care for dependent children; and (iii) whether this then impacts the individual's well-being [90]. As the data utilised in this study cover both regimes, the impact of these changes was explored further as part of the qualitative exploration of the data flow in the assessment process.

5.4 Care Service Assessments and Agreements

Data used in this research were derived from structured assessment and service agreements, which were extracted from the BCC's CareFirst information system.

The results presented here are for assessments for April 2013 to December 2016, inclusive. As the data spanned the period pre and post the implementation of the Care Act, the study noted that (i) there was a change in eligibility criteria and assessment practice and (ii) systems and processes were experiencing a period of change at that time, in preparation for and during the adoption of Care Act changes. The data sub-sample included over 69,147 distinct users, registered for more than 238,000 assessments and comprising eight major assessment sub-processes. Each extracted assessment consisted of sixteen associated variables.

5. Data Continuity and the Assessment Process

Record	Description	Assessment	Agreement
ASM.ID	Assessment ID	X	-
PERID	Person ID	X	X
DOB	Date of birth	X	X
Agreement Start	Start date of the agreement	-	X
Agreement End	End date of the agreement	-	X
Assessment Start	Start date of the assessment	X	-
Assessment End	End date of the assessment	X	-
Service	Alphanumeric coding of the service	-	X
Service Description	Description of the service	-	X
Element	Alphanumeric coding of the element	-	X
Element Description	Description of the element	-	X
QSA.Desc	Quality standard assessment process description	X	-
QSA.Group	Quality standard assessment process group	X	-
Assessment reason	Reason of taking assessment	X	-
Form Outcome	Outcome of assessment form	X	-
Service Team	Corresponding assessment form	X	-
Postcode	Full postcode (unit level)	X	X
Gender	None	X	X
Ethnicity	Ethnic classification (using census categories)	X	X
Client Group	Disability status	X	X
Wards	None	X	-
Constituencies	None	X	-

Table 5.2: The service assessment and agreement records used in this study.

For agreements, open and closed data for the same period were used to study the progress of individuals. The data included over 29,385 distinct people and more than 90,600 service agreement records. Each service agreement consists of twelve variables, see Table 5.2.

Note that there would be some duplication of individuals with such categorisation, as a person may be registered for more than one assessment and agreement within a period. The data are further filtered and focused on four core sub-processes: contact assessment, assessment, support planning and service agreement, see Table 5.3.

Process	Number of records	Number of individuals
Contact Assessment	124,575	56,701
Assessment	37,581	26,632
Support Plan	42,593	23,936
Agreement	94,400	29,385

Table 5.3: Number of service records and unique individuals of sub-process in assessment process.

5.4.1 Process completion

Each assessment-process stage should be subjected to a *completion status*, reflecting the decision made during that sub-process. The investigation of possible completion statuses has identified 42 different options. For the purposes of this research, the researcher groups the 42 different outcomes into five categories, see Table 5.4.

‘Proceed’, ‘close’ and ‘did not take place’ were self-explanatory. ‘Qualified closure’ referred to an assessment process that has ended, but required more data or denoted a subsequent assessment process following a hospital admission. Finally, ‘unknown’ referred to either an unknown outcome or a data quality issue.

Example	Number of Outcomes	Number of Teams	Category
Close, No further services, etc.	13	-	Close
Closure - safeguarding only, Equipment only, etc.	7	-	Qualified Closure
Further assessment, Create support plan, etc.	15	-	Proceed
Await authorisation, New Event, other, etc.	5	-	Unknown
Closed at adult’s request and Closure - declined assessments	2	-	Did Not Take Place
AD Erdington, AD Selly Oak etc.	-	10	Adults (Location)
LD North, LD Transitions, etc.	-	6	Learning Disability
MH Central, MH Homeless, etc.	-	10	Mental Health
City Hospital, Solihull Hospital, etc.	-	8	Hospital Settings
OA Northfield, OA Reviews, etc.	-	13	Older Adults (Location)
PD Activ8, PD/LD Complex Reviews, etc.	-	5	Physical Disability
ACAP, HI Rehab, Rapid Response, etc.	-	33	Others

Table 5.4: The category of form of outcome and corresponding team and the samples.

5.4.2 Data cleansing and pre-processing

The data contained 432 service teams supporting social care across the city. The teams are mapped with team codes provided by the Council; this mapping allows the researcher to reduce the service teams to 85 with seven categories;

this distribution will be used during the case studies, see Table 5.4.

Pre-processing scripts and the statistical tools in R were used, removing erroneous characters, conducting range checks and identifying missing values [63, 110]. Using similar methods to those in Chapter 3 and Chapter 4, of the 292,343 assessments studied, 54,193 (18.53 per cent) were removed because of ‘bad data’. The study employed open-source geographical information systems to perform spatial-temporal mapping. Eastings and Northings - geographic cartesian coordinates for eastward and northward-measured distances - are transformed into latitude-longitude coordinates using the ‘rgdal’ package in R.

5.5 Initial Findings

The analysis sought to understand the relationship between different stages of the assessment process, from referral to agreement in the CareFirst system. The study first looks at the continuity and structure of the process flow, see Figure 5.1. This may reflect the quality of care and impact on the effectiveness of service delivery [81], and/or reflects characteristics of and interaction with the system itself. The flow suggests a linear pattern of referrals, where each sub-stage should contain a decision that either closes the assessment or proceeds to the next stage. Analysis of the continuity of the assessment process is based on three-plus-one (agreement) sub-processes (highlighted in bold in Figure 5.1).

The number of unique recipient records in each sub-process were identified using the unique identifier assigned to every recipient. From the data-flow standpoint, this step might assume results would show a flow of individuals’ information through the process, either ending in a service being delivered or a record of a decision closing the assessment: The research recognised that, due to the limitation of the system, ‘shortcuts’ may be made as practitioners seek to make their jobs more manageable.

The results yielded interesting findings. First, there were numerous service users who appeared in sub-stages without appearing in earlier stages. Second,

whilst the numbers of users moving from CA to AS dropped considerably (expected if the service users' needs cannot be met), the records did not reflect the closure of assessment. Rather, many records reported users requiring further assessment. Third, of the total number of unique individuals in the datasets, only 40 per cent appeared in all four sub-processes. An analysis of the flow of all recipients in the assessment process was highlighted.

The study presented a more detailed analysis of results through three case studies.

5.6 Case Study 1: Qualitative Exploration of Dataflow in the Assessment Process

The first case study provided a qualitative exploration of data flow within and between the phases of assessment. Note that analysis only involved data from four core sub-processes (not from Hospital Referral (HR), Initial Assessment (IA), Enablement (ENB) and Open Services (OS) / Reassessment (RE)) and that the focus was quality and flow of data, not why it was as such.

The study concentrated on three linked processes: CA to AS, AS to SP and SP to AG. To improve understanding of each sub-process, a matrix is generated to examine the flow of data through these linked processes, see Table 5.5. Finding highlights that, as many as a quarter of individual records appear in a stage but not the proceeding stage. For example, 8,350 recipients receive agreements but did not have a corresponding support plan. To understand the potential anomalies, the research considered other sub-processes that were in place and that may account for these figures; this could be expanded below.

	CA	AS	SP	AG
CA	-	-	-	-
AS	3,967 (6.54%)	-	-	-
SP	-	8,930 (25.11%)	-	-
AG	-	-	8,350 (25.86%)	-

Table 5.5: Matrix of number of people that appear in a stage but not the proceeding stage.

Assessment is a complex process in which information can be recorded and obtained in several ways. The study explored other possible datasets that could potentially help explain the source of individuals: (i) data from other sub-processes such as HR, IA, and RE named as HIR; (ii) data from the ENB stage; and iii) data from excluded lists. Table 5.6 highlights the numbers from all three sources. ENB is obtained by extracting its related records from open/closed agreement data. The excluded list refers to a CA where there are insufficient data for the Council to take forward the case.

Sub-Process Name	Number of People
Hospital Referral (HR)	22,771
Initial Assessment (IA)	15,628
Reassessment (RE)	16,344
Enablement (ENB)	9,363
Excluded List	10,773

Table 5.6: Number of people involve in other non-core stage within assessment process.

Table 5.7 uses information from Table 5.5. The records were matched and linked using personal identity numbers to those external sources. The results show that there are still 681 (2.55 per cent of AS clients), 1,512 (6.3 per cent of SP clients) and 2,425 (8.25 per cent of AG clients) unique individuals whose information does not appear in the previous adjacent stage.

Link	Number of People	Exclude from			Remainder
		HIR	ENB	Excluded List	
CA to AS	3,967	3,210	43	33	681
AS to SP	8,930	7,324	42	52	1,512
SP to AG	8,350	5,172	485	268	2,425

Table 5.7: Number of people who are filtered from HIR, ENB and excluded list.

In addition to analysing the complete dataset, the matrix-base method shown in Table 5.5 is also applied to the data pre and post April 2015 (recognising the change in eligibility criteria at this time). Two findings were apparent: first, that the pattern of individuals' data being recorded in one stage of the process but not in the preceding stage remains a feature of the recording process; second, that the data after April 2017 involve around 10,000 fewer service users, which may be a reflection of the new Care Act eligibility criteria. There is further scope to study in more detail on the impact of the introduction of the 2015 Care Act on BCC's processes and data; this remains the topic of future research.

The analysis of mapping the data emphasised the complexity of data recording in assessment processes. The analysis of the complete dataset identified approximately 4,500 service users who could not be accounted for when considering their entrance or exit from the social care process. The case study showed the fragmented nature of the data across the four-year period and the two assessment regimes. It should be recognised that this was a data-led study and therefore did not reflect the use of the system by practitioners. There were likely to be elements of the process that were not recorded or could not be recorded easily due to system limitations and/or practical workarounds.

5.7 Case Study 2: Identifying Anomalies in the Assessment Process

The case study examined 27,238 unique individuals whose information were only presented in CA (almost 50 per cent) and investigated the outcomes associated with each. This, as with Case Study 1, demonstrated a significant number of cases where recorded data did not flow sequentially between and through stages. The CA sub-process represented the start of the workflow, and should therefore include a decision to proceed or not as part of the assessment process. It was assumed that some client information would only appear in this stage and not

subsequent stages.

To understand how data were being recorded in the system, the study considered recorded outcomes in CA. The research explored other sources that may explain the number of records in CA, including referrals to enablement services or records appearing in the excluded list. The results revealed that 124 unique people had progressed to the ENB stage and, by matching people to the excluded list, the study was able to filter 2,298 individuals from the CA data. Therefore, this case study investigated a total of 24,816 remaining CA records.

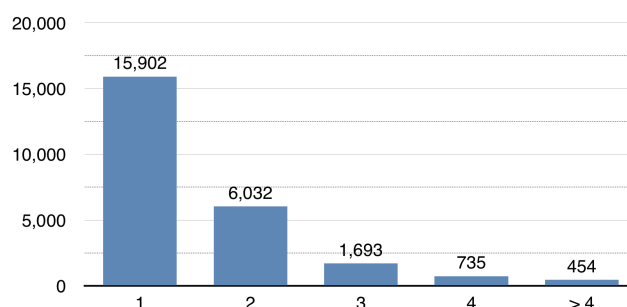


Figure 5.2: Number of frequency of assessment taken by individuals who only appear in CA.

Figure 5.2 reflects the number of assessments a person receives within CA. Sixty-four per cent of people receive a single assessment. If the process is followed correctly, then, for each single assessment, there should be a corresponding record reflecting one of the possible ‘closed’ categories set out in Table 5.4. However, the data reveal that, instead of Closure (CL), 53 per cent of records highlighted the need for Further Assessment (FA), which indicates that the record should be held for revision or progressed to AS for additional support.

The impact upon clients whose records denote FA was significant in the context of access to services, as is the ability to manage demand in an environment where savings needed to be made. The absence of a recorded closure of assessment at this stage led to questions about the reliability of service user data in the CareFirst system and also the outcomes for the service users. Furthermore, this may also reflected an unmet care need that will require management in the

future.

Start and end assessment dates indicate when people register for assessment and for how long. These variables can be used to calculate the length of assessment in days, see Figure 5.3. The graph illustrates a high correlation between frequency of start and end dates; 94 per cent of individuals end their assessment within the first month and almost 58.5 per cent leave the process within a week.

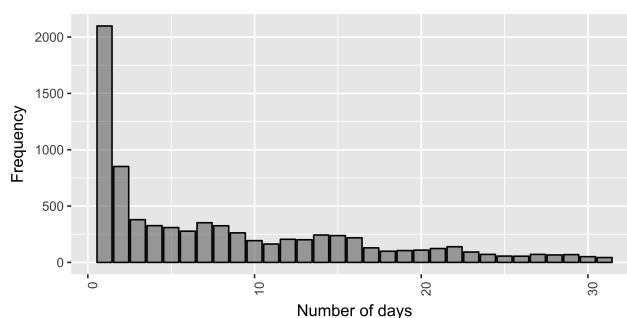


Figure 5.3: Frequency of length of provision of CA people who receive one assessment and FA as outcome form.

The data expose a relationship between assessment duration and forms of outcome. People who were assigned to FA as an outcome normally terminate the assessment within ten days, compared to slightly more than two weeks for those who were assigned to CL, despite being a larger proportion. The result also shows that 25 per cent of people with outcome of FA were assessed within a day - about 5 per cent higher than those from CL. The fact that the FA occurred earlier than a CL within the group was another unexpected finding.

This study also investigated the provision of assessments by location. Ward regions are used to display the geographical dispersal of people who receive one assessment over the period. To address low number of assessments per ward and a fluid population, frequency of records per ward was normalised by the total population per ward from the Birmingham 2011 census [94]. The colour of the area is determined by the number of people who only register for one assessment per 1,000 of the population; a darker area indicates that more people have been assessed (Figure 5.4). Note that this case study only included unique individual

records.

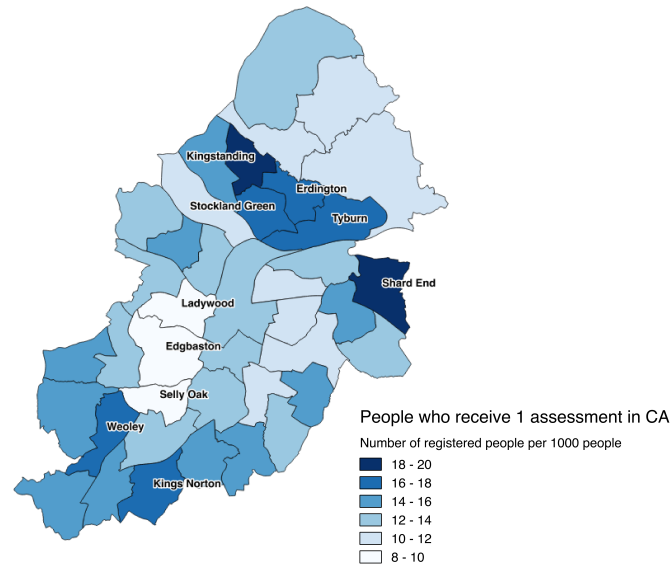


Figure 5.4: Geographical dispersal of CA people who receive one assessment across Birmingham's ward region (per 1000 population).

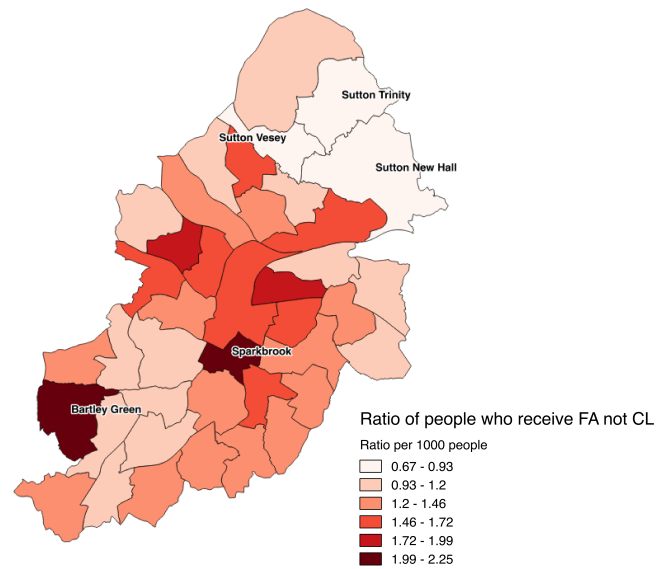


Figure 5.5: Geographical dispersal ratio of CA people who receive one assessment of FA but not CL across Birmingham's ward region (per 1000 population).

The map displays where there is only one documented response at the CA stage across the city region. A deeper analysis of the one documented response in Figure 5.4 allows the research to explore the proportion of those responses that are either stated as CL or FA in Figure 5.5. The colour of the area is determined by the ratio of outcome, FA against CL per 1,000 population; a darker area indicates that more people are assigned to FA. By identifying possible locations where FA is a significant outcome recorded, it may be possible to target these areas to better understand the reasons behind these data.

5.8 Case Study 3: Characteristics of Completed Stages

The study investigated the progress of service users through the sub-processes and the outcomes of each stage. The data showed that 11,575 people (16.42 per cent) of a total of 70,474 successfully progress through the assessment process to receive a service. However, this only accounted for 40.57 per cent of individuals at the AG stage.

The analysis maps the outcomes and corresponding assessment teams for all registered people in the assessment process (Table 5.3); Figure 5.6 displays these results as a matrix, matching outcome groups (rows) to assessment teams (columns), using the supporting data set out in Table 5.4 that determine the number of subgroups in each category. The subgroups are then reordered alphabetically, see sample at the top left sub-figure of Figure 5.7. Individuals whose information consists of two or more distinct outcomes and/or teams are excluded to avoid record bias; this accounts for only 0.8 per cent of all unique recipients.

The colour indicates the magnitude of people involved in each criteria; a darker shade represents fewer people and, in contrast, the lighter shades are graded by percentile distribution - the darkest cells denote a frequency at the (lowest) 10th percentile and the brightest cells form the 95th percentile. The

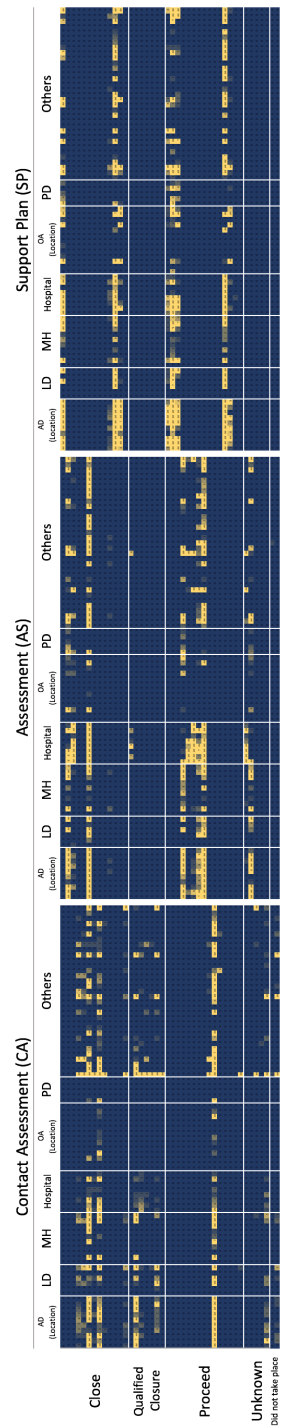


Figure 5.6: Matrix of form of outcomes (rows) against the corresponding teams (columns) in assessment process.

5. Data Continuity and the Assessment Process

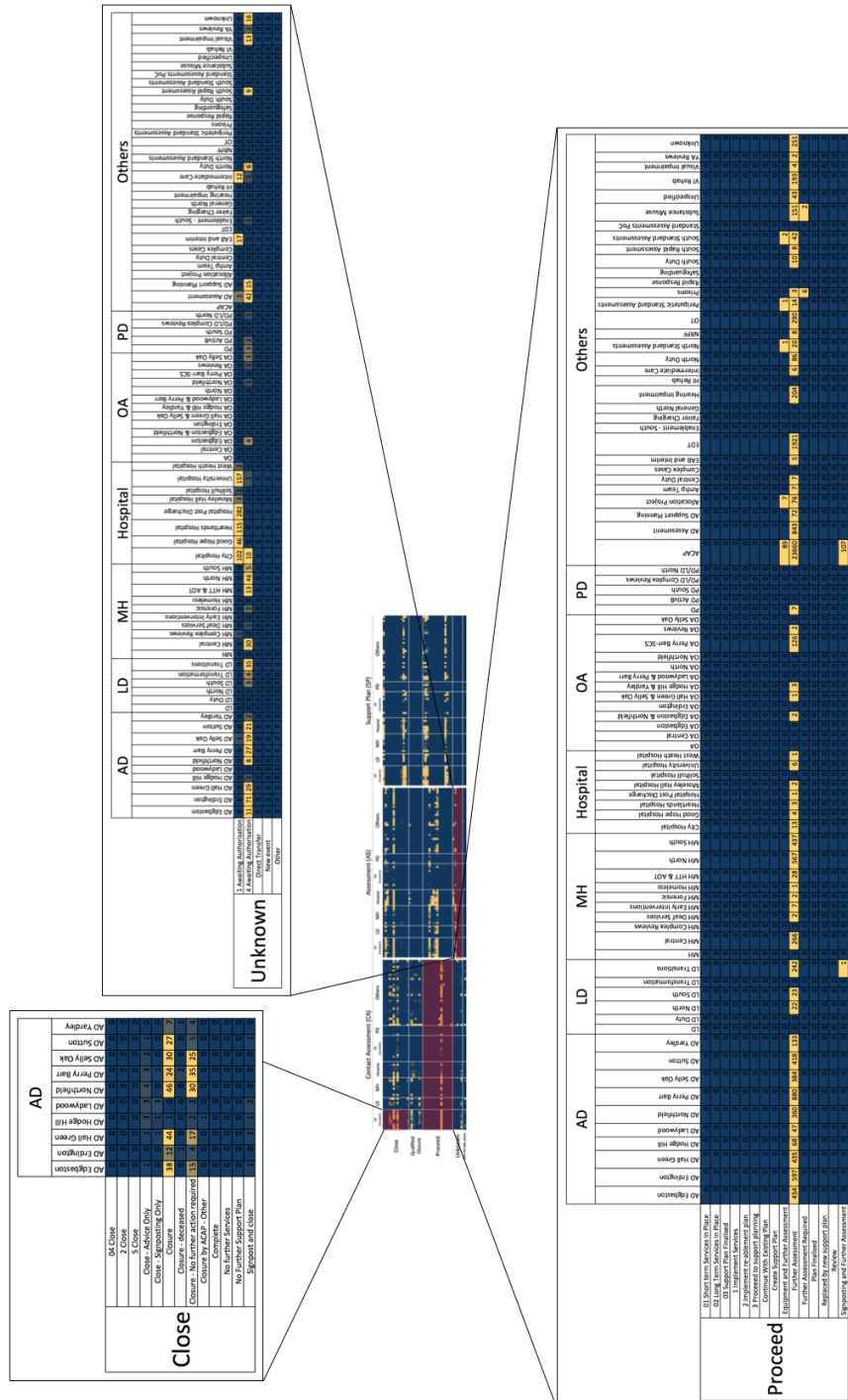


Figure 5.7: Sample (top left) and key findings (the others) within the matrix.

light grey grid in the matrix helps to distinguish the boundary of each group and aids interpretation among the sub-processes.

The representation of data in Figure 5.7 allows the researcher to focus on emerging patterns in the data at each sub-process. The top left sub-figure displays a sample of how the format and layout of the remaining matrix cells are displayed. The two key findings from the matrix are that:

1. The ‘proceed’ outcome indicates where service users require further support from the Council. The corresponding team that accounts for most of the decision-making for FA in CA is Adults and Communities Access Point (ACAP) (70.69 per cent), who initiate the CA, collect and triage users’ basic information and assign the assessment where appropriate. Further assessment of the outcomes also causes this study to reflect on the quality and the accuracy of data collection in the assessment process by the Council. Given these findings, the Council might consider reducing the number of possible assessment outcomes.
2. The ‘unknown’ outcome indicates an absence of sufficient data for an accurate determination to be made regarding the assessment. Interestingly, the matrix shows that there are significantly fewer unknown outcomes recorded in the CA process than there are in the AS process. In theory, none of the ‘unknown’ outcomes should appear at the AS stage. This is unusual, as the ‘unknown’ refers to key data that are unavailable and should have been considered at the CA part of the process. The data also show that these assignments are mostly handled by hospital-related subgroups. In contrast to the previous key finding, this potentially highlights poor nomenclature and/or miscommunication and co-ordination between social workers in different departments along the workflow from CA to AS.

Overall, the data exposed that, within each outcome group, especially in ‘close’ and ‘proceed’, many subgroups were recorded using similar headings. For

example, ‘plan finalised’ and ‘support plan finalised’ in the ‘proceed’ outcome had identical meanings. This added further evidence to Case Study 1 and the argument regarding the inconsistencies in the recording of outcomes in the system by practitioners, which required further investigation by the Council. The case study suggested merging outcomes and standardising terminology, both of which should go some way to ensuring better data collection across the assessment process.

This case study has sought to understand the flow of data through the assessment process and identify gaps among the sub-processes. The researcher believes that, by taking a data-driven approach to this topic, it will lay the foundation to better data collection and analysis, upon which better planning, budget setting and financial scrutiny can be built.

5.9 Discussion

This research seeks to examine the assessment process for adult social care in Birmingham, including the creation and collection of data, the potential outcomes for service recipients at each stage of the process and identifying possible areas for consideration that may support (or impact on) proposed financial savings. Basic knowledge and experience of social care service provisions from previous studies allow different techniques to be applied in this study. By integrating understand of the nature of information (general analysis in Chapter 3) journey within the assessment process and spatial analysis over the information (mapping with normalisation in Chapter 4) at different sub-processes, the study is able to maximise utilisation of the attributes provided in the available dataset and show how the flow of information is distributed along the assessment process (Figure 5.6).

The assessment process in Figure 5.1 shows the complexity of the data flow for a service user from referral to agreement. There are a range of possible outcomes from this process and these are impacted by the quality of the data

available at each stage, as highlighted by the existence of an excluded list that contains details of those service users for whom there are insufficient data for the Council to take any meaningful action. The three case studies highlight a range of issues facing the Council in managing and delivering services whilst attempting to meet difficult savings targets as part of the budget setting processes; the case studies also indicate that these challenges are compounded by aspects of data collection and management.

The first case study highlights that, within the data, a significant number of records appear in sub-stages of the process but have no connection to other sub-stages. This highlights that not all cases follow the predefined operational workflow and, whilst the numbers are relatively low in comparison to the whole dataset, these records highlight a risk to the service users in that it is unclear how the assessments are completed outside of the recognised process. The case study shows a possible fragmented process of co-operation and communication of departments along the sub-processes, and that practitioners may, in a significant number of cases, be using workarounds to data input. In the context of financial analysis, this highlights a significant risk to the Council achieving budgetary savings as well as their ability to plan for future demand for services.

The second case study investigates the extent to which records are complete at any sub-stage in the process. The data again highlight a significant proportion of the records as incomplete and yet no further action is recorded to have been taken. The research also identifies anomalies with regard to the higher proportion of further assessment against closure. Three-quarters of all wards in Birmingham display a higher proportion of further assessment to closure outcomes by the end of the first sub-stage of the process. Without further investigation, it is difficult to understand the reasons behind the absence of the data as well as the fragmented process. However, its potential impact upon both the service users and the Council could be significant.

The last case study considers frequency of service use. This can be crucial for future planning and commissioning of services, as well as for the development

of the social care tendering process and for third-party providers, in that this provides some certainty of the profile of service users and their needs. This study also highlights the difficulty of future budget planning for the local authority.

CHAPTER 6

Applications and Impact of Research

This chapter aims to discuss the impact of this research to the public sector and related community. It also exhibits the strength of this research in comparison to studies documented in other literature. The benefit from integrating data analytics with local government social care services data and the enhancement it provides to the decision-making processes highlight improvements that can be made to the performance of service provision. At the same time, in order to maximise the impact to the planning and process of services delivery, embedding the research outcomes and skill-set back to the Council are essential. This chapter also describes generalisability of the analyses and approaches used within this research to other local authorities.

6.1 Uniqueness of the Research

There is related literature that focuses separately upon the application and advancement of data analytics and also on the service provision of health and social care. However, to the best of our knowledge, the two domains have been examined separately up to this point in time. This might be the case because social care data contains sensitive information about care service users and how the services were being delivered to the recipients. The identification of a person could be compromised if data ethics and governance standards were not effectively employed. This could therefore impact the safeguarding of people who received the social care service from the authority. We believe this work to be unique therefore as it is the first to combine data analytic technology with government-owned sensitive social care data. The recommendations from this work have helped to improve the performance of the social care service

provision for citizens, and provide foundations for improved resource allocation and management of future plans by the authority. Furthermore, the research has helped establish new opportunities for the local government to collaborate with educational institutions to work on other data challenges and help improve governance at a city level.

6.2 Assessing Practice

This research provided analysis and recommendations for the Council to understand and approach social care services from a better perspective. The research applied analytic tools and visualisation approaches to gain new insight from the information held within the local authority. This has helped to inform and generate meaningful outcomes from existing data resources and has emphasised the value of the institutional data, especially with regard to social care. There were a number of recommendations with regard to service provision, from the assessment stage to the point at which recipients started to receive the actual service. However, some of these recommendations will require further investigation by the Council. The main objective of this research did not seek to expose or criticise practitioners or social workers, but rather focus on the use of data and show the benefit of utilising different types and methods of available technologies to support the Council in tackling specific service provisioning problems.

6.3 On-going Project

6.3.1 The Children's Trust

The Birmingham Children's Trust [14], an independent organisation which was previously run by the city Council, was established in April 2018 to help solve the problem of service provisioning and make the city a safer place for vulnerable children and younger adults to live. The Trust works closely with a number of stakeholders, from individual family and care partners to other public sector

organisations, and involves them in the decision-making process to maximise an end-result of the support to each individuals need. The ultimate goal of this project is to keep children safe, happy, healthy and to have a better living conditions.

6.3.2 Care Service Children Assessment Data

The research presented in this thesis is being used to support The Birmingham Children's Trust. Currently, our research focuses on the assessment process of children after a referral was successfully proposed in accordance with eligibility criteria of the services. In order to conduct this research, the Council extracted data where the majority of attributes are similar to that which is referred to in Chapter 5. The assessment dataset includes 21 associated variables for 774,865 assessments, relating to 63,056 unique recipients whose age is below 26, see Table 6.1.

Record	Description	Chapter 5	Children
PERID	Person ID	X	X
DOB	Date of birth	X	X
Gender	Gender status	X	X
Ethnicity	Ethnicity classification	X	X
Religion	Religion classification	X	X
Disability_Primary	Primary disability purpose	X	X
Disability_Secondary	Secondary disability purpose	X	X
Postcode	Full postcode (unit level)	X	X
ASM.ID	Assessment ID	X	X
Opened	Start date of the assessment	X	X
Completed	End date of the assessment	X	X
Code	Assessment description code	-	X
Assessment_Description	Description of assessment	-	X
Outcome	Outcome description code	-	X
Outcome_Description	Description of outcome	-	X
Authorised	Date that authorised	-	X
Responsibility_ID	Responsibility ID	-	X
Responsibility_Start	Start date of the responsibility	-	X
Responsibility_End	End date of the responsibility	-	X
Team_Code	Code of the corresponding team	-	X
Team_Name	Corresponding of assessment description	-	X

Table 6.1: Records comprising a childs assessment

6.3.3 Methodology

Unlike the top-down approach that has been used for analysing the adult social care assessment data in Chapter 5 (starting from the referrals to analysis of the assessment process), this proposed research aims to approach the problem from a bottom-up perspective. Whilst adult data was already categorised into different assessment stages, the childrens' assessment data was not recorded and as such an alternative approach was required. Therefore, analysis focused upon the identification and establishment of patterns within the data as an alternative means of categorisation. This includes the analysis of assessment description, outcome description and the corresponding team, since these attributes indicate how the service is being received by the recipients and what was the resulting outcome. For example, over a period of time, the service user may receive a statutory visit from the care leavers team before proceeding to case work supervision and eventually an assessment being recorded by the audit team. Finding such patterns within this complex data is much more complicated than the adult assessment data. This is primarily because the structure or sequence of actions could follow a very varied form at different periods in the year and may be dependent on the recipients' condition at that moment. This impacted upon the interpretation of the data and required consultation with an expert from the Council or related third party.

6.4 Embedding the Research back to BCC

This research was established from a collaboration between the University of Warwick and BCC. As part of this, the researcher was able to work as an intern data scientist at the Council for a period of one year in the department of Adult Service Commissioning and in the Department of Business and Finance. The researcher helped train internal staff in analytic and visualisation software, including R and GIS, and provide new skill sets around various analytic methods. This opportunity has demonstrated to the local authority the potential of

a data scientist role within the organisation. An awareness as to the insufficient number of skilled staff was emphasised in internal departmental reviews, and a need to be able to handle more sophisticated data modelling, statistical analysis and machine learning. This collaboration and knowledge transfer from the university to the local government has also been shown to benefit community services for vulnerable people in the East of England [79].

In the Commissioning Department, the researcher has been able to examine and explore factors that impact a recipients choice of alternative Direct Payment allowing service users to independently control and pay for the service they require. Supervised learning algorithms such as decision trees and logistic regression were utilised for categorisation among different age group of individuals. Another task focused on applying spatial analysis to identify the geographical location of direct payment service recipients throughout the city. The two outcomes helped the Council to better target specific group of recipients and improve performance of direct payment service provision. The techniques were embedded into the internal BCC office for staff to replicate the work themselves. Note that it was difficult to apply machine learning techniques in the dataset provided in the previous chapters than the data provided during internship program because i) limiting number of extracted variables and ii) the concern of privacy and safeguarding of service users when interpreting the result or publishing the work (potential ethical issues).

While working in the Business and Finance Department, the researcher had an opportunity to apply data analytic packages for data visualisation such as ‘ggplot2’ and ‘plyr’ in the R statistical software. The role in this office was to create a model to help automate the input of data, which comprised of over a hundred features of social care services. The data consisted of attributes that had been integrated from social care and financial departments and that was not similar to the data provided for this research. Notable benefits of the developed software was an ability to adapt and handle different updated versions of the input data. The software produced roughly 200 time-series analysis re-

sults from the following five given tasks: (i) Construct the result that reports primary information of service recipients such as the number of open monthly agreements for clients, the spending per week, the newly registered users and their average cost and the number of open compared to closed agreement users; (ii) Derive outcomes of average weekly cost against the frequency of external home supports' service users and graphs of weekly cost of all service subjects and client groups (subset of the subject); (iii) Identify the number of service provision as well as unique recipients that registered for service placements from out of Birmingham city; (iv) Specify the cost per week of all services and services related to hospitals in all 10 constituencies as well as the percentage change in accumulated weekly cost per area between 2015 and 2017; and (v) Analyse the different service provisioning between two age bands - 18 to 64 and above 65 - in all 10 constituencies, between 2015 and 2017.

As an intern data scientist, the position allowed the researcher to get closer to the social care service problems and generated an opportunity to work closely with experts in different departments. The consultation helped improve efficiency of the implementation process and the quality of the outcomes in order to meet the expected requirements. Note that this intern position was held between the 27th September 2016 and 27th September 2017.

6.5 Planning of Social Care Services

Social care service with prudent planning may led to a more effective way to control and manipulate provisioning, but planning with direction that targets specific vulnerable groups of individuals or emphasises particular problems may lead to more effective outcomes [107]. However, an ageing population and increased service demands have caused significant challenges for the local government. Moreover, planning has become more important for the local authority, especially when budgetary challenges have had significant impact in recent years. This has led to a reduction in the number of staff and a difficulty in resource

allocation within the organisation. In BCC, by 2021, the local government plans to spend its money more wisely over the eligible and most needed clients with best return for the cost involved, supporting the independent living of users to prevent expensive residential care and better provide alternative services from local organisations to specific service cases [19]. In more deprived city councils, including Coventry and Newcastle, there is also a problem in providing social care as the proportion of services does not meet the needs of the recipients [53].

Using a traditional methods to manage user information and the flow of data along a sometimes fragmented process has not allowed local governments to tackle more sophisticate challenges. Therefore, selecting the right tools, techniques and approaches to analyse the data to help the authorities achieve its ultimate goals is essential. This research shows the use of in-house data and results from data analytics to: Guide the government in what is required to be improved in the service provision from many perspectives and case studies; Identified the potential areas of the city council that are likely to become more vulnerable and require further investment; What process have caused bottle-necks to service provision; and many more. These emphasised the capability and importance of utilising available advanced-technology to support the local government in planning the direction of service provision in the forthcoming years.

6.6 Generalisability of the Research

The data collection process is likely to be similar across the UK's local authorities with social care responsibilities. Therefore, applying the proposed analyses and approaches to similar social care data are possible. This is dependent on how the data is being collected and stored, what attributes or variables are involved in the context of social care services within each city council, the difference in domestic regulation used in different regions of the country, and the impact of other factors from external private sectors. Outside the UK, the ser-

vice provisioning, model and architecture of the process, criterion for eligible clients and regulation regarding other aspects from the government may be different. These might depend on the demography, population profiles, quality of living, level of demand of citizens, policy and regulation, and availability of this kind of social care service provisioning of the local government.

CHAPTER 7

Conclusion and Recommendations

This research has been undertaken in association with Birmingham City Council, the largest local authority in Western Europe, and has investigated the use of technology and state-of-the-art data analytic techniques to better understand social care services provided by the Council. This research is particularly relevant given the recent period of financial austerity and the proposed changes to future service planning and provision as a result - the Council is expected to make savings of £815 million over the nine-year period 2011/12 to 2019/20. Delivering savings of this scale, whilst protecting and safeguarding the most vulnerable citizens within a growing urban population, is one of the biggest challenges for the local authority.

This research has made three contributions towards these aims:

Firstly, Chapter 3 describes the novel application of data analytic techniques that allow the past provisioning of social care services provided by the city of Birmingham to be better understood, including an investigation of the trends in the delivery of services and future demand to be forecasted. New spatial-temporal data analysis is presented and is evaluated through three case studies: An evaluation of the impact of a new contractual framework on older adults home support; An investigation of residential respite care for disabled children; and a study of care services for older adults. The research identifies and underpins new ways of integrating data analysis and visualisation with the monitoring and analysis of social care service closed agreements to support the Birmingham City Council's resource and service allocation.

Secondly, Chapter 4 shows new data-led research that connects the data and its analysis with the ongoing business planning and budget setting process

at Birmingham City Council. Three case studies are again used to illustrate this research and its value, all three of which are taken from the Council's strategic planning concerning Maximising the Independence of Adults (MIA): An evaluation of proposals to promote independent travel and reduce reliance on Council-funded transport; An investigation into internal care services, with particular reference to younger adult day care; and an inquiry into home enablement services and proposals for cost savings. The analysis demonstrates how insight can be obtained from the data, through a targeted evaluation of the data alongside historical records of service management frameworks and key council priorities and objectives.

Thirdly, Chapter 5 highlights the employment of data analytic techniques to examine the flow of information from referral through the assessment process and the resulting service provision. This contribution is again illustrated through illustrative key findings: Qualitative exploration of data-flow in the assessment process; Identifying anomalies in the assessment process; and identifying the key characteristics of stages in the data life-cycle, in order to identify opportunities for service improvement and, as a result, potential resource savings.

As we have demonstrated, there is related literature that focuses separately upon the application and advancement of data analytics and also on service provision in health- and social-care. However, to the best of our knowledge, the two domains have not received joint attention. This may be the case because social care data contains sensitive information about care service users and how the services are delivered to the recipients. The identification of a person could be compromised if data ethics and governance standards were not effectively employed.

This could therefore impact the safeguarding of people who received the social care service from the authority. We believe this work to be unique therefore as it is the first to combine data analytic technology with government-owned sensitive social care data. The recommendations from this work have helped

to improve the performance of the social care service provision for citizens, and provide foundations for improved resource allocation and management of future plans by the authority. Furthermore, the research has helped establish new opportunities for the local government to collaborate with educational institutions to work on other data challenges and help improve governance at a city level. At the time of writing this research is already having academic impact, including receiving the 2018 Best Management Paper Award at the The 19th Annual International Conference on Digital Government Research, Delft, The Netherlands. The case studies are receiving further attention at the Council, in order to maximise their impact on social care service provision and strategic planning. We are also in discussion with the Council and the newly formed Children's Trust to understand which of the approaches that we have outlined will result in most effective practical impact.

7.1 Future Research

We believe that this research offers capabilities which are not replicated in commercial tools. As such, it is possible to continue the research with more sophisticated statistical analysis methods and data analytic techniques, which could themselves be 'packaged' and made available through general release. However, the success of such an approach is dependent on the availability and format of data sources and the management of ethical concerns relating to privacy, safeguarding and data law.

Spatial-temporal analysis can be further used to analyse lower level postcodes (at the sector and unit postcode-level). This will improve the granularity and comprehension of services provided to domestic areas, to improve community-based social care and support policy making with regard to a particular problematic area. For example, in reallocating budget support from an area of low demand to one of high demand.

With the methods used in this research, the Council can better target and

filter anomalies in services - in particular services that are inconsistent in their provision over time (see Figure 3.5) and assessment outcomes that were affected from poor nomenclature (see Figure 5.7). This will further support the data collection process and potentially lead to new standards in how social care data can be collected and stored.

The analysis of other Council-owned datasets that require geographical analysis, can be performed using similar approaches to those proposed here. Integrating existing social care data with other domain datasets, such as financial, healthcare, transport, and housing, will help extend the knowledge of service provision and, significantly, the causes or effects relating to it. For example, it is suggested that variables including whether a person lives alone, the number of family members and issues within family, modes of transport available to the service users, personal or family income and the health needs of family members, will all add valuable context to current data.

The Council should investigate further the issue of data fragmentation and the procedure of human input and interaction with the internal care system by social workers and practitioners. This will enhance the decision-making and supporting processes and ultimately improve the performance of service assessments.

As this research will be embedded within the Council, it is important that the local authority starts recruiting data scientists and data analysts to maintain this level of data analysis and utilise its in-house datastore to its full capacity. We note that externalising such services will raise ethical and safeguarding issues. We formalise our research workflow in Figure 7.1 and look forward to further discussions as to how this can be most effectively put into routine practice to improve the lives of Birmingham's 1 million plus citizens

7. Conclusion and Recommendations

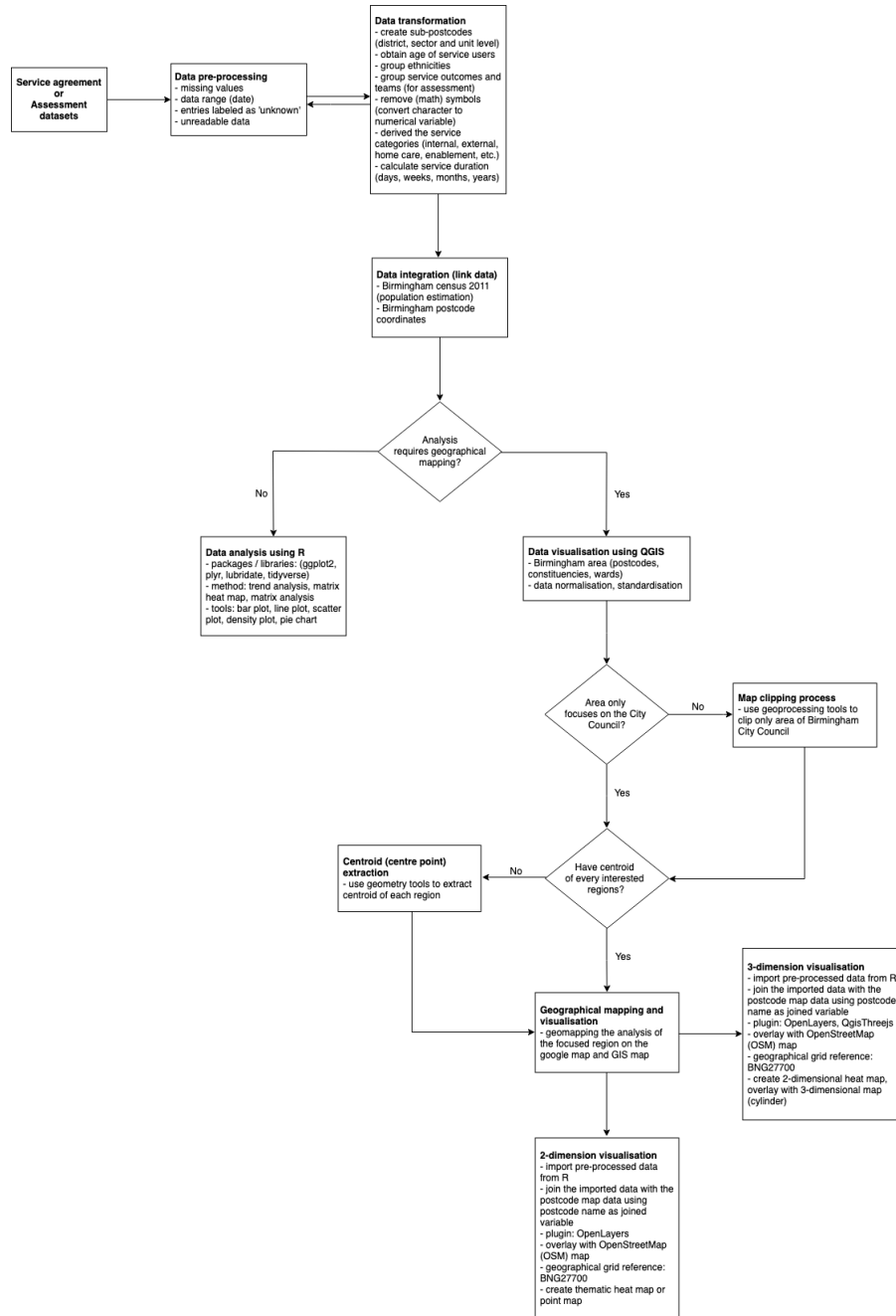


Figure 7.1: Formalisation of this research workflow.

Bibliography

- [1] M. Abendstern, J. Hughes, P. Clarkson, C. Sutcliffe, and D. Challis. 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, 2011.
- [2] ADASS. ADASS budget survey 2016 report. Technical report, London, UK, 2016.
- [3] N. Agarwal. Big data: Big benefits and imperiled privacy. PWC, June 2014.
- [4] E. Al Nuaimi, H. Al Neyadi, N. Mohamed, and J. Al-Jaroodi. Applications of big data to smart cities. *Journal of Internet Services and Applications*, 6(1):1–15, 2015.
- [5] V. Albino, U. Berardi, and R. M. Dangelico. Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology*, 22(1), 3-21 2015.
- [6] A. Anttonen and S. Jorma. European social care services: Is it possible to identify models? *Journal of European Social Policy*, 6(2):87–100, 1996.
- [7] W. B. Arthur. *The nature of technology: What it is and how it evolves*. Simon and Schuster, 2009.
- [8] Audit Commission. Improving value for money in adult social care. Technical report, London, UK, 2011.
- [9] Audit Commission. Reducing the cost of assessments and reviews: An adult social care briefing for councils. Technical report, London, UK, 2012.
- [10] G. Auditor. Adult social care in england: overview. Technical report, London, UK, 2014.

- [11] J. Baldock. Social care in old age: more than a funding problem. *Social policy & administration*, 31(1):73–89, 1997.
- [12] J. Besag and J. Newell. The detection of clusters in rare diseases. *Journal of the Royal Statistical Society. Series A (Statistics in Society)*, 154(1):143–155, June 1990.
- [13] A. Bilson and K. E. C. Martin. Referrals and child protection in england: One in five children referred to children’s services and one in nineteen investigated before the age of five. *British Journal of Social Work*, 47(3):793–811, 2016.
- [14] Birmingham Children’s Trust. Birmingham childrens trust business plan 2018 to 2023. Technical report, Birmingham, UK, 2018.
- [15] Birmingham City Council. Business plan and budget 2016+ consultation factsheets: Maximising the independence of adults. Technical report, Birmingham, UK, 2015.
- [16] Birmingham City Council. How are we doing? the local performance account for directorate for people adults’ social care services. Technical report, Birmingham, UK, 2015.
- [17] Birmingham City Council. Budget for birmingham 2016/17. Technical report, Birmingham, UK, 2016.
- [18] Birmingham City Council. Business plan and budget 2016+. Technical report, Birmingham, UK, 2016.
- [19] Birmingham City Council. Adult social care and health business plan 2017 to 2021. Technical report, Birmingham, UK, 2017.
- [20] M. Brandon, S. Bailey, P. Belderson, P. Sidebotham, C. Hawley, C. Ellis, and M. Megson. New learning from serious case reviews: a two year report for 2009-2011. Technical report, London, UK, 2013.

- [21] T. Burchardt, P. Obolenskya, and P. Vizard, editors. *Social Policy in a Cold Climate*, chapter 9, pages 187–214. CASE Studies on Poverty, Place and Policy. Policy Press, Bristol, eds. edition, April 2016.
- [22] P. Bywaters, G. Brady, L. Bunting, B. Daniel, B. Featherstone, C. Jones, K. Morris, J. Scourfield, T. Sparks, and C. Webb. Inequalities in english child protection practice under austerity: A universal challenge? *Child & Family Social Work*, pages 1–9, July 2017.
- [23] A. Caragliu, C. D. Bo, and P. Nijkamp. Smart cities in europe. *Journal of Urban Technology*, 18(2):65–82, 2011.
- [24] Care Act. *Care Act 2014*, chapter 23. The Stationery Office, London, UK, 2014.
- [25] C. P. Chen and C. Y. Zhang. Data-intensive applications, challenges, techniques and technologies: A survey on big data. *Information Sciences*, 275:314–347, 2014.
- [26] A. Clarke. How can local authorities with less money support better outcomes for older people? Technical report, York, UK, 2011.
- [27] G. Cooper, K. G. Sherlock, and M. Hoy. Method and apparatus for rate limiting. Technical Report U.S. Patent 7,917,647, McAfee LLC., California, USA, 2011.
- [28] B. C. Council. The mayor’s proposed budget 2014/15 - 2016/17, Aug. 2015.
- [29] N. C. Council. Ambition in the face of austerity: Newcastle city council’s budget proposals for 2016-17, Feb. 2016.
- [30] S. C. Council. Southampton smartcities card, Aug. 2009.
- [31] S. C. Council. Budget consultation 2016/17: Have your say, Apr. 2016.

- [32] M. Craglia, R. Haining, and P. Signoretta. Identifying areas of multiple social need: a case study in the preparation of children services plans. *Environment and Planning C: Government and Policy*, 21(2):259–276, 2003.
- [33] S. L. Cutter, J. T. Mitchell, and M. S. Scott. Revealing the vulnerability of people and places: A case study of georgetown county, south carolinarevealing the vulnerability of people and places: A case study of georgetown county, south carolina. *Annals of the Association of American Geographer*, 90(4):713–737, Dec. 2000.
- [34] C. J. Date and H. Darwen. *A guide to the SQL Standard: a User's Guide to the Standard Relational Language SQL*. 4. Addison-Wesley, The University of Michigan, 1989.
- [35] Department of Health. A vision for adult social care: Capable communities and active citizens. Technical report, London, UK, 2010.
- [36] Department of Health. Personalised commissioning in adult social care. Technical report, London, UK, 2016.
- [37] B. C. C. S. S. Directorate. Digital birmingham, Aug.
- [38] C. Dwork. Differential privacy. *ICALP'06: Proceedings of the 33rd international conference on Automata, Languages and Programming - Volume Part II*, July 2006.
- [39] J. S. Ernst. Mapping child maltreatment: Looking at neighborhoods in a suburban county. *Child Welfare*, 79(5):555–572, Oct. 2000.
- [40] A. Evers, J. Lewis, , and B. Riedel. Developing child-care provision in england and germany: Problems of governance. *Journal of European Social Policy*, 15(3), Aug. 2005.
- [41] J.-L. Fernandez, T. Snell, and G. Wistow. Changes in the patterns of

- social care provision in england: 2005/6 to 2012/13. Technical report, London, UK, 2013.
- [42] D. Fisher, R. DeLine, M. Czerwinski, and S. Drucker. Interactions with big data analytics. *Interactions*, 19(3):50–59, 2012.
- [43] R. Florida and G. Gates. Technology and tolerance: The importance of diversity to high-technology growth. In *The city as an entertainment machine*, pages 199–219. Emerald Group Publishing Limited, 2003.
- [44] S. for Social Care Research. National seminar - social care research: Status 2010 - proceedings, Nov. 2010.
- [45] S. for Social Care Research. Supporting the future of social care through research: Annual report 2010/11. Technical report, London, UK, 2010.
- [46] M. Foster, J. Harris, K. Jackson, and C. Glendinning. Practitioners’ documentation of assessment and care planning in social care: The opportunities for organizational learning. *The British Journal of Social Work*, 38(3):546–560, Apr. 2008.
- [47] J. Glasby, R. Miller, and C. Needham. Adult social care. In L. Foster, A. Brunton, C. Deeming, and T. Haux, editors, *In Defence of Welfare 2*, pages 94–97. Social Policy Association, London, 2011.
- [48] C. Glendinning. Home care in england: Markets in the context of underfunding. *Health & Social Care in the Community*, 20(3):292–299, Feb. 2012.
- [49] J. Godwin. Better data will help early intervention teams protect vulnerable children, Dec. 2013.
- [50] E. M. Goldberg and R. W. Warburton. *Ends and Means in Social Work: The Development of Outcome of a Case Review System for Social Workers*. George Allen and Unwin, Crows Nest, Australia, 1980.

- [51] M. J. Guralnick. Effectiveness of early intervention for vulnerable children: A developmental perspective. *American Journal on Mental Retardation*, 102(4):319–345, 1997.
- [52] R. E. Hall, B. Bowerman, J. Braverman, J. Taylor, H. Todosow, and U. Von Wimmersperg. The vision of a smart city. Technical report, Brookhaven National Lab., Upton, NY (US), 2000.
- [53] A. Hastings, N. Bailey, G. Bramley, and M. Gannon. Austerity urbanism in england: The 'regressive redistribution' of local government services and the impact on the poor and marginalised. *Environment and Planning A*, 49(9):2007–2024, 2017.
- [54] S.-A. Hazlett and F. Hill. E-government: the realities of using it to transform the public sector. *Managing Service Quality: An International Journal*, 13(6):445–452, 2003.
- [55] L. Hernandez-Munoz, G. Feldman, V. Javidroozi, A. King, and R. Mack. Transforming birmingham city with smart applications. *International Journal of Conceptual Structures and Smart Applications (IJCSSA)*, 4(2):16–37, 2016.
- [56] HM Treasury. Spending review 2010. Technical report, London, UK, 2010.
- [57] R. Hollands. Will the real smart city please stand up? intelligent, progressive or entrepreneurial? *City*, 12(3):303–320, 2008.
- [58] R. Hollands, P. Chatterton, B. C. Byrnes, C. Read, and G. Leeds. The london of the north? youth cultures, urban change and nightlife in leeds. 2004.
- [59] R. Hood, A. Goldacre, R. Grant, and R. Jones. Exploring demand and provision in english child protection services. *The British Journal of Social Work*, 46(4):923–941, June 2016.

- [60] HSCIC. Personal social services: Expenditure and unit costs, england - 2014-15, final release. Technical report, Leeds, UK, 2015.
- [61] R. Humphries. Social care funding and nhs: An impending crisis? Technical report, London, UK, 2011.
- [62] R. Humphries, R. Thorlby, H. Holder, P. Hall, and A. Charles. Social care for older people: home truths. Technical report, London, UK, 2016.
- [63] R. Ihaka and R. Gentleman. R: A language for data analysis and graphics. *Journal of Computational and Graphical Statistics*, 5(3):299–314, 1996.
- [64] J. Iparraguirre. Reductions in local government spending on community-based social care and unmet social care needs of older people in england. *The Journal of the Economics of Ageing*, pages 1–12, 2017.
- [65] R. L. Kane and R. A. Kane. Assessing older persons: Measures, meaning, and practical implications. Technical report, New York, USA, 2011.
- [66] D. King and R. Wittenberg. Data on adult social care - improving the evidence base for adult social care practice. Technical report, London, UK, 2015.
- [67] K. Kourtit and P. Nijkamp. Smart cities in the innovation age. *Innovation: The European Journal of Social Science Research*, 25(2):93–95, 2012.
- [68] S. La Valle, E. Lesser, R. Shockley, M. S. Hopkins, and N. Kruschwitz. Big data, analytics and the path from insights to value. *MIT Sloan Management Review*, 52(2):21–32, 2011.
- [69] M. Langford and G. Higgs. Measuring potential access to primary health-care services: The influence of alternative spatial representations of population. *The Professional Geographer*, 58(3):294–306, May 2006.
- [70] J. Le Grand, A. Wood, and T. I. Report to the secretary of state for education and the minister for children and families on ways forward for

- childrens social care services in birmingham. Technical report, London, UK, 2014.
- [71] W. Lea. *Care Act 2014*. Section 6: Care and Support Statutory Guidance: Issued Under the Care Act 2014. The Stationery Office, London, UK, 2014.
- [72] C. Leadbeater, J. Bartlett, and N. Gallagher. Making it personal. Technical report, London, UK, 2011.
- [73] J. Lewis and A. West. Early childhood education and care in england under austerity: Continuity or change in political ideas, policy goals, availability, affordability and quality in a childcare market? *Journal of Social Policy*, 46(2):331–348, Apr. 2017.
- [74] Local Government Association. Transforming local public services: using technology and digital tools and approaches, June 2014.
- [75] Local Government Association. Adult social care funding: 2016 state of the nation report. Technical report, London, UK, 2016.
- [76] M. Lymbery. Austerity, personalisation and older people: The prospects for creative social work practice in england. *European Journal of Social Work*, 17(3):367–382, 2014.
- [77] J. Malley and J.-L. Fernández. Measuring quality in social care services: Theory and practice. *Annals of Public and Cooperative Economics*, 81(4):559–582, Nov. 2010.
- [78] F. Malomo and V. Sena. Data intelligence for local government? assessing the benefits and barriers to use of big data in the public sector. *Policy & Internet*, 9(1), Mar. 2017.
- [79] M. Manning and A. Toderas. The benefit of predictive analytics in councils, Aug. 2017.

- [80] J. Manyika, M. Chui, B. Brown, J. Bughin, R. Dobbs, C. Roxburgh, and A. H. Byers. Big data: The next frontier for innovation, competition, and productivity. Technical report, USA, 2011.
- [81] B. McCormack, E. A. Mitchell, G. Cook, J. A. N. Reed, and S. Childs. Older persons’ experiences of whole systems: The impact of health and social care organizational structures. *Journal of Nursing Management*, 16(2):105–114, 2008.
- [82] J. Milner, S. Myers, and P. O’Byrne. *Assessment in Social Work*, chapter 11. Assessment in Adults’ Services. Palgrave, Basingstoke, UK, 4 edition, 2015.
- [83] Minister of State for the Cabinet Office and Paymaster General by Command of Her Majesty. Open data white paper: Unleashing the potential. 2012.
- [84] E. R. Munro, R. Brown, and E. Manful. Safeguarding children statistics: The availability and comparability of data in the uk. Technical report, London, UK, 2011.
- [85] F. Nelli. *Python Data Analytics*, volume 1st. ACM, 2015.
- [86] NHS Digital. Community care statistics, social services activity, england 2009-2010. Technical report, London, UK, 2011.
- [87] NHS Digital. Community care statistics: Social services activity, england 2013-2014. Technical report, London, UK, 2014.
- [88] NHS Digital. Community care statistics: Social services activity, england 2015 to 2016. Technical report, London, UK, 2016a.
- [89] NHS Digital. Personal social services: Expenditure and unit costs, england 2015 to 2016. Technical report, London, UK, 2016b.
- [90] H. of Parliament. The care and support (eligibility criteria) regulation 2014: Social care, england. Technical report, London, UK, 2014.

- [91] Ofsted. Ofsted: Raising standards improving lives 2012-2013. Technical report, Manchester, UK, 2013.
- [92] Ofsted. The impact of funding reductions on local authorities. Technical report, London, UK, 2014.
- [93] Ofsted. Birmingham re-inspection of services for children in need of help and protection, children looked after and care leavers. Technical report, Manchester, UK, 2016.
- [94] ONS. 2011 census: Key statistics for Birmingham and its constituent areas: Ks101 usual resident population. Technical report, London, UK, 2013.
- [95] ONS. National population projections: 2014 - based statistical bulletin. Technical report, London, UK, 2015.
- [96] ONS. The English indices of deprivation 2015-statistical release. Technical report, London, UK, 2015a.
- [97] ONS. Population estimates: analysis tool, June 2017.
- [98] T. O’Sullivan. *Decision making in social work*. Palgrave, Basingstoke, UK, 2011.
- [99] F. Pedregosa, G. Varoquaux, A. Gramfort, V. Michel, B. Thirion, O. Grisel, M. Blondel, P. Prettenhofer, R. Weiss, V. Dubourg, and J. Vanderplas. Scikit-learn: Machine learning in python. *Journal of Machine Learning Research*, 12:2825–2830, oct 2011.
- [100] D. Rhind. Drowning in data: who and what can we trust? 2014.
- [101] M. Rodrigues, C. Bonfim, J. L. Portuga, I. G. D. Gurge, and Z. Medeiros. Using spatial analysis to identify areas vulnerable to infant mortality. *Rev Panam Salud Publica*, 34(1):36–40, July 2013.
- [102] L. Santhanam. Can big data save these children?, Mar. 2016.

- [103] C. Slasberg, P. Beresford, and P. Schofield. How self directed support is failing to deliver personal budgets and personalisation. *Research, Policy and Planning*, 29(3):161–177, 2012.
- [104] C. Slasberg, P. Beresford, P. Schofield, and E. Harlow. The increasing evidence of how self-directed support is failing to delivery personal budgets and personalisation. *Research, Policy and Planning*, 30(2):91–105, 2013.
- [105] H. Slattery. Big data wave breaks on child protective services, Apr. 2015.
- [106] O. C. Study. Digital government strategies for transforming public services in the welfare areas. Technical report, Paris, France, 2016.
- [107] T. Symons. Datavores of local government: Using data to make services more personalised, effective and efficient, July 2016.
- [108] T. Symons. Wise council: Insights from the cutting edge of data-driven local government, Nov. 2016.
- [109] A. Tat-Kei Ho. Reinventing local governments and the e-government initiative. *Public administration review*, 62(4):434–444, 2002.
- [110] Team R. *R: A Language and Environment for Statistical Computing*. Citeseet, 2013.
- [111] The Guardian. Census 2016: Australians who don’t complete form over privacy concerns face fines, July 2016.
- [112] The Kings Fund. The budget: Health and social care funding. Technical report, London, UK, 2015.
- [113] N. Thomas and B. Percy-Smith. ‘it’s about changing services and building relationships’: evaluating the development of children in care councils. *Child & Family Social Work*, 17(4):487–496, 2012.
- [114] A. Turnpenny and J. Beadle-Brown. Use of quality information in decision-making about health and social care services a systematic re-

- view. *Health and Social Care in the Community*, 23(4):349–361, July 2015.
- [115] B. Ubaldi. Open government data: Towards empirical analysis of open government data initiatives. *OECD Working Papers on Public Governance*, (22):1–60, May 2013.
- [116] United Nation. World urbanization prospects: The 2018 revision. Technical report, New York City, USA, 2018.
- [117] R. Vaithianathan, T. Maloney, N. Jiang, I. De Haan, C. Dale, E. Putnam-Hornstein, T. Dare, and D. Thompson. Vulnerable children: Can administrative data be used to identify children at risk of adverse outcomes. *Report Prepared for the Ministry of Social Development. Auckland: Centre for Applied Research in Economics (CARE), Department of Economics, University of Auckland*, 2012.
- [118] I. L. Valle, L. Holmes, C. Gill, R. Brown, D. Hart, and M. Barnard. Improving children’s social care services: Results of a feasibility study. Technical report, London, UK, 2016.
- [119] S. Walker and C. Beckett. Social work assessment and intervention. *Russell House Russell House*, 2003.
- [120] L. Wenzel, L. Bennett, S. Bottery, R. Murray, and B. Sahib. Approaches to social care funding - social care funding options. Technical report, London, UK, 2018.
- [121] D. M. West. E-government and the transformation of service delivery and citizen attitudes. *Public administration review*, 64(1):15–27, 2004.
- [122] H. Wollmann, I. Koprić, and G. Marcou. *Public and social services in Europe: From public and municipal to private sector provision*. Springer, 2016.

- [123] C. Yiu. The big data opportunity: Making government faster, smarter and more personal. Technical report, London, UK, 2012.
- [124] H.-L. Yu, C.-H. Yang, and L.-C. Chien. Spatial vulnerability under extreme events: A case of asian dust storm's effects on children's respiratory health. *Environment International*, 54:35–44, Feb. 2013.
- [125] M. Zamfir. Personalisation through personal budgets: Its effectiveness for older adults in social care services. findings from an english-based literature review. *Research, Policy and Planning*, 30(2):77–89, 2013.