TRAJECTORY AND SEQUENCE ANALYSIS OF ADMINISTRATIVE DATA

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Declaration of originality

The work on thesis is of my own and all else is appropriately referenced. From the research, we were able to derive articles which have been published and also those that are submitted for publication in peer-reviewed journals. The co-authors of these papers were my supervisors. Professor Ara Darzi provided input in drafting the research proposal. Dr Alex Bottle helped in my training of statistical modelling and analysis. Professor Paul Aylin and Dr Alex Bottle helped me in planning the study design, conducting analysis, and editing the manuscripts. Mr Collin Bicknell, a consultant vascular surgeon, was also involved in the studies evaluating abdominal aortic aneurysm (AAA) patients. He participated in data analysis and editing of the manuscripts on the AAA patients.

Copyright declaration

Abstract

Health policy makers struggle to curb readmission rates despite various health policies. The National Health Service is spending more than half of its healthcare budget to manage emergency inpatient admissions. There is a subgroup of patients who use disproportionately more health resources and have higher rates of unplanned hospitalisation. They are defined as high-impact users. The characteristics and long-term healthcare use of high-impact users are poorly understood. Previous methods and models to identify and predict them have not performed well. More evidence is required to assess the causes of emergency admissions among them and to investigate whether they undergo a repeated cycle of similar events that trigger their long-term use of healthcare.

Trajectory modelling and sequence analysis has been used in social and psychological sciences to understand changes in behaviour in the population. It has shown to have an advantage to categorise pupils based on common developmental pathways, and identify the chronological order of events in the life of the pupils. The hypothesis of the research is that trajectory modelling and sequence analysis can be applied to epidemiological administrative data to assess use of hospital care among high-impact users. Trajectory and sequence analysis was successfully applied to various patient cohorts with different medical conditions, using both hospital and primary care administrative datasets.

Within each population cohort, discrete groups of patients with independent trends of hospital care use were identified. High-impact users accounted for a significant proportion of the patient population. They had persistently high readmission rates. Significant predictors associated with high-impact users were identified. High-impact users had worse outcomes than the rest of the patient population. They had distinct common sequences of causes of readmissions compared with other groups. Cardiopulmonary conditions were the main contributors to the sequences of readmissions among high-impact users in all patient populations.

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'In the name of Allah, The Most Gracious, The Most Merciful' (Quran 27:30)

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Regional analysis of high-impact health service users among heart failure patients in England. Rao A, Dani K, Majeed A, Darzi A, Aylin P, Bottle A. Submitted to BMJ Safety and Quality

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Regional analysis of high-impact health service users among heart failure patients in England. Rao A, Dani K, Majeed A, Darzi A, Aylin P, Bottle A. HSR UK (Health Services Research), Nottingham, 04-05 July 2018

Abbreviations

AAA	Abdominal Aortic Aneurysm
AF	Atrial Fibrillation
AUC	Area Under Curve
BIC	Bayesian Information Criteria
BNP	B-type natriuretic peptide
CMS	Centers for Medicare and Medicaid Services
COPD	Chronic Obstructive Pulmonary Disease
CPRD	Clinical Practice Research Datalink
DTP	Diphtheria-Tetanus-Pertussis
EVAR	Endovascular Aneurysm Repair
GBTM	Group-Based Trajectory Modelling
GP	General Practitioner
GP	General Practitioner
HAC	Hospital Associated Condition
HDU	High Dependency Unit
HES	Hospital Episode Statistics
HF	Heart Failure
HTMV	High Titre Measles Vaccine
ICD-10	International Classification of Diseases version 10
ICH	Intra-cranial haemorrhage
IHD	Ischaemic heart disease
IMT	Intima Media Thickening
IPV	Inactivated Poliovirus Vaccine
ITU	Intensive Therapy Unit
LOS	Length of Stay
MI	Myocardial infarction
NHS	National Health Service
OCC	Odds of Correct Classification
ONS	Office of National Statistics
OPCS 4.7	Office of Population Censuses and Surveys Classification of Interventions and Procedures version 4.7
OR	Odds Ratio
PP	Posterior probability
PPR	Potentially preventable readmissions
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
rAAA	Ruptured Abdominal Aortic Aneurysm
RCT	Randomised Controlled Trial
ROC	Receiver Operator Characteristics
SAH	Sub-arachnoid haemorrhage
SAS	Statistical Analysis Software
TIA	Transient Ischaemic Attack

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Equations

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Chapter 1. Introduction

1.1 Overview

This chapter explains the reason for conducting this research and the need to apply trajectory and sequence analysis to public administrative data. Various efforts have been made to reduce readmission rates, but the number of emergency hospital admissions is rising. The National Health Service is spending more than half of the healthcare budget to manage emergency inpatient admissions. There is a subgroup of patients who use most of the health resources and are at a high risk of readmission. These patients with higher rates of unplanned hospitalisations are defined as high-impact users. The NHS has recommended that programs and interventions should be targeted on these patients to reduce readmission rates in patient populations. However, characteristics and long-term healthcare use of high-impact users are poorly understood. Previous methods and models to identify and predict them have not performed well. More evidence is required to assess the causes of emergency admissions among them and if they undergo repeated cycle of similar events that trigger their long-term use of healthcare. I adapted trajectory and sequence analysis methods from other science fields to identify and predict high-impact users, visualise their trends in healthcare use and sequence of common adverse events. I selected patients with cerebrovascular conditions and abdominal aortic aneurysm repair to apply trajectory and sequence analysis to medical and surgical cohort of patients respectively. Patients with heart failure were selected to apply trajectory and sequence analysis to primary care data.

MOST OF THE HEALTH BUDGET IS SPENT ON MANAGING EMERGENCY HOSPITAL ADMISSIONS

Health policy makers and institutions struggle to curb readmission rates despite various local and regional policies.(1) In the UK, the National Health Service (NHS) spends £2.2 billion to treat 6.5% of the patient population that are readmitted within 30 days of discharge from hospital.(1) Patients who undergo repeated emergency hospital admissions also have higher rates of elective hospital admissions.(2) A significant proportion of patients require repeated hospital admissions and spend a significant time in the hospital annually.(3-5) For example, it is estimated that 20-27% of the stroke patients are readmitted during the first year after being diagnosed with the condition.(3,4,6)

Recurrent admissions to hospital had been associated with decline in functional health of elderly patients, regardless of the cause of admission and complete recovery from the operation.(7) It was shown that 75% of elderly patients who were hospitalised did not return to their baseline functional status and 15% of them were discharged to nursing home. During hospitalisation, multiple factors interact to undermine functional health(7). It was proposed that immobilisation can cause deconditioning of muscle, accelerated bone loss, functional incontinence, and pressure sores – these factors increased the risk of fall and fracture. Simultaneously, decreased plasma volume due to vasomotor instability, decreased ventilation, dehydration, malnutrition and sensory deprivation can lead to infection and delirium. The persistence of these factors significantly impairs functional health of elderly patients with limited body reserves who have prolonged length of stay in the hospital. As a consequence, patients are at a high risk of being transferred to nursing homes.(8)

Various efforts have been made to reduce readmission rates.(9) The programs to decrease readmission rates have focused on discharge planning and the community support of the discharged patients.(6,10) They have been conducted at a local level and implemented on all patients including those who were stable with very low risk of readmission to the hospital.(11,12) Discharge planning ensures appropriate measures set in place for the patient's easy transition from the hospital to their residence.(9) It may also include comprehensive geriatric assessment of the patients as well as educating them and their families about their condition. A visit by a specialist nurse or a care manager, follow-up by a telephone call or other means of communication via occupational therapist or community workers are examples of support provided after discharge.(9)

Despite various community management programs, the number of emergency hospital admissions is rising.(13) In 2006, a White Paper was published to expand case management approach as well as other community-based programs to curb down readmission rate.(13) There have been conflicting reviews of the efficacy of case and disease management programs to reduce readmission rates.(14,15) Many of the interventions fail to significantly improve the health status of these patients and reduce total cost of care.(1,16) The health measures were applied when patients were already experiencing rapid health decline, and it was too late to intervene.(11) Also, the programs have been resource intensive as they

HIGH-IMPACT USERS ARE THOSE WITH HIGH UNPLANNED READMISSION RATES AND UTILISE 2/3RD OF THE TOTAL COST OF HEALTHCARE

require integration of services from various health professionals, training of staff and large investments for administrative structure build-up.(11)

It has been strongly recommended that these interventions should be targeted at those subgroups of patients who use most of the health resources and are at a high risk of readmissions, commonly known as the high-impact users.(12) High-impact users have been defined as those patients with higher rates of unplanned hospitalisations.(13) They are shown to utilise as much as two-thirds of the healthcare resources.(17) The risk profiling of the patient population to identify these patients provide health policymakers an opportunity to plan an optimum and individualised patient care. They can allocate appropriate resources, analyse trends in the health status of a population, and find the risk factors that can be modified to prevent decline in the health status at a population level.(1) NHS England (National Health Service) suggested recognising high-risk patients as early as possible to improve 'impactibility' of interventions.(18) It emphasised on the need for a better risk stratification model that can be applied to a large patient population, is continuously able to assess changes in the use of healthcare by the subgroups of the patient population, and is cost-effective.(18) The model should be similar to a screening program that can identify these patients and the preventable risk factors to allow affordable and timely interventions and prevent them from entering a vicious cycle of adverse events.(18) The proposed model characteristics are mentioned in table 1. To attain these features, a methodology is required that can identify risk factors and foresee these high-impact patients with strong predictive power.(18) Further research is required to understand the trends of hospital care usage among high-impact users, the sequence of events involved in their high readmission rate and to evaluate whether simple and proven measures can prevent these adverse events.(19-21)

NHS recommendation for Risk Stratification
Event: important health condition
Accepted intervention for identified patients
Sufficient time for intervention
Accurate predictive risk model
Model should apply to a large population
Policy regarding who should be offered intervention
Natural history of adverse events should be understood
Economically balanced
Continuous process

Table 1. Suggestive features of risk stratification model (https://www.england.nhs.uk/wp-content/uploads/2015/01/nxt-steps-risk-strat-glewis.pdf)

MANAGEMENT PROGRAMS SHOULD BE TARGETED TO HIGH-IMPACT USERS, BUT IMPROVEMENT IN METHODOLOGY IS REQUIRED TO IDENTIFY AND PREDICT THEM. FURTHER RESEARCH IS REQUIRED TO ASSESS IF THESE PATIENTS HAVE DISTINCT SEQUENCE OF SIMILAR EVENTS

The classification and assessment of changes in the frequency of hospital care use among high-impact users has been arbitrary and variable with no standard methodology.(22,23) In previous studies, patients are broadly categorised into two groups: high- and low-impact users.(13) The main focus of the previous studies was to identify predictive factors associated with high readmission rate in general patient population by conducting logistic regression model analysis.(1,13,23) However, these models have not performed well in predicting high-impact users.(13,16,24,25) They only measured change over two-time points and had limited ability to assess dynamic developmental changes over time.(26) T-test, ANOVA and multiple regressions are common statistical tests used in clinical studies. They assess change over a specified time and are not used to study long term trends of outcomes.(26) Cluster analysis is used to classify population into subgroups, however, it only performs cross-sectional analysis and it does not focus on identifying risk factors associated with each group.(27,28) Most of the studies do not follow patients for long-term.(20,25,29,30)

Secondly, it is imperative to understand the natural history of adverse events that lead to higher rates of readmissions in patients.(18,19,31) Since 2010, if the observed readmission rate is higher than expected then hospitals in the US are penalised and receive reduced payment reimbursements.(32) It is assumed that the higher readmissions are the result of poor quality of patient care. By improving hospital care, discharge planning and care transition into the community, the health trusts should be able to reduce readmission rates.(31) However, not all readmissions are avoidable.(33) Previous studies have documented a variable proportion of general patient population undergoing avoidable readmissions, ranging from 5% to 79%.(33) There is, however, still a need to evaluate the causes of avoidable readmissions in the high-impact group and see if they differ from those of low-impact users.

Understanding the chronological order and the sequence of the causes of readmissions may help us assess any repeated chain of events that lead to an increased use of hospital care by high-impact users. Previous studies have shown that the temporal order of events have significant impact on the outcomes of the patients.(19) For example, incidence of heart failure following atrial fibrillation was shown to be associated with a higher mortality rate compared to those patients who were diagnosed with atrial fibrillation after heart failure.(34) In another study, pneumonia patients had poor prognosis if there was resolution of blood pressure and temperature before other symptoms.(19) Similarly, it has also been revealed that a particular sequence of vaccination that is measles vaccination followed by DTP (diphtheria-tetanus-pertussis) or IPV (inactivated polio vaccine), was an important determinant of a higher mortality rate in female infants.(35) So far, the association of

distinct and common sequences of causes of readmissions with the increased hospital use is not certain. Further evaluation is also required to identify common avoidable conditions that lead to hospital admissions in high-risk patients.

It may be that a common and repetitive series of complications indicate a decline in health status of the patient due to a 'snowball' effect and resulting in becoming a high-impact user (*Figure 1*). There is a gradual decline of body reserve function with usual ageing process; however, chronic condition accelerates it.(36) The elderly patient may be able to function independently despite decline in body reserve function, but one becomes more vulnerable to disability if acute insult to the body occurs. The acute event could be an infection, physical and psychological trauma, or aggressive progression of chronic condition. The acute insult, which is significant enough to cause hospitalisation, leads to functional decline where the patient may or may not recover. The phenomenon of functional decline impinges on a vicious cycle of immobility, which may be due to any reason, and decrease in muscle mass causing deconditioning.(37) The hospital stay leads to further functional decline, and if it persists longer, it can result in frailty, which causes further immobility and sarcopenia. With more adverse events, the process of decline speeds up, and does not give any chance to the patient to recuperate, and eventually leads to death.(38)

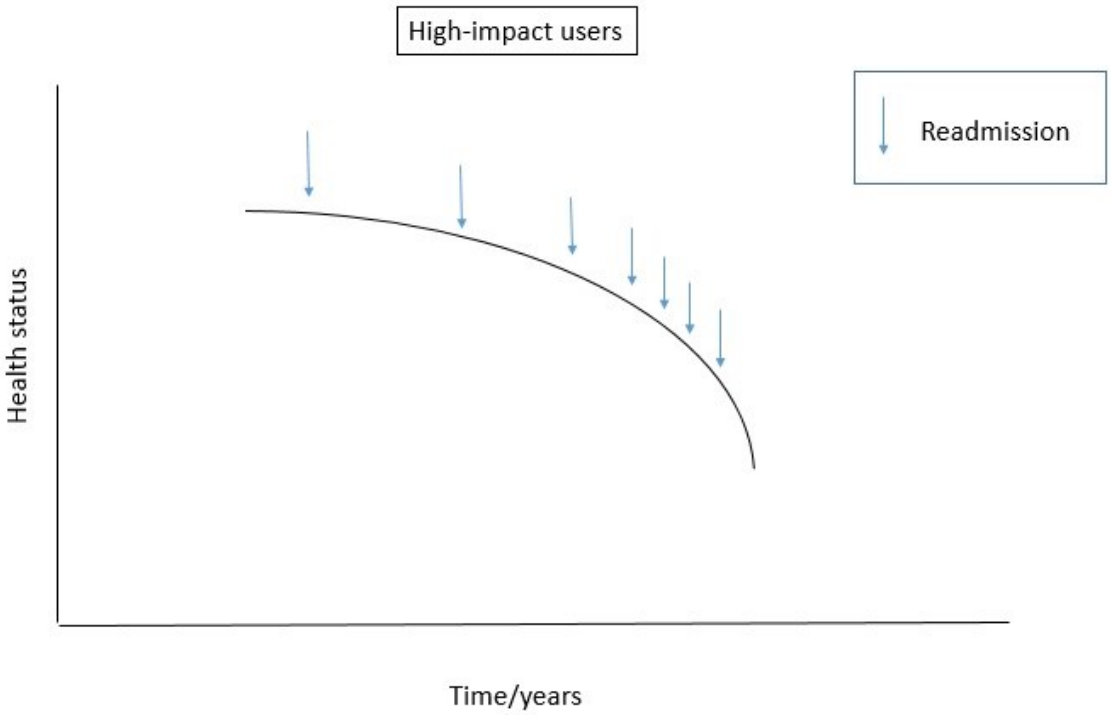


Figure 1. The effect of readmissions on the health status of the high-impact user

Group-based trajectory modelling (GBTM) has been used in social and psychological sciences to understand changes in behaviour in the population and categorise pupils based on common developmental pathways.(39,40) This growth model is novel in medical research but can be used to study variation in the long-term progression of the disease and its impact on the use of healthcare resources.(21) This model can identify subgroups in the population with similar progression of outcomes and recognise the covariates associated with each group.(40) Similarly, sequence analysis is a well-established technique in social science and criminology that helps understand the chronological order of events in the life of the pupils.(41) It has been used to study population behaviour and assess the sequence of events related to the adverse outcomes. It can cluster and visualise common sequence of events in the population.(42) We have not come across studies that have analysed temporal sequence of causes of readmissions in the high-impact users by using hospital administrative data. The studies evaluating causes of readmissions with the use of hospital administrative data have merely searched for the common causes of readmission.(43,44)

GROUP-BASED TRAJECTORY MODELLING (GBTM) AND SEQUENCE ANALYSIS HAS BEEN USED IN SOCIAL AN D PSYCHOLOGICAL SCIENCES TO STUDY CHANGES IN BEHAVIOUR OF POPULATION .RECENT MEDICAL STUDIES HAVE STARTED TO USE THEM TO ASSESS CLINICAL OUTCOMES.

Administrative data has been used in epidemiological studies to understand various aspects patient care pathways, impact of an intervention or health policy on the patients' outcomes and use of healthcare resources with a pragmatic approach.(1,13,45,46) Administrative data offers 'systemwide information about health conditions and services in a consistently coded format'.(47) It is primarily collected for billing purposes, but it can be used for research.(48) Recall of patients does not bias the data collection as in self-reported surveys.(48) The hospital administrative data has been used in recent years to study various aspects of patient care.(46,49-57) Hospital readmission rate and other use of health care resources has been studied in different patient cohorts using administrative dataset. However, the data is a gross compilation of hospital admissions or other services used by the patients.(11,44,57-65) In most studies, it has been used to estimate a general overview of readmission rate with cross-sectional approach and recorded observation of patients for 30 days.(22,44,56-59,66-69) The application of trajectory modelling and sequence analysis to the administrative data can provide an opportunity to review a large cohort of patients, convert the data to

ADMINISTRATIVE IS BILLING DATA THAT CAN BE USED TO STUDY TRENDS IN OUTCOME AMONG LARGE COHORT OF PATIENTS WITH PRAGMATIC APPROACH.

longitudinal series, follow-up patients for longer period, assess their trends of healthcare use, and understand the natural history of adverse events during their lifetime. (43) Hospital readmission is commonly available information in the hospital administrative data.(50) The data provides information on causes of readmissions for preventable complications, based on ICD discharge coding, which is shown to be valid and sensitive.(50,70)

1.2 Hypothesis of the study

The hypothesis of the research is that trajectory modelling and sequence analysis can be applied to administrative data to assess use of hospital care among high-impact users.

1.3 The aims of the research are:

1. Review previous literature on the methodologies used to identify high-impact users
2. Apply trajectory modelling to administrative datasets to identify and predict high-impact users
3. Apply sequence analysis to administrative datasets to identify common sequences of hospital admissions linked to high-impact users

1.4 The objectives of the research are:

1. Review of previous literature on the characteristics of high-impact users and the use of trajectory and sequence analysis to study them.
2. Identification and prediction of high-impact users among medical and surgical patients by applying trajectory modelling to hospital administrative data
3. Identification of common and distinct sequences of causes of readmissions among high-impact users in medical and surgical patients by applying sequence analysis to hospital administrative data.
4. The application of trajectory modelling and sequence analysis to primary care data linked to hospital data.

TO APPLY GBTM AND SEQUENCE ANALYSIS TO ADMINISTRATIVE DATA, PATIENT COHORTS WERE CHOSEN BECAUSE:

1. DISCRETE ACUTE ONSET WITH INITIAL TREATMENT IN THE HOSPITAL PROVIDING A STARTING POINT FOR PATIENT FOLLOW-UP.
2. HIGH POPULATION MORBIDITY.
3. HIGH RATE OF READMISSIONS INCURRING A HUGE COST BURDEN.

1.5 Selection of patient cohorts

The exemplary medical conditions used to select patient cohort and apply trajectory and sequence analysis on the administrative data include cerebrovascular conditions and repair of abdominal aortic aneurysm for medical and surgical patients' cohorts, respectively. Cerebrovascular conditions include ischaemic stroke, TIA (transient ischaemic attack) and non-traumatic intra-cranial haemorrhage. Patients with diagnosis of heart failure were selected to apply the analysis on the other administrative dataset which was National primary care data linked to hospital data.

1.5.1 Patients with cerebrovascular conditions

Patients with cerebrovascular conditions were selected to apply trajectory and sequence analysis on medical patients. They are one of the top causes of morbidity worldwide.(3) Cerebrovascular conditions include ischaemic stroke, TIA (transient ischaemic attack) and non-traumatic intra-cranial haemorrhage.(3) Thromboembolic event in the diseased artery resulting in an acute blockage of the blood supply to a region of the brain causes ischaemic stroke.(4) TIA is a temporary blockage of blood supply to a part of brain. Intra-cranial haemorrhage results from rupture of a blood vessel or an abnormal vascular structure, which results in a bleed in the brain. Subarachnoid haemorrhagic, a subtype of haemorrhagic stroke, is caused by bleeding on the surface of the brain, whereas in intra-cerebral haemorrhage, bleeding occurs within the brain tissue.(4) They are associated with high short and long-term readmission rate.(4) The first-year readmission rate among stroke patients ranges from 25-50%.(4) Patients with acute onset of stroke are mainly admitted to acute medical units or specialist stroke units in the NHS hospitals in England, which means that majority of these cases were recorded in the hospital administrative data.(71) An analysis of these patients would have better representation to evaluate National trends in the readmission rate. It also provides an identifiable starting point for the patient cohort for the analysis. Moreover, the incidence of cerebrovascular conditions is high, and that gives an opportunity to apply the model to a large cohort of patients.(72) During their hospital stay for stroke management, these patients go through various treatments, which allows for various aspects of hospital care to be assessed that can contribute to increase in readmission rate.(73) Previous studies, thus, have assessed different types of factors, patient-related and management-based, that alter the readmission rate.(5) The results from previous studies provide a relevant background to compare the results from the present study.

1.5.2 Patients with Abdominal Aortic Aneurysm repair

Patients who had abdominal aortic aneurysm (AAA) repair were selected to apply trajectory and sequence analysis to a surgical cohort of patients. AAA is a localised swelling of the aorta which is the main blood vessel that runs from heart into the abdomen to supply blood to organs in the abdomen and lower limbs.(59) If untreated, they present with the high risk of rupture of the aneurysm leading to death. There are two types of repair of AAA, open and endovascular (EVAR). Open repair is the technique where a large opening of the abdomen is made to fix the aneurysm; whereas, EVAR is the endovascular repair of the aneurysm that is minimally invasive and done through small incision to enter the blood vessel.(59) Commonly, the operations from AAA are done as elective or planned procedures, and repair of ruptured AAA are done as emergency procedures.(59) The readmission rate among patients undergoing vascular procedure is high.(74) It ranges from 8.9% to 24.4%.(59) Specifically, the readmission rate after AAA (abdominal aortic aneurysm) repair varies from 12.5% to 23.2%.(59) The Centre for Medicare and Medicaid Services (CMS) has reported vascular procedures to be one of the top 7 conditions that cause potentially preventable readmissions.(74) As expected shortly, hospitals with higher than expected 30-day readmission rate for vascular procedures will be penalised by reduction in their reimbursement payments.(74)

Repair of abdominal aortic aneurysm (AAA) has been associated with poor outcomes, as well as with very high readmission rates.(74) With the introduction of screening for AAA at a national level, the number of elective or planned repairs increased, and the number of repairs for ruptured AAA (rAAA) was expected to decline. However, there are still a significant proportion of patients who suffer from rAAA and undergo repair.(75) Mortality after repair of AAA remains high despite the advancement in operative technique and the use of EVAR.(75) The risk factors associated with higher longer-term readmission rate among patients who underwent AAA repair are poorly understood and need to be identified so that a predictive model can be constructed which can help clinicians to predict those patients that may end up with poor morbidity after the operation.(76) With early identification of these patients, appropriate measures can be put in place to improve their quality of life. Moreover, the causes of emergency readmissions are still to be ascertained, to see whether are avoidable or not.(77)

The characteristics of high-impact users among vascular surgery patients are not well known.(77) They are a small proportion of the total patient population, but their resource consumption is significantly high. There is not a standard and robust methodology to model and visualise changes in the frequency of long-term readmission rate in this subgroup.(21,59) Earlier models perform poorly to predict these patients among AAA repair patients.

1.5.3 Patients with Heart Failure

Patients suffering from heart failure (HF) were chosen for this study to apply the model to the primary care data linked to hospital dataset. Heart failure (HF) is a condition in which heart is unable to pump blood efficiently to the body due to various reasons. (60) HF is one of the leading causes of morbidity and mortality worldwide.(62,78) Many patients suffering from HF undergo multiple hospital admissions, and the readmission rate in the first six months has been documented to be as high as 45%.(60) In the US, hospitalisations of HF account for most of the cost for HF patients (nearly 75% of $10 billion)(79), and HF is,

therefore, one of the conditions for which the US Centre for Medicare and Medicaid Services penalises the hospitals for higher than expected 30-day readmission.(80) However, there has been no improvement in the readmission rate following the implementation of the policy.(81) Programs to reduce readmission have been costly and difficult to conduct or apply at a larger scale. To improve clinical viability, targeting these programs to the high-impact users has been suggested.(82)

The identification of high-impact users among HF patients has been imprecise and previous risk stratification models have performed poorly.(83) Most studies in this area concern the prediction of a single unplanned readmission. Even here, there is a lack of unanimous agreement on the determinants of high readmission rates due to limitations in previous studies, such as a small sample size, single centre studies, use of binary outcome (low or high risk for readmission), and measurement of all-cause readmission rate rather than potentially preventable readmissions.(83,84) The predictors are mainly obtained from hospital clinical data and do not include important covariates like use of primary care service, psychological factors, frailty, cognitive impairment etc. Previous risk models to predict readmissions had various limitations.(84). They were developed on RCT populations and hence were not representative of general patients with HF due to selection bias. Moreover, the impact of various social factors on the readmission rate has largely not been assessed, and most studies have merely evaluated the basic demographics like age, sex, ethnicity and socio-economic status.(85) Previous models were derived to predict short-term risk (i.e. 30 days to 1 year) only and do not distinguish between patients with a set of readmissions at the end of their life or other short-term crisis – in whom the rate soon returns to zero or near zero – and those whose high readmission rate is sustained, in part due to suboptimal management in hospitals and/or in primary care.(86)

Chapter 2. Literature review

2.1 Overview

This chapter reviews previous literature on the statistical techniques used to classify high-impact users, and it evaluates how trajectory and sequence analysis has been used to assess outcomes in clinical studies. The two main techniques used to classify high-impact users were either selection of these patients based on top percentiles from cost analysis or choosing them based on high readmission rate over defined period by the previous studies. The methodology had various shortcomings. All studies showed that high-impact users accounted for 1% to 20% of the patient population and utilised more than half of the resources as compared to other users –they were associated with worse outcomes.

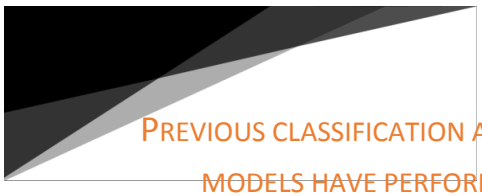
There has been recent use of trajectory and sequence analysis to study outcomes in medical conditions, but none of the studies have used these techniques to assess use of healthcare by high-impact users.

2.2 Introduction

NATIONAL HEALTH SERVICE HAVE RECOMMENDED TO TARGET VARIOUS MANAGEMENT PROGRAMS TO HIGH-IMPACT

High-impact users are a small but significant group of patients with high hospital readmission rate: they are accountable for nearly half to two-thirds of the healthcare resources.(13) Based on cost-analyses by health economists, the proportion of high-impact users ranges from 1% to 20% of the total patient population depending on the minimum value chosen for the top percentile when ranked according to the cost incurred.(29,87) Repeated hospital admissions contributed to the majority of the healthcare cost.(88) Hence, in clinical studies, their categorisation is based on the number of hospital admissions in a specified period.(89,90) They are also found to have an increased use of outpatient care, community care, and emergency department visits.(13,16,91) Also, their rate of mortality is high as compared with the rest of the patient population.(92)

Identification and prediction of high-impact users has gained importance in recent years in an attempt to improve patient care and save health care cost.(1,16) Various interventions to enhance care pathway have been tried.(93-96) However, majority of them have not performed well. The interventions have focused on patient education, discharge planning, and follow-up provisions. The implementation of these programs needed a lot of resources to set-up and did not have much impact on reducing the readmission rate among patients. Failure of these interventions was due to its blanket approach to all patients which includes a large number of patients who have good health status after hospital discharge and do not get repeated hospital admissions.(97-99) As suggested by recent policy issued by National Health Service England, these interventions should be targeted at high-impact users only.(18)



PREVIOUS CLASSIFICATION AND PREDICTION MODELS HAVE PERFORMED POORLY TO IDENTIFY HIGH-IMPACT USERS. LITTLE IS KNOWN ABOUT CHARACTERISTICS, RISK FACTORS AND LONG-TERM OUTCOMES OF HIGH-IMPACT USERS.

Various methods have been used to classify high-impact users and to understand their characteristics; cost analysis and increased numbers of annual hospital admissions are commonly used techniques to classify them.(13,29,100) Significant risk factors have been identified with them, and attempts have been made to build a reliable prediction model.(13,24) Studies have also been conducted to assess the common causes of in-patient readmissions.(25) However, there is still much to be understood about the characteristics and prognosis of high-impact users. It is important to know how these patients evolve over the course of time, that is, what happens to their hospital care in the years following treatment.(101,102) Are there any social and community factors that make them prone to repeated hospital admissions? Do they continue to have multiple hospital admissions in the following years after being labelled as high-impact users? All such questions need to be considered while deciding for high-impact users. During the hospitalisation process, the patient undergoes functional decline and is prone to further hospital admission. It remains to be investigated if these patients undergo a vicious cycle of repeated chain of similar causes of hospital admissions. In addition to this, it is equally important to know if any patients may not have a high readmission rate initially but later become high-impact users in the long-term.(103)

In recent years, trajectory and sequence analysis had been used in medical studies to categorise populations into subgroups to understand their features using longitudinal data.(19,104,105) These techniques have been successfully used for more than 25 years in social science, psychology and criminology to study patterns of behaviours of groups in a study population.(19,21,106,107) Trajectory modelling classifies study populations into different groups based on repeated observations of behaviour.(40,108) The trajectory pathway taken by each group is displayed on a graph, and the predictors of abnormal behaviour or outcome are identified.(108) When applied to datasets, sequence analysis codes for each event and arranges them in chronological order.(42) The sequence of events from all patients are analysed, and common sequences for the group of patients are identified.(42)

2.2.1 Aim of the review

The review aims to assess the methodology for classification of high-impact users. It will be interesting to see how trajectory and sequence analysis have been used to assess outcomes in medical conditions and whether any previous studies have applied these techniques to help understand patterns of healthcare use with regards to high-impact users.

2.3 Methods

2.3.1 Search strategy

Embase, Medline Ovid, and Web of Science were the databases used for conducting the literature review. The research was conducted between 24th May 2017 and 10th June 2017. The combination of various mesh terms was used for searching the database as illustrated in *Table 2*. The references of the relevant articles were screened to identify other studies which could be included in the review. Other public search engines, like Google Scholar, were also used to look for any study not listed in library databases. Also, the literature search was not limited to studies in other languages. The PRISMA protocol was used to conduct the review of the studies *(Figure 2).*(109)

2.3.2 Data extraction and analysis

The following inclusion criteria was used:

1. Patient population of any age with any diagnosis.
2. Studies that have used any clinical data or methodology to classify high-impact users based on hospital readmission rate.
3. Studies that have used trajectory analysis to classify patient population using clinical data.
4. Studies that evaluated any outcome in high-impact users.
5. Studies using any clinical data to assess the impact of chronological order of diagnoses or side effects or medical complications or surgical interventions on any clinical outcome of the patients.

The following exclusion criteria was used:

1. Studies that only evaluated economic outcomes.
2. Studies that only evaluated outcomes among frequent attendees of emergency department or outpatient clinics or primary care.
3. Non-clinical studies, like studies based in sociology, psychological research, molecular biology and criminology that used trajectory and sequence analysis to evaluate trends in participants and biological markers.

The information extracted from the studies included patient's basic demographics, year of publication, research design of the study, type of clinical data used, aims of the study, outcomes measured by the study, methods used to classify high-impact users, use of control groups, predictors associated with high-impact users, follow-up period, and the effect of chronological order of events on the outcomes of the patient population. The main outcome measured was the readmission rate among the patients. Other outcomes included mortality, out-of-hours GP visits, discharge to nursing home, outpatient visits and annual cumulative length of stay in the hospital. The studies that only focused on frequent attendees of emergency departments were excluded because these are different cohort of patients as compared to frequent admitters to hospitals.(22,110) Their predictors are variable, and the interventions that aimed at reducing their visits to emergency

departments are different from those targeted for high-impact users of in-patient hospital care.(95,111-113)

2.3.3 Statistical analysis

I was not able to identify more than two studies with similar outcomes to conduct a meta-analysis of the studies.

1	high impact.mp.
2	high-impact.mp.
3	high risk.mp.
4	frequent admitters.mp.
5	frequent attenders.mp.
6	high risk population/ or high-risk.mp. or high risk patient/
7	exp hospitalization/
8	hospitalisation.mp.
9	Patient Readmission/ or readmission.mp.
10	exp readmission rate/
11	trajectory analysis.mp.
12	group based trajectory modelling.mp.
13	trajectory modelling.mp.
14	*Sequence Analysis/
15	sequence.mp.
16	*Time Factors/
17	pattern.mp.
18	*Chronology as Topic/
19	chronological.mp.
20	*complication/co [Complication]
21	*diagnosis/
22	1 or 2 or 3 or 4 or 5 or 6
23	7 or 8 or 9 or 10
24	22 and 23
25	11 or 12 or 13
26	14 or 15 or 16 or 17 or 18 or 19 or 20 or 21

Table 2. MESH terms used for literature search.

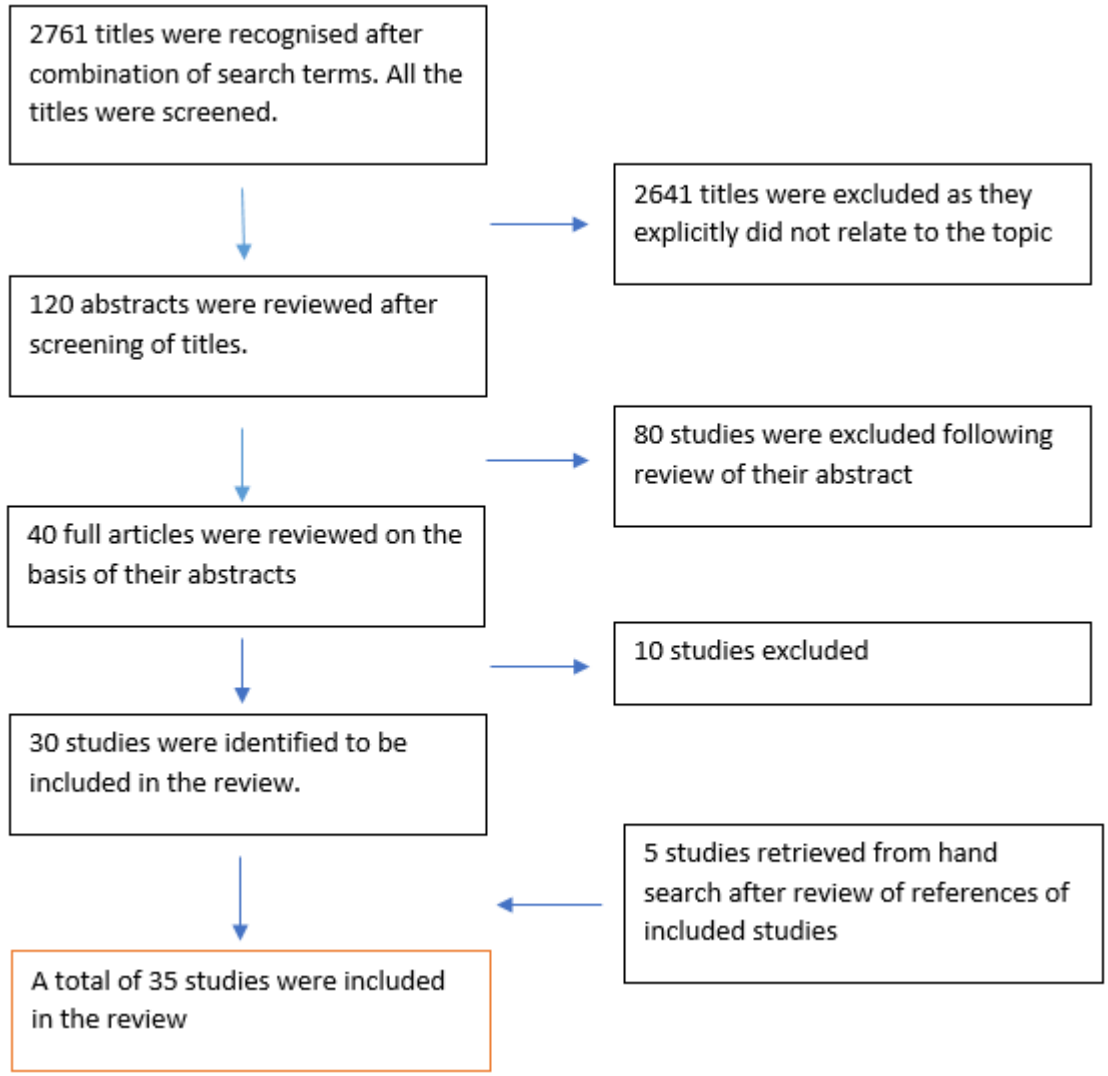


Figure 2. PRISMA diagram for the selection of studies included in the review.

2.4 Results

There were a total of 35 studies included in the review. The studies used various definitions to classify high-impact users. The outcomes measured among them were also different. 22 studies categorised patient populations to identify high-impact users. Nine studies performed trajectory analysis on patients with medical conditions. The trajectory analysis was used to categorise patients based on different outcome measures, but none of the studies used the statistical technique to classify high-impact users based on readmission rates. Four studies evaluated the impact of the chronological order of events on the outcome of the patient population. None of the studies assessed this sequence of events in the high-impact users.

2.4.1 High-impact users

22 studies aimed to identify high-impact users and to understand their characteristics (*Table 3*).(13,16,17,20,24,25,29,87-90,92,100-103,114-119) However, the majority of studies performed cross-sectional analysis to categorise patients. Five studies used follow-up periods between 6 months to 6 years.(101-103,116). In the study conducted by Rosenheck *et al.,* the high-impact users were followed for three years to examine the impact of an intensive psychiatric community care program on the use of hospital care.(101) The care program significantly reduced readmission rates among high-impact users who were admitted as medical inpatients. Saxena *et al.* observed the number of outpatient, emergency department and inpatient hospital visits in high-impact users for four years.(20) High-impact users had a higher rate of use of healthcare in all aspects as compared to the rest of the patient population. Among Afro-American asthmatic patients, the effect of a specialist intervention program on the high-impact users was shown to reduce readmission rate after six months.(116) In the study by Freeborn *et al.,* a follow up for six years was done on the high-impact users, the study found an increased hospital care use for patients with chronic and psychological conditions.(103) In another study by Wodchis *et al.,* it was shown that only 45% of the high-impact users remained high-impact after a year in the 3-year period and only a small proportion of low-impact users became high-impact in the final two years.(102) Most of the studies were able to identify significant predictors associated with high-impact users. The predictors differed in various studies due to diverse population characteristics as well as aims of the study. However, common risk factors were older age, multiple co-morbidities, poor socio-economic status and previous increased hospital admissions.(17,20,88,90,91,103,117)

In most of the studies, the patient population was categorised into two groups: low- and high-impact users. In 2 studies, there were more than two groups. In one study, the patients were stratified on basis of the gradient of utilised cost (top 1%, 2-5%, 6-50%, and bottom 50%)(17). Whereas in the second study, they were classed into three groups based on top, middle and bottom one-third of the cost incurred.(103) Certain studies also formulated a prediction model for the readmission rate along with classifying high-impact users.(13,16,20,24) Chechulin *et al.* assessed the significant predictors of high-impact users

using cost analysis.(24) The predictors were then applied to a different cohort of patients, and the sensitivity and specificity of the model was 42.2% and 97% respectively. The study was based on two cohorts: original and validation cohort – the original and the validation cohort had more than 10 million patients. Bottle *et al.* randomly divided the patient population into 2 groups. One set of patients was used to create a model, and the other set was used to validate it. The sensitivity of the model was assessed by using c-statistics, which showed that the area under curve (AUC) was 0.72, depicting moderate predictability of the model.(16) Similar technique was used by Billings *et al.* to validate the model.(16) Billings et al. showed that their model had the sensitivity and the positive predictive value of 66.6% and 0.67 respectively.(16) Other studies, however, did not validate their model or classification technique.

High-impact users were also associated with other poor outcomes in addition to high emergency readmission rates. They were shown to have increased total number of days spent in the hospital annually.(119) They were also shown to have higher number of elective admissions, increased use of community care, higher usage of outpatient clinic services and higher mortality rate.(87,91,92,117) Similarly, when common causes of readmissions were assessed, higher rate of admissions for cardio-respiratory and gastrointestinal conditions and external injuries were found in high-impact users.(25)

2.4.2 Trajectory analysis for medical conditions

Review of trajectory modelling in the assessment of outcomes of medical conditions included nine studies (*Table 4*).(104,105,120-125) Group-based trajectory modelling was used in their analysis. None of the studies used trajectory analysis to classify high-impact users based on cost utilisation or readmission rate. Most of the studies used clinical data, except one, where a population-based data was extracted.(126) 2 studies each examined outcome in surgical (122,125) and cancer patients.(104,123) The classified groups in the studies ranged from 3 to 5. However, none of the studies validated their trajectory model. Significant predictors associated with high-risk patients were identified for a particular outcome analysed in the study. Group with non-adherence to anti-depressants had an association with poor socio-economic status.(121) Older cancer patients with trajectory of persistently low physical function and activity had abnormal baseline BMI and poor self-efficacy of performing strength and endurance exercise.(123) Non-Caucasian ethnicity was significantly associated with women who had persistently high vasomotor menopausal symptoms.(120) In the study to evaluate trajectory of cognitive function after hip fracture, the group with postoperative cognitive decline was related to premorbid functional and cognitive impairment, and delirium.(122) Poor quality of life trajectory after cancer diagnosis was linked to increased co-morbidity score in another study.(104) Cristancho *et al.* showed that stressful life events before the fracture, current smoking, higher anxiety, less social support, antidepressant use, past depression and type of implant was predictive of the group with high depressive symptoms after hip fracture repair.(125) In yet another study by Gill *et al.,* the trajectories of disability a year before death were modelled, and those with severe disability were shown to be linked to female sex.(124)

Once the groups with different trajectories were identified, other outcomes were also assessed between groups. Women with persistently increased vasomotor menopausal symptoms had higher proportion of patients with carotid intima media thickening (IMT), which was used as a marker for cardiovascular disease.(120) Trajectory group with increased cognitive decline and poor quality of life had higher mortality as compared to other groups.(104,122) In the study by Cristancho *et al.,* trajectory group with higher depressive symptoms also had poor functional status, mobility, and increased pain at the end of follow-up time.(125) The trajectory model was only validated in one study using a validation cohort, and AUC for c-statistics was 0.75.(126)

2.4.3 Studies evaluating the impact of sequence of event

Four studies that assessed the impact of the chronological order of events on the outcome of interest were also included in the literature review.(19,34,35,63) One of the studies used sequence analysis methodology to assess relationship between common sequences and adverse outcomes.(19) Another study assessed the timing of readmission in different types of diabetes and common causes of readmission during each period in the one-year follow-up.(63) Three studies used local clinical data from hospital whereas one study made use of hospital administrative data.(63)

Hougham *et al.* assessed what sequences of resolution of clinical indicators were associated with poor outcome once the patients with pneumonia were discharged from the hospital.(19) Various clinical symptoms (fever, tachycardia, tachypnoea, hypotension, hypoxia, decreased oral intake and altered mental status) at discharge have been associated with poor outcomes in earlier studies. Nonetheless, this study focused on the sequence of these symptoms that lead to worse outcomes. The study was conducted on 1362 patients: the patients with the sequence of resolution of the symptoms 'altered mental status-decreased oral intake-hypoxia' were associated with increased 30-day mortality, prolonged length of stay (LOS) and increased total costs ($p<0.05$).

Aaby *et al.* evaluated the effect of sequence of vaccination on the female infant mortality.(35) In a Sudanese trial, 510 infants who had HTMV (high titre measles vaccine) were randomised into two groups, those who had HTMV alone and those who had HTMV followed by DTP vaccine (diphtheria–tetanus–pertussis). The female-male mortality ratio was 3.89 (95% CI 1.02–14.83) among those who did not have DTP vaccine. Infants who had subsequent doses of DTP after HTMV had increased mortality ratio ($p = 0.043$). Also, the mortality ratio was also higher in infants who had simultaneous HTMV and DTP vaccines (OR = 5.38 (1.37–21.2).

In the study by Wang *et al.,* 382 patients who were diagnosed with heart failure (HF) and atrial fibrillation (AF) were assessed for the timing of occurrence and its impact on

mortality.(34) The patients who were diagnosed with AF first and then developed HF had higher mortality (men: HR [hazards ratio] 2.7; 95% CI, 1.9 to 3.7; women: HR 3.1; 95% CI, 2.2 to 4.2) in comparison to those who had HF and were later diagnosed with AF (men: HR 1.6; 95% CI, 1.2 to 2.1; women: HR 2.7, 95% CI, 2.0 to 3.6).

In a recent study by Liu *et al.,* the temporal pattern of all-cause readmission among hospitalised patients with diabetes in China was assessed.(63) Among 37,260 patients, the first readmission after the diagnosis of diabetes was more 90 days in most cases, and then subsequent readmissions occurred within 8 to 30 days. The study also measured the most common cause of readmission after each time interval following discharge from index admission. It was found that the most frequent cause of readmission was same for each time interval but differed for the type of diabetes. The most recurring readmission after each time interval (0-7 days, 8-30 days, 31-60 days, 61-90 days, >90days, and one year) was cerebral infarction and diabetic complication in patients with type 1 and two diabetes respectively.

Study	Aim	Patient population	Methodology	Predictors associated with high-impact
Belcher 1999	Identification of high-impact users and their predictors	US local hospital data [1995-1996] (n=4930) High-impact (1.5%)	Elderly patients (age > 65), 6 or more hospital or emergency department admissions within 1 year	Not assessed
Billings 2007	Prediction of high-cost users and to run business-case analysis to assess rate of reduction in the future hospitalisation	US Medicare disabled patients for Medicaid managed care in year 2000-2004 (n=98,000) Proportion of High-impact (not mentioned)	Adult with disability and an emergency hospital admission within one year of first index admission	Algorithm for risk scoring based on past medical history, chronic conditions, emergency department visits, specialist care visits
Botha 2009	Identification of high-impact users among psychiatric patients	South African local clinical data (n=146) High-impact (65%)	Psychiatric patients with ≥ three admissions in 18 months or ≥ 5 in 36 months or ≥ 2 admissions in 12 months and treated with clozapine, or ≥ two admissions in 12 months and 120 days in hospital	Under-utilization of depot antipsychotics and early discharge from hospital as particular contributors
Bottle 2006	Identification of high-impact users and their predictors	English NHS hospital data (HES) [2000-2001] (n=2,747,509) High-impact (9.8%)	3 or more emergency admissions in a year	Number of emergency admissions in the preceding year, number of emergency admissions in the preceding 36 months, co-morbidity score, older age, socio-economic deprivation, source of admission, non-Caucasian ethnicity
Calver 2006	Identification of high-impact users and their predictors	Australian provincial administrative data [2001-2002] (n=302,788) High-impact (5%)	Cost analysis over 1 year based on diagnosis-related group	End-stage renal disease, angina, depression, secondary malignant neoplasm

Castro 2013	Effect of asthma intervention program on the readmission rate among the high-impact users	US local hospital data [1996-1999] (n=96)	Adult Afro-American patients with asthma with 1 or more hospital admissions in 1 year	Not assessed
Chechulin 2014	Comparing two different cost-analysis to predict high-impact users	Canadian administrative database [2008-2010] (n=10,300,856) High-impact users (5%)	Cost analysis over 1 year based on unit cost and volume of services used	Older age, male sex, social deprivation,
Fisher 1999	To identify high-impact users among psychiatric patients	Canadian local hospital data [1993-1995] (n=1533) High-impact (5.4%)	3 or more hospital admissions over 1 year.	Not assessed
Freeborn 1990	Identification and prediction of high-impact users with long-term follow-up	US local hospital data [1976-1981] (n=501) High-impact (26.0%)	Patients age > 65. Cost analysis for all health services, procedures and investigations based on local coding system of procedures. Population divided into 3 groups: top, middle and lower 1/3rd cost for 4 or more years	Older age, sex, perceived poor health status and number of medical conditions
Garfinkel 1988	Identification of high-impact users and their association with health status	US Medicare data [1980] (n=17,123) High-impact (those with top 10% of the cost utilisation)	Cost analysis over 1 year for all the health services used, except ambulatory dentistry and nursing home care	Restricted activity days, chronic conditions and functional limitations
Grace 2013	To identify high-impact users	Portugal local hospital [2004-	3 or more admissions over 5 years	Young age, compulsory psychiatric

	among psychiatric patients	2008] (n=1348) High-impact (10.2%)		admissions, schizophrenia and bipolar disorders
Heslop 2005	Identification of high-impact users and their predictors	Australian administrative data [2001-2002] (n=12,166) High-impact (20%)	Cost calculated for each hospital admission. The patients with top 20% of the cost labelled as high-impact	Length of stay and tracheostomy
Korkeila 1998	Identification of high-impact users among psychiatric patients	Finland National registry [1990-1993] (n=49,455)	Psychiatric patients with 4 or more hospital admissions in 1 year	previous admissions, long length of stay (LOS) and diagnosis of psychosis or personality disorder
Low 2016	Identification of high-impact users and their predictors	Singapore, administrative data [2014] (n=16,306) High-impact (10.1%)	3 or more hospital admissions in 1 year	Age, cerebrovascular disease, history of malignancy, haemoglobin, serum creatinine and albumin, number of outpatient visits, emergency department visits and previous hospital admissions, and number of dispensed medication at discharge
Morlino 2011	Identification of high-impact users among psychiatric patients	Italian local survey data [2001-2005] (n=1075)	Psychiatric patients with 3 or more hospital admissions in 1 year	Younger age, more frequently unmarried, unemployed, receiving a disability-pension, and either homeless or living in a residential facility.
Rais 2013	Identification of high-impact users	Canadian provincial administrative data [2009-2010]	Cost analysis over 1 year based on unit cost. Top 5% of the hospital and home care utilisers.	Not assessed

		(n=1,182,650) High-impact (5%)		
Roick 2004	To identify high-impact users among psychiatric patients	German local hospital data [2004] (n=307) High-impact (12.0%)	3 or more admissions over 30 months	Previous hospitalisations and current scores of psychopathology
Roos 2003	Identification of high-impact users and its relationship with socio-economic deprivation	Canada, administrative data [1995] (n=655,202) High-impact (1%)	Cumulative LOS over 1 year. Top 1% of the patients who spent most days in the hospital.	Socio-economic deprivation
Rosella 2014	Identification of high-impact users and their predictors	Canadian provincial administrative state data [2003-2008] (n=91,233) High-impact (top 5.0% of cost utlisers)	Cost analysis based on aggregated diagnosis groups. Cost calculated on the previous 2-year use of primary, secondary, elective and emergency and pharmaceutical use.	Older age, multiple co-morbidities, and poor self-perceived health.
Rosenheck 1998	Effect of intensive psychiatric community care on the high-impact users	US Veteran Affairs data [1987-1990] (n=873)	Psychiatric inpatients who had 180 days or more of length of stay or 4 or more psychiatric prior admissions in neuropsychiatric facilities, or 40 or more days of psychiatric hospitalisation, or 2 or more admissions in general medical hospitals	Not assessed
Saxena 2015	Identification of high-impact users and their predictors	Singapore, administrative data [2008-2013]	3 or more emergency admissions in a year	Age, male sex, number of previous hospital admissions, heart failure and

		(n=28 million) High-impact (0.9%)		previous use of outpatient clinics
Wodchis 2015	Identify characteristics and cost associated with high-impact users	Canadian provincial administrative data [2009-2010] (n=8,197,026) High-impact (5%)	Cost analysis over 1 year based on resource intensity weight multiplied by applicable cost amount	Not assessed
Zulman 2015	To assess the relationship between multi-morbidity and healthcare utilisation patterns among the high-impact users	US Veteran Affairs administrative data [2010] (n=5,200,000) High-impact (5%)	Cost analysis over 1 year based on absolute and share of costs generated through outpatient, inpatient, pharmacy and contracted care.	Multiple co-morbidities, diabetes, depression, ischaemic heart disease, hypertension

Table 3. The list of studies that have assessed characteristics of high-impact users.

Study	Aim	Outcome measure in the model	Data	Follow-up	Groups categorised by model (n)
Beishuizen 2017	To investigate which cognitive trajectories occur after hip fracture	MMSE (mini-mental state examination) scoring (scale data). Repeated measure 4-monthly	Netherlands clinical data (n=231)	1 year	3 groups
Cristancho 2016	To characterise trajectories of depressive symptoms arising after hip fracture	Depression rating scale measured with increasingly weekly intervals	US clinical data (n=482)	1 year	3 groups
Farris 2017	To identify physical and mental health-related quality of life (HRQoL) trajectories after a prostate cancer diagnosis	Short Form (SF-36) validated questionnaire (scale data) to measure physical and mental health-related quality of life. Repeated measure 2-yearly	Canadian multi-centre clinical data (n=817)	6 years	3 groups for each outcome
Frilander 2016	Assessed the associations of obesity with knee pain and functional limitations	Body mass index (BMI). Measured every 10 years	Finnish population-based study (n=1913)	50 years	3 groups
Gill 2010	To assess course of disability at the end of life in older patients	Disability based on 4 activities and scored 0-4. Measured every month	US Community data (n=754)	1 year	5 groups
Kheirbek 2013	To describe the trajectory of patients with end-stage heart failure in the last 12 months of life	Prognosis was calculated every month based on severity of comorbidities	US local hospital data (n=744)	1 year	5 groups
Mardby 2016	Analyse adherence to anti-depressants and identify non-adherence group in adult patients	Continuous measure of medication acquisition (CMA). Binary outcome with cut-off at 80%. Repeated measure monthly	Swedish population prescribed Drug Register (n=54,248)	2 years	5 groups
Morey 2015	Examine trajectories of physical activity (PA) and physical function (PF) in older cancer patients who had lifestyle counselling	Physical activity: total minutes of exercises every week. Physical function: questionnaire-based score (Short Form 36). Counting and scale data used. Repeated measure 3-monthly	US clinical data from local hospital trust (n=641)	2 years	PA: 3 groups PF: 5 groups
Thurston 2016	To assess relationship between vasomotor menopausal symptoms (VMS) and cardiovascular disease in women	Presence or absence of VMA (binary outcome). Repeated measure annually	US multi-centre clinical data (n=875)	12 years	4 groups

Table 4. Methodology used in studies that used trajectory model to assess different outcomes.

2.5 Discussion

2.5.1 Summary of the results

The review included studies that have looked into categorisation of high-impact users and use of trajectory and sequence analysis in medical conditions. Over the last few years, many studies have attempted to define high-impact users in different patient cohorts. The methodology used to define them was mainly based on either cost analysis with patients of top percentiles cost usage or readmission rate. However, the method that was used to choose the cut-off value for cost analysis or the number of readmissions to categorise high-impact user was not mentioned. All studies showed that high-impact users accounted for 1% to 20% of the patient population and utilised more than half of the resources as compared to other users –they were associated with worse outcomes. Trajectory analysis in the medical conditions was able to classify patients based on repeated measurements of chosen outcome. The categorisation was based on observation of the study population over a period, which in these studies was as long as 50 years. These studies were identified to have more than two groups when trajectory modelling was performed on the longitudinal data, and the model was successfully applied to various population sizes. The group trajectory with persistently worse outcomes was also associated with other adverse events. Sequence analysis technique was only used in one previous study by Hougham *et al.* and common pattern of clinical symptoms were identified with higher mortality and longer length of stay in patients with pneumonia. Other studies showed that a particular chronological order of events was associated with worse outcomes, especially mortality.

2.5.2 General limitations identified in the methodology of previous studies

In general, studies included in the review had certain common methodological deficiencies. Many studies had very small number of patients.(91,101,103,120,122,125,126) In very few studies there was a follow and even that period of follow-up was very short.(91,100,103,125) Furthermore, the studies evaluated readmission rate in general patient population.(13,16,29) It is difficult to make sense as to how predictors of high-impact users among them can be used to foresee high-impact users among target population with particular diagnosis. Additionally, most of the studies were conducted in North America.(16,24,25,88,92,103,116,118,119) As a result, the generalisation of the results to other regions and countries can prove to be difficult due to differences in population characteristics and management pathway. In addition to this, a significant number of studies were conducted on psychiatric patients.(90,91,101,114,125) The risk factors analysed in these studies were related to mental health conditions, and the categorisation of high-impact users was based on hospital readmissions for mental health conditions. Further research is required to identify high-impact users and their predictors among medical and surgical patients. So far, the studies have made an effort to prove that high-impact users exist among

MOST OF THE PREVIOUS STUDIES ONLY CLASSIFIED HIGH-IMPACT USERS. LIMITED EFFORTS WERE MADE TO PREDICT THEM AND THE MODELS WERE NOT VALIDATED.

TRAJECTORY ANALYSIS OF CLINICAL STUDIES PRODUCED WELL-DEMARCATED GROUPS AMONG PATIENT POPULATION, SIGNIFICANT PREDICTORS ASSOCIATED WITH GROUPS WHO HAD WORSE OUTCOME PATTERNS WERE IDENTIFIED AND ITS RELATIONSHIP TO OTHER ADVERSE EVENTS WAS ALSO ESTABLISHED.

patient population and they utilise significant amount of healthcare resources and cost. However, none of the studies have taken a step forward to assess the behaviour of healthcare use of the high-impact patients once they are identified. The studies lack direction about how to predict these patients so that management programs can be targeted towards them. Furthermore, it is also important to investigate whether these patients suffer from common series of preventable adverse events during their life.(48,54)

2.5.3 Critical appraisal of previous methodologies used to identify high-impact users

The methodology used to identify high-impact users has varied across the studies and was not standardised. For instance, studies using cost-analysis mainly dealt with health economics. The predictors assessed in these studies lacked various clinical risk factors that could have been associated with groups with worse outcome.(17,24,25,29) Cost-analysis was conducted on general patient populations with various medical conditions. However, previous studies have shown that specific medical conditions have different rate, predictors and causes of readmission.(44,83,127-129) In various studies, the cut-off value used to identify high-impact users, that is, the top percentile in cost analysis or number of annual readmissions differed. This cut-off was not based on any statistical test or standard clinical protocol. Some studies were focused on the classification of high-impact users among psychiatric patients (90,100,101,114), which impairs the generalisability of the methodology of the study as well as the characteristics of high-impact users to other patients with medical and surgical conditions. None of the studies used another dataset to validate the procedure of identifying high-impact users. The classification of these high-impact users was performed in cross-sectional analysis in most studies. Once identified, there was no follow-up of the groups to assess long-term outcomes. Once the high-impact users were identified, the rest of the patients were clumped into one group and labelled as low-impact users. This assumption may overlook the other subgroups in the patient population that have moderate hospital care usage and have the potential to become high-impact users.(103) Studies have demonstrated that after the patients were divided into more than two groups based on percentiles and quartiles of cost algorithms, there was movement of patients from one group to others.(17,103) It was also not evaluated whether these patients had constantly increased usage of hospital resources. It an earlier study, it was shown that half of the high-impact users become low-impact after one year and, as time progressed, a small proportion of low-impact users turned into high-impact.(103)

SEQUENCE ANALYSIS OF ADVERSE EVENTS IN MEDICAL CONDITIONS HAS SHOWN TO HAVE SIGNIFICANT IMPACT ON THE OUTCOME OF PATIENTS.

2.5.4 Recent role of trajectory analysis in medical research

Trajectory analysis is a well-established technique in psychological and social studies where the groups in the population are not bifurcated as 'black and white' and a statistical strategy is required to differentiate groups with similar properties and follow-up patterns.(130-133) Recent use of this model in studying the patterns of outcomes in medical conditions has proven to be effective. It produced well-demarcated groups, significant predictors associated with groups who had worse outcome patterns were identified, and its relationship to other adverse events was also established. In contrast to previous clinical studies, the model predicted more than two conventional groups: low- and high-impact groups. The models used in most of these studies, however, were not validated and its predictability was not tested. In addition to this, the population size was rather small, and the studies made use of clinical data from local hospitals. Hence, further research is required to apply this model to large dataset. New studies using trajectory models should include a greater number predictors other than those based on clinical data that could be associated with worse outcomes, like socio-demographic conditions, risk factors related to community care, and management care pathway.(62,85,134)

2.5.5 Potential role of sequence analysis in the assessment of clinical outcomes

Sequence analysis of adverse events in medical conditions has shown to have significant impact on the outcome of patients.(19,35) Common distinct sequences of events were identified in patients with high mortality. It was also noted that there was a chronological pattern of causes of hospital admissions in patients with diabetes.(63) However, it is true that the investigation of pattern of chronological events with adverse outcomes is very recent.(19) The initial studies have conducted basic observations of less than five events and assessed their order in general patient population.(35) The timing of the events was mainly assessed to investigate its relationship with mortality. Nonetheless, the effect of the pattern of a large number of events on a particular clinical outcome is yet to be explored. Psychological studies and studies evaluating behavioural outcomes in population have used sequence analysis methodology to successfully assess common sequence of events that lead to abnormal behaviour in a particular cohort of population.(106,135,136) This approach is similar to the one used in the genome analysis to identify sequence of DNA in abnormal cell pathology.(137)

2.5.6 Research implications of the results from the literature review

The literature review has proved fruitful in identifying a gap in the classification and prediction of high-impact users and assessment of their sequence of adverse events during follow-up period. The application of trajectory analysis is expanding in clinical data and has the potential to be used in large dataset to categorise high-impact users. With this technique, the data can be converted into a longitudinal series, and as a result of this,

patterns of long-term outcomes can be assessed. The classification of high-impact users will be based on repeated observations of outcome and will be robust as opposed to the traditional methods of identifying them using cross-sectional approach. While conducting the analysis, the model can include predictors based on social and management-based factors to recognise preventable measures in the community and to avoid adverse outcomes during patient care. It is still to be ascertained whether the high-impact users follow a distinct sequence of adverse events that lead to increased utilisation of hospital resources. If they are observed to undergo a repeated vicious cycle of events, then it is important to identify these factors in the hope of preventing their occurrence. In consequence, this can lead to a reduction in hospital readmission rate, admission to nursing home and visits to emergency department, which in turn may improve their quality of life, frailty and functional health.(12,138-140)

2.5.7 Conclusion of the literature review

In conclusion, previous methodologies to classify high-impact users have been based on cross-sectional analysis, which has lacked standardised approach. The predictors of high-impact users were mainly clinically based with basic patient demographic information. More work is required to evaluate other risk factors and their relationship with high-impact users. Previous studies did not follow-up on these patients to observe long-term outcomes. It is important to obtain knowledge of common adverse events and the sequence of their occurrence among these patients to identify series of a chain of adverse events and stop the vicious circle of poor prognosis early on. Trajectory and sequence analysis has the potential to assess various clinical outcomes in medical patients using different types of datasets. They have the ability to identify and predict high-impact users and understand their characteristics. And therefore, it is a model worth studying when it comes to high-impact users.

Chapter 3. Methods

3.1 Overview

This chapter describes the methods used in the research to apply trajectory and sequence analysis to the administrative data. Hospital Episode Statistics (HES) data was used to extract information on patients diagnosed with cerebrovascular conditions and abdominal aortic aneurysm repair. Clinical Practice Research Datalink (CPRD) linked to Hospital Episode Statistics (HES), and Office of National Statistics (ONS) deaths database was used to apply trajectory and sequence analysis to primary care data linked to secondary care to assess the use of healthcare among heart failure patients. Various co-variates were evaluated for their association with the high-impact users. They were identified from previous clinical and population-based studies. Trajectory analysis was used to classify the patient population into subgroups, identify and predict high-impact users, and assess co-variates with significant association with high-impact users. Sequence analysis was used to find common causes of emergency readmissions in patient population and different subgroups. It identified common sequences of causes of readmissions and types of healthcare visits among high-impact users. Trajectory analysis visualised trends of readmission rates among subgroups of the patient population. Sequence analysis generated Lasagne plots to visualise sequences of types of healthcare visits among subgroups of the patient population.

3.2 Database used in the study

3.2.1 Hospital administrative data

FEATURES OF HOSPITAL EPISODE STATISTICS DATA:

1. HIGH SENSITIVITY FOR CODING PRIMARY DIAGNOSES.
2. INCLUDES INFORMATION ON ALL PATIENTS ADMITTED TO NHS HOSPITALS.
3. THE PRIMARY DIAGNOSES ARE CODED IN STANDARDISED FORMAT USING ICD-10 CODES.

Hospital Episode Statistics (HES) data was used to extract information on patients diagnosed with cerebrovascular conditions and AAA repair.(71) The data is collected monthly by the Department of Health, UK Government, and includes information on all the inpatient hospital admissions to public hospitals in NHS (National Health Service) England.(71) All patients, including private ones, which require emergency treatment, are initially admitted in these hospitals. The data has been collected every month since 1987 and published annually for every financial year which starts on 1st April and ends on 31st March of the following year.(71) Each hospital admission is recorded as a 'spell' consisting of 'episodes' which denotes the care under each consultant during the patient's stay.(141) If a hospital admission requires a transfer to another hospital before the patient is discharged, then the episodes and spells that cover the whole hospital stay are linked together to form a 'superspell'.(141) Each patient has a unique anonymous identifier that was used to produce longitudinal data series. The primary diagnosis of the spell is the main condition treated during the hospital stay after all investigations, diagnostic examinations and procedures have been carried out. It accounts for the majority of the length of stay in the hospital.(141) There are up to 19 secondary diagnoses that are either co-morbidities or other conditions identified and treated during the hospital stay. All the conditions are coded using ICD-10 classification (International Classification of Diseases version 10). The procedures are coded using OPCS 4.7 (Office of Population Censuses and Surveys Classification of Interventions and Procedures version 4.7).(141) The most resource intense procedure is the primary procedure while 23 other secondary procedures that the patient had in previous episodes or currently as minor procedures are also recorded. The accuracy and validity of the coding of primary conditions and procedures in Hopsital Episode Statistics is of high quality.(70)

3.2.2 Primary care data linked to hospital data

Data were obtained from Clinical Practice Research Datalink (CPRD) linked to Hospital Episode Statistics (HES) and Office of National Statistics (ONS) deaths database. CPRD is the largest national primary care database with over 13 million enrolled patient medical records across the country and contains 8.5% of the patient population in England.(142) It includes information on demographics, medical diagnosis and procedural information for each consultation with the general practitioner (GP). It is recorded by trained general

CPRD IS THE LARGEST NATIONAL PRIMARY CARE DATABASE. IT IS LINKED TO HES DATA AND INCLUDES INFORMATION ON OVER 13 MILLION PATIENT MEDICAL RECORDS. IT IS ALSO LINKED TO ONS WHICH HAS INFORMATION ON FACT AND DATE OF DEATH.

practitioners, regularly audited and had been shown to have high validity.(143) The fact and date of death are obtained from ONS (Office of National Statistics). Around 660 practices have volunteered in CRPD to share patient data. Half of the general practices associated with CPRD are linked to HES data (non-English practices are not linked to HES, as other UK countries have their HES-type databases that are not included in CPRD). Moreover, 95% of the HES data is linked to ONS data. The linkage of the databases allows the reviewing of the chronological order of each patient's history of consultations with their GPs and other medical encounters in the primary care setting, (144) inpatient hospital admissions and time of death.(6,43)

3.3 Patient selection

3.3.1 Patients with cerebrovascular conditions

3.3.1.1 Original cohort

The inclusion criterion of the study population was adult patients over the age of 18 diagnosed with ischaemic stroke, transient ischaemic attack (TIA), or non-traumatic intra-cranial haemorrhage. Patients diagnosed with cerebrovascular conditions in the financial year 2009-2010 were identified using corresponding ICD-10 codes: Ischaemic stroke (I63x), TIA (transient ischaemic attack) (G45x, H34x), and non-traumatic intracranial haemorrhage (subarachnoid haemorrhage [I60x], intra-cerebral haemorrhage [I61x], other non-traumatic intra-cranial haemorrhage [I62x]). These codes have been used in previous studies as well.(67,72,145,146) Patients who were discharged alive after the first index admission but died during the follow-up period were included as well. The patients were followed up for a minimum of 4 years. Follow-up of stroke patients has been of variable duration in earlier studies to assess long-term readmission trends among stroke patients.(4,43,147,148) HES data linked to ONS to include information on the mortality of the patients was only available up to 2014 at that time. Since the study aimed to review long-term readmission rates, the patient cohort was selected to provide minimum follow up of 4 years. A follow-up longer than 4 years may have left out recent stroke patients who underwent current stroke management.(149-151)

3.3.1.2 Validation cohort

The validation cohort consisted of adult patients with the diagnosis of cerebrovascular conditions during the year 2008-2009. These patients were also followed up for at least 4 years.

THE SELECTED COHORT OF PATIENTS WITH THE CEREBROVASCULAR CONDITION WAS FOLLOWED UP FOR 4 YEARS, WHILE, AAA REPAIR AND HF CONDITIONS WERE FOLLOWED UP FOR 5 YEARS. TRAJECTORY ANALYSIS WAS APPLIED TO EACH PATIENT COHORT AND WAS ALSO VALIDATED USING A DIFFERENT SET OF PATIENTS, VALIDATION COHORT.

3.3.2 Patients with AAA repair

3.3.2.1 Original cohort

All adult patients over the age of 18 who had primary AAA repair from the year 2006 to 2009 were included in the study. Patients who died during the follow-up period were included in the study as well. The statistical model used can adjust and estimate the trajectory of these patients based on observation of their previous readmission rate. The patient cohort comprised two main types of repair, EVAR (endovascular aneurysm repair) and open repair. Initially, specific ICD-10 codes were used to identify AAA patients, as used in previous studies: elective AAA (I714, I719) and ruptured AAA (I713, I718).(152,153) Afterwards, the type of repair of AAA was recognised using OPCS 4 codes, as used in earlier studies, and combined with ICD-10 codes to select the patient cohort.(46,154) The following OPCS codes were used: open repair (L18x, L19x, L20x, L21x, L25x) and EVAR (L26x, L27x, L28x). The patients were followed up for a minimum of 5 years.

3.3.2.2 Validation cohort

For the validation of the model, the identified risk factors associated with the high-impact users were applied to a new cohort of patients, who had primary AAA repair in the year 2003-2004 and were followed up for a minimum of 5 years.

3.3.3 Patients with HF

3.3.3.1 Original cohort

Patients over the age of 18 with a first-time diagnosis of heart failure recorded between 1st Apr 2008 and 31st March 2009, who were identified through linked data were included in the study if they contributed to CPRD and allowed linkage to the other datasets. Medical codes ("medcodes") from CRPD were used to identify patients who were first documented to have heart failure. Medcodes correspond to Read codes, which are part of standard terminology system used by general practices in the UK (*Appendix I*). Also, ICD-10 (International Classification of Diseases) codes (I50X) were used to identify patients who were diagnosed with HF in hospital. All patient records were traced back at least 5 years to verify the absence of any earlier HF diagnosis, and also to retrieve data on their past medical history, social and management-related factors. All information on any hospital admission with its primary diagnosis and mortality was obtained during the study period. And patients were followed up for five years up to March 2014.

3.3.3.1.1 Coding for different regions

The CPRD data has information coded for different regions in England. The regions include North-East, Yorkshire and Humber, North-West, East of England, London, South-East, South-West, South-Central, and West-Midlands. This information was used to select patient cohort in various regions. The number of patients was very low in Yorkshire and Humber region;

hence, they were grouped with North-East region. The number of patients for each region was in similitude. They were followed up for almost 5 years, and trajectory and sequence analysis was conducted on patient population in each region.

3.3.3.2 Validation cohort

For validation of the identified high-impact users and significant predictors associated with them, the model was applied to a different cohort of HF patients who were diagnosed during the financial year from 1st April 2007 to 31st March 2008.

3.4 Co-variates assessed in the study

3.4.1 Patients with cerebrovascular conditions

The co-variates assessed in the study cohort were identified from previous clinical and population-based studies on the outcomes of the cerebrovascular patients.(43,67,72,145,146,155) They were categorised as patient characteristics, disease management, disease-associated adverse conditions and hospital-acquired conditions (HACs). All information on the emergency admissions was obtained during the follow-up period. ICD-10 and OPCS 4.7 codes were used to identify main diagnosis and procedure associated with each hospital admission. The patients were also tracked back ten years to look for any relevant co-morbidities and history of the previous stroke.

3.4.1.1 Co-variates assessing patient characteristics

The patient characteristics include patient demographics, socio-economic deprivation, co-morbidity score, history of stroke, living alone and past medical history. Previous clinical studies were consulted to find relevant conditions, especially cardiovascular diseases, which seem to impact the readmission rate in the cerebrovascular patients.(58) Carstairs deprivation index was used to categorise patients into quintiles based on deprivation levels.(156) The quintile ranges from 1 to 6, where a score of 5 refers to the most deprived residences and 6 means not known (missing postcode). There were very few patients with the deprivation score of 6 and sensitivity analysis did not show any difference in the results by their inclusion in the study. Charlson co-morbidity score with NHS adaptation was used to measure the burden of multiple past medical conditions associated with each patient.(157)

3.4.1.2 Disease management factors

Disease management factors included discharge to nursing home, thrombolysis, disease-related procedures (carotid endarterectomy, craniectomy, carotid stenting, aneurysm repair, craniotomy), the use of other procedures (tracheostomy, intubation, urinary catheterization, invasive or non-invasive ventilation, percutaneous endoscopic gastrostomy or nasogastric tube insertion, renal replacement therapy), and length of stay (LOS). In the category of management factors, the effect of the use of various procedures, both minor and major, during the index admission for the cerebrovascular condition was also assessed because they may lead to complications that could alter short- or long-term readmission rate.(31) During the descriptive analysis, since the number of recorded procedures were too low for valid group comparison, they were grouped as disease-related and other procedures for valid comparison analysis.

3.4.1.3 Disease associated adverse events

The disease-associated adverse events comprised hearing loss, vision loss, paralysis, cranial nerve palsy, speech and swallowing disorders, amnesia or coma, and hydrocephalus, hypotension, hypertension, atrial fibrillation, renal failure, depression and anxiety, dementia, epilepsy or seizure, and thromboembolic event (recurrent stroke, myocardial infarction, acute coronary syndrome, acute limb ischaemia, pulmonary embolism). These disease-related events show the impact of a particular type of stroke-related disability on the readmission rate.(43) Certain other medical conditions were also included in this category because they were shown to be highly prevalent in stroke patients.(158) Conditions with thrombo-embolic pathology were grouped, such as myocardial infarction, acute peripheral vascular disease, pulmonary embolism and acute mesentery ischaemia. Since these conditions have similar pathological mechanism and their treatments involve management with antiplatelet and anticoagulation therapy, we expect them to affect readmission rate similarly.

3.4.1.4 Hospital-acquired conditions (HACs)

Common hospital-acquired complications (HACs) were recognised from previous studies.(43,67,72,145,146,155) Individually and collectively, they have been shown to impact readmission rate. The conditions were general procedural complications (bleeding, skin infection, foreign body complications), drug errors and side effects, trauma, falls and fractures, pulmonary embolism, deep venous thrombosis, pressure ulcers, pneumothorax, metabolic disorders, infections (urinary and chest infection, gastroenteritis, cellulitis), and blood transfusion reactions.(43,67,72,145,146,155) It may seem that certain co-variates were linked together and may produce duplicate effect, such as use of urinary catheter and urinary tract infection. However, each individual co-variate assessed in the model was shown to impact readmission rate independent of other related factors.(58)

3.4.2 Patients with AAA repair

Co-variates were adapted from previous studies.(59,77) They were divided into patient characteristics, procedural characteristics, procedure-related complications and general hospital-acquired complications (HACs). The identified cohort of patients was tracked back three years to check if they had any previous AAA repair. The patients were followed up for at least five years. The data was retrieved for each patient every time they had an admission to the hospital. HES linked to mortality information from Office of National Statistics (ONS) data was used to find last hospital admissions resulting death. ICD-10 and OPCS 4.7 codes were used to identify main diagnosis and procedure associated with each hospital admission.

3.4.2.1 Co-variates assessing patient characteristics

Age, gender, ethnicity, socio-economic deprivation, and co-morbidity score were evaluated as patient characteristics. The impact of history of vascular conditions was also evaluated, such as history of stroke, ischaemic heart disease, diabetes, hypertension and peripheral vascular disease. The Charlson score was used to calculate the co-morbidity burden associated with each patient.(157) Higher score was associated with the severity of co-morbidity. The Charlson score was obtained from the sum of weights allocated to past medical problems as listed in previous studies.(157) The population-weighted quintiles of

CPRD HAD ADDITIONAL COVARIATES BASED ON PROVIDED ON SOCIAL AND LIFESTYLE FACTORS, INVESTIGATIONS RELATED TO DISEASE, RELEVANT MEDICATION USE AND USE OF PRIMARY CARE SERVICES.

the Carstairs deprivation score were used to classify patients according to their neighbourhood deprivation levels.(156)

3.4.2.2 Co-variates assessing procedural characteristics

Procedural characteristics included length of stay (LOS), use of other vascular procedures and other related operations. Transluminal angioplasty/stenting, treatment of aneurysmal segment and bypass procedures of mesenteric, upper and lower limb vessels were included in other vascular procedures. The category of other related operations included bowel resection, revision of procedure, fasciotomy, and amputation.

3.4.2.3 Co-variates assessing procedure-related complications

The list of procedure-related complications was obtained from a previous systematic review of AAA patients.(59) It included wound complications (infection, bleeding, dehiscence), gastrointestinal complications (bowel obstruction, gastrointestinal bleeding, ileus, gastroenteritis), renal failure, urinary tract infection, chest infection, anaemia, heart failure, and graft complications (infection, failure, stenosis, leakage).

3.4.2.4 Co-variates assessing hospital-acquired conditions (HACs)

As assessed by previous studies, HACs consisted of drug errors and side effects, trauma and falls, chest infection, urine infection, gastroenteritis, pulmonary embolism, deep venous thrombosis, pressure ulcers, pneumothorax, metabolic disorders, and blood transfusion reactions.(75) The presence of each condition was scored as 1 and a total score was obtained for each patient. Information on the risk factors was obtained from secondary diagnosis fields for each hospital admission.

3.4.3 Patients with HF

The assessed risk factors were identified from previous studies and categorised into patient-based, social and lifestyle related, and management-based factors.

3.4.3.1 Co-variates assessing patient demographics

The patient-based factors consisted of age at diagnosis, sex, and past medical history recorded in the last 5 years preceding the diagnosis of HF. Age was grouped into categories for use in the model in the following brackets: 18-45, 45-54, 55-64, 65-74, 75-84, and 85+ – an adaption from previous studies.(159)

3.4.3.2 Co-variates assessing social and lifestyle factors

The social and lifestyle factors included impact of bereavement, marital or relationship problems, history of smoking and heavy alcohol intake. These factors were chosen because they have impact on the prognosis of heart failure.(85) The patients with ex-smoking and current smoking status in the preceding years were identified through medcodes. Former and current smokers were categorised as 1 and 2. Bereavement was defined as loss of an immediate family member. The GP (General Practitioner) visits for bereavement were also coded using medcodes. The relationship problems included separation, break-up, divorce, or cheating on a partner, each with medcodes recorded by the GP.

GBTM RELIES ON REPEATED MEASURES OF THE OUTCOME OVER TIME IN A LONGITUDINAL DATA SERIES. IT RELAXES THE ASSUMPTION OF ONE TRAJECTORY FOR ONE POPULATION AND ALLOWS EACH SUBGROUP TO FOLLOW ITS TRAJECTORY.

3.4.3.3 Co-variates assessing management-based factors

The management-based factors consisted of GP visit coded for the monitoring of renal function, flu vaccination, measurement of blood pressure and exercise recommendation. Other factors included 3 or more emergency admissions for any reason vs <2 admissions in the year preceding the diagnosis of HF, annual GP visits (including out-of-hours) and out-of-hours GP visits in the year preceding the diagnosis of HF. Previous annual GP visits and annual out-of-hours GP visits did not have a linear relationship with the high-impact users. Hence, they were categorised according to percentile ranges (<25th, 26-50th, 51-75th and >75th percentiles). 3 or more emergency hospital admissions in the preceding year had been adapted from previous studies.(140) The effect of HF diagnosed as an inpatient and history of use of medications for treatment of signs and symptoms of HF was also evaluated. Medication use for the management of signs and symptoms of heart failure included prescriptions for drugs like a loop and thiazide diuretics, beta-blockers, angiotensin-converting-enzyme inhibitors, angiotensin II receptor antagonists, digoxin, and bumetanide; the Read codes for these were obtained from a former study.(160) The information on social factors and management-based factors was obtained for 5 years before the date of diagnosis of HF. The medcodes for social/lifestyle and management factors are listed in *Appendix I*.

3.5 Detailed methodology of GBTM and Sequence analysis

3.5.1 A Simple overview

3.5.1.1 Application of Group-based trajectory modelling (GBTM)

Group-based trajectory modelling assesses and predicts systematic changes in the outcome for each individual in the study population.(40) It relies on repeated measures of the outcome over time in a longitudinal data series. It relaxes the assumption of one trajectory for one population and allows each subgroup to follow its trajectory. Proc Traj software in SAS program was used for the application of the model to the administrative data. The program only accepts a particular layout of the data for it to apply the model. Hence, the administrative data had to undergo certain changes before it could be used for analysis.

The layout of HES and CPRD data is a compilation of hospital inpatient visits and GP consultations respectively. Each row in the data represents a hospital admission or a GP visit. There are several columns in the HES data that contain information on patients ID, demographics, primary and secondary diagnosis of the patient during that admission, primary and secondary operations/procedures, date of discharge, date of admission, destination of discharge and residence of the patient, total length of stay, inpatient mortality, and admission to ITU/HDU. Similarly, in CPRD data, there are columns for patient demographics, outcome of clinic visit, date of visit, referral to secondary care, prescribed medications, social and lifestyle factors. Each patient is given a unique ID in both datasets. For the chosen year, the patients admitted for the diagnosis of interest were selected using appropriate codes for the disease. Once the patient population was identified, they were searched in datasets for previous years till year 2003 to find what were the reasons for admissions and their co-morbidities in the previous years. All the patient admissions for the follow-up period were retrieved in the datasets from the following years. The data was then transposed multiple times so that the reason for admission, length of stay, and the date of admission for the subsequent healthcare visits were aligned in the columns and each row then represented each patient. The numbers of admissions for each of the following years were calculated and this information was recorded in the new columns. The final dataset included patient population with a particular diagnosis in the specified period, who had number of columns showing details of the hospital admission for the index diagnosis, past medical history, reasons and dates of admissions in the subsequent years. An example of the coding transcript for data management is provided in *Appendix 2*.

3.5.1.1.1 Selection of best-fit model

GBTM classifies patients into groups with similar trends of readmission rates. It assumes that the patient population consists of a mixture of groups with a distinct pattern of outcomes. Conventional statistical approaches do not accurately identify the observed shapes of trajectories of different groups. The primary outcome of the study was participant's total number of emergency admissions every year. Their annual numbers of emergency admissions were calculated for every year for the next 4 and 5 years among patients of cerebrovascular conditions and other patient cohorts, AAA and HF patients, respectively. Among heart failure patients, total number of out-of-hours GP visits was the secondary outcome. It consists of GP consultations outside normal working hours during weekdays and over weekends. For each participant with HF, the annual total numbers of GP visits were also calculated.

Using GBTM, the participants were grouped together according to their trends of the annual number of emergency admissions during the follow up period. Then the average of the total number of emergency admissions every year for that group was calculated by GBTM and displayed in the graph.

In order to determine the optimum number of subgroups within a population, the choice of model was based on the following criteria: the smallest value of Bayesian Information Criteria (BIC), largest value for average posterior probability for each group, odds of correct classification (OCC) > 5 and each trajectory with significant parameter estimates (p

FEATURES OF GBTM:

1. CALCULATES AN OPTIMAL NUMBER OF GROUPS WITH TRAJECTORY SHAPES, PROPORTION OF THE POPULATION IN EACH GROUP AND THE OBJECTIVE PROBABILITY OF THE INDIVIDUAL AS PART OF A TRAJECTORY GROUP.
2. A SEMI-PARAMETRIC MODEL.
3. THE SELECTION OF MODEL IS BASED ON BAYESIAN INFORMATION CRITERION, MAXIMUM POSTERIOR PROBABILITY, AND ODDS OF CORRECT CLASSIFICATION.

<0.05).(40) At first, a 2-group model was specified for patient population and the values of the above criteria noted. This way, further models were tested with increasing numbers of groups from 2 to 6. The best fit model was selected for the number of groups that fulfilled all the criteria of model selection with smallest value of BIC *(Appendix 3).*

In order to determine the optimum number of subgroups within a population, the choice of model was based on the following criteria: the smallest value of Bayesian Information Criteria (BIC), largest value for average posterior probability for each group, odds of correct classification (OCC) > 5 and each trajectory with significant parameter estimates (p <0.05). These criteria are usually chosen to test the model with the best estimate of number of groups and predictors associated with them.(40,64,161) BIC is based, in part, on the likelihood function to measure the efficiency of the model to predict different groups in the data. Each individual is given a probability score for one's membership in the group. For each group, the mean of the probability scores of the individuals in the group is calculated and used as an indicator of adequate internal reliability if the value is more than 0.7.(21) Odds of correct classification measure how improved the membership probability of individuals belonging to the in-group is as compared with other groups.

3.5.1.1.2 Shape of trajectory and covariates associated with each group

The trajectory shape for each group was determined by the model with the application of different types of parameters (polynomial order). The simplest shape of a trajectory is a horizontal line, with just the intercept as its parameter, and the order of complexity increases to cubic, which is a curved pathway. The model with most complex and most accurate shape of trajectory, noted with significantly reduced standard error, was selected. The group with highest annual readmission rates was labelled as high-impact users, and those with persistently lowest use of readmission rate were categorised as low-impact users. Other groups with moderate readmission rate were intermediate users. A multinomial logistic regression model was used to assess the impact of covariates on the probability of group membership while controlling for other confounding factors.(40) The group with persistently lowest use of hospital care, low-impact users, were used as a reference group. The association of each covariate was measured as the odds ratio of the impact of that co-variate on the probability of membership in the specified group relative to the stable low-impact group.

SEQUENCE ANALYSIS ASSESSES CHRONOLOGICAL ORDER OF MULTIPLE CLINICAL EVENTS FOR EACH PATIENT. EACH CLINICAL EVENT IS COLOUR CODED, AND SERIES OF EVENTS ARE DISPLAYED USING LASAGNE PLOTS. SEQUENCE ANALYSIS ALSO IDENTIFIES A COMMON TEMPORAL ORDER OF EVENTS DISTINCT TO EACH SUBGROUP OF PATIENTS.

3.5.1.1.3 Validation of model

The sensitivity and specificity of the model to detect high-impact users was assessed by comparing with those patients who were actually observed to have high readmissions annually, for 3 or more years during the follow-up period.(13) High annual readmission rate was defined as 90th percentile of the number of readmissions among the patient population.

The predictability of the model was also assessed by its application to a different cohort of patients with the same condition diagnosed in the financial year before the original cohort of patients. The significant predictors associated with high readmission rates that were identified from the first model were applied to the new cohort to check its predictability of the patients who were observed to have high annual readmission rate for the majority of the follow-up years. Secondly, the trajectory analysis was also performed on the validation set to check if the best model fit produced a similar number of groups and the significant risk factors identified from the model as compared to the ones recognised earlier with the original cohort of patients.

3.5.1.2 Basics of sequence analysis

The second step of the research was to perform sequence analysis.(42) In earlier clinical studies, the temporal order of events has not been investigated thoroughly, especially if the identification of a large sequence of multiple events is required.(19) The chronological order of 2 to 3 events had been studied by splitting patient cohort into a group with a particular order of events and comparing outcomes among them.(35) Sequence analysis in this research was conducted by software *'TraMineR'* in R statistical language.(41) Multiple clinical events of particular interest are fed into the program which allows it to search and identify order of them for each patient. The administrative data was manipulated and shuffled so that the time, diagnosis and treatment of every health care visit during the follow-up period were aligned in successive columns in the data.(106) The type of healthcare visit was also labelled to show whether they were elective or emergency and GP visit or hospital admission. Each row demonstrated the events that occurred with each patient, in chronological order. Sequence analysis was performed on the transformed dataset as it can search, identify and visualise sequences of events with each patient.(41) Each category of healthcare visit and its diagnosis was coded with a unique alphabet. For each patient, the string of sequence of alphabets was created based on their chronological order. Common chains of events were identified within each group. Furthermore, each event was also colour-coded, and the horizontal lines with different colours denoted events occurring in chronological order with a patient. In this way, a colour-coded plot, Lasagne graph, was created where the horizontal lines from the patients are stacked on each other.(42)

3.5.2 Technical application of Group-based trajectory modelling (GBTM)

GBTM is a semi-parametric model that relaxes the assumption of one pattern of readmission for the whole patient cohort. (39) In this model, each subgroup follows its trajectory. The model can use three different types of analysis: Logit binary, zero-inflated Poisson and censored normal analysis. Logit analysis uses a binary outcome. The censored normal function is used for continuous data, where the outcome is measured on a rating scale, and most of the observations are clustered at minimum or maximum of the scale. (39) We chose zero-inflated Poisson analysis because it is used for count data where the number of patients with zero observations is larger than expected with a purely random Poisson variation. (39) The probability of observing the data trajectory $\mathbf{y}_i$ given membership in group *k* is shown in *equation 1*.

$$\Pr(\mathbf{Y}_i = \mathbf{y}_i | C_i = k, \mathbf{W}_i = \mathbf{w}_i)$$

$$= \prod_{y_{ij}=0} [\rho_{ijk} + (1-\rho_{ijk}) e^{-\lambda_{ijk}}] \prod_{y_{ij}>0} (1-\rho_{ijk}) \frac{\exp(-\lambda_{ijk}) \lambda_{ijk}^{y_{ij}}}{y_{ij}!}.$$

Equation 1. The probability of observing the trajectory of a group. P_{ijk} is the extra-Poisson probability of a zero. The time-dependent co-variate (optional) in period j is w_{ij} and is linearly related to Log(λ_{ijk}).

The model calculates an optimal number of groups with trajectory shapes, proportion of the population in each group and the objective probability of the individual as part of a trajectory group.

The administrative data used for the model underwent multiple changes. The administrative data used in the study accumulated multiple hospital admissions and primary care GP visits for each financial year. The data had to go multiple transpositions so that each row in the table represented each patient and columns were created to display hospital admissions in chronological order. This way, the annual readmission rate for each successive year in the follow-up period was measured for every patient, and administrative dataset was converted into a longitudinal data series. The information on each co-variate was extracted from this very data.

For each patient cohort, the models were tested with a number of subgroups ranging from 2 to 8. The shape of trajectory of the annual admission rate for each subgroup was determined by testing various polynomial orders. The simplest shape was a straight horizontal line, as described by the intercept alone with the polynomial order of 0. Other shapes of the trajectories with an increasing polynomial order were linear (value 1), quadratic (value 2) and cubic (value 3). For instance, the first model with two subgroups was tried. Then the shape of trajectory for each subgroup was tested with a more complex polynomial. The model fit is considered acceptable once the polynomial order for each subgroup has the lowest standard error with a probability of less than 0.05. The BIC for

EACH INDIVIDUAL IN THE GROUP IS GIVEN A PROBABILITY SCORE BASED ON ONE'S LONGITUDINAL PATTERN OF OUTCOME. THE AVERAGE POSTERIOR PROBABILITY OF A GROUP OF MORE THAN 0.70 WAS CONSIDERED A RELIABLE PREDICTOR OF HOMOGENEITY AMONG THE INDIVIDUALS BELONGING TO THE GROUP.

model with two subgroups was noted (see below). The models with more subgroups were then verified using a similar approach.

The Statistical Analysis Software (SAS 9.4) was used to manipulate the administrative data for it to be used for analysis. The software macro 'Proc Traj' was installed in SAS to run GBTM on the data.(162) The program performs multi-level trajectory analysis which means that trends of more than one outcome can be measured simultaneously and their relationship can be assessed. This function was used to evaluate trajectory of out-of-hours GP visits along with readmission rate in patients with HF.

3.5.2.1 Details about criteria for choosing best-fit model

3.5.2.1.1 Bayesian information criterion (BIC)

It is used for the comparison of different models. For each model, the value of BIC was obtained, and the model with the maximum value of BIC is recommended. It is calculated as shown in the *equation 2*.

$$\mathrm{BIC} = \log(L) - 0.5*\log(n)*(k)$$

Equation 2. Calculation of BIC (L=maximum likelihood, n=sample size, k=number of parameters in the model).

BIC is always a negative value; hence, the maximum BIC is the one with the least negative value. Also, Bayes factor (B_{ij}) is a measure of the ratio of the probability of model *i* being the correct model to the probability of model *j.* Since the calculation of the odds of it being a correct model is very difficult, a good approximation of Bayes factor is the Log of the difference between values of BIC between model $_i$ and model $_j$ ($e^{(BICi-BICj)}$). This was used in the study to identify the best fit model. Jeffreys's scale of evidence for Bayes Factors was also used to predict substantial evidence in favour of the chosen model *(Table 5).*

Jeffreys's Scale of Evidence for Bayes Factors	
Bayes factor	Interpretation
$B_{ij} < 1/10$	Strong evidence for model j
$1/10 < B_{ij} < 1/3$	Moderate evidence for model j
$1/3 < B_{ij} < 1$	Weak evidence for model j
$1 < B_{ij} < 3$	Weak evidence for model i
$3 < B_{ij} < 10$	Moderate evidence for model i
$B_{ij} > 10$	Strong evidence for model i

Table 5. Jeffreys's scale for Bayes Factors (B_{ij}) for competing model $_i$ and $_j$, where model $_i$ has fewer groups than model $_j$. (Adapted from "Bayesian Model Selection and Model averaging' by L. Wasserman. 1997.)

ODDS OF CORRECT CLASSIFICATION INDICATES THAT THE MAXIMUM PROBABILITY BELONGING TO THE GROUP IS BETTER THAN THE PROBABILITY AT RANDOM GUESSING.

3.5.2.1.2 Posterior Group Membership Probabilities

The calculation of the group membership probability is shown in *equation 3*.

$$\hat{P}(j|Y_i) = \frac{\hat{P}(Y_i|j)\hat{\pi}_j}{\sum_j \hat{P}(Y_i|j)\hat{\pi}_j},$$

Equation 3. The equation used to calculate posterior probability ($\hat{P}(j|Y_i)$) of the individual i to a group j based on one's longitudinal pattern of behaviour, Y_i, and the estimated population ($\hat{\pi}_j$) of the group j.

The average of the posterior probabilities of all individuals in the group is calculated. The average posterior probability of a group of more than 0.70 was considered a reliable predictor of homogeneity among the individuals belonging to the group.

3.5.2.1.3 Odds of Correct Classification (OCC)

For each subgroup, OCC was calculated *(Equation 4).* The OCC of more than 5 was used as a cut-off for the distinct classification of the group. The best-fit model was selected if all the groups had OCC of more than 5. The numerator in the equation measures maximum posterior probability for the group and the denominator evaluates posterior probability based on random assignment. OCC of value 1 would mean that the maximum probability belonging to the group is not better than the probability at random guessing.

$$\mathrm{OCC}_j = \frac{\frac{AvePPj}{1-AvePPj}}{\frac{\pi j}{1-\pi j}}$$

Equation 4. Calculation of odds of correct classification of group j. ($AvePP_j$= Average group posterior probability, π_j=population size of the trajectory group j)

THE VALIDATION OF THE MODEL WAS CONDUCTED IN THE FOLLOWING WAYS:

1. PREDICTED HIGH-IMPACT USERS WERE COMPARED TO PATIENTS IN ORIGINAL COHORT WITH MORE THAN 90TH PERCENTILE OF AN ANNUAL NUMBER OF READMISSIONS FOR MORE THAN 3 YEARS WERE IDENTIFIED.
2. THE IDENTIFIED SIGNIFICANT COVARIATES ASSOCIATED WITH THE HIGH-IMPACT USERS WERE APPLIED TO THE NEW VALIDATION COHORT TO PREDICT HIGH-IMPACT USERS.
3. GBTM WAS APPLIED TO THE NEW VALIDATION COHORT.

3.5.2.2 Multinomial logistic regression to assess the effect of covariates

The effect of covariates on the subgroups was evaluated using logistic regression. The multinomial logistic regression analysis was performed within the *Proc Traj* program in SAS. Once the optimum number of groups were identified in a patient population, the co-variates were added to the model and the program assessed the effect of the covariates. All covariates were added to the chosen model to assess effect of a covariates while controlling for other factors.

The membership of an individual to a trajectory is based on probability but not certainty; hence, the conventional cross-group comparisons to assess correlation between the covariates and the groups cannot be used. Hence, multinomial logistic regression was used to assess the impact of a covariate on the probability of group membership while controlling for other confounding factors.(40) In trajectory modelling, it is assumed that time-stable co-variates influence the probability of belonging to the group. The group with persistently lowest annual admission rates were labelled as 'low-impact users' and used as a reference group so that the odds ratio for each covariate can be interpreted as the odds of membership of a particular group compared with the odds of membership of the low-impact user group, adjusted for other covariates.

3.5.2.3 Validation of the identified best fit model

3.5.2.3.1 Validation of original cohort

The internal validation of the predicted high-impact users was conducted by directly measuring annual readmission rates for each patient. 90th percentile of an annual number of readmissions among patient population for each year was =>2. The data was analysed to identify patients with =>2 readmissions every year in ≥ 3 years during the follow-up period. These patients were used as a standard to check those patients predicted by the trajectory modelling to be high-impact users. This way the

MULTINOMIAL LOGISTIC REGRESSION WAS USED TO ASSESS THE IMPACT OF A CO-VARIATE ON THE PROBABILITY OF GROUP MEMBERSHIP WHILE CONTROLLING FOR OTHER CONFOUNDING FACTORS

sensitivity and specificity of the model to detect high-impact users was calculated.(1,13)

3.5.2.3.2 Validation using a different cohort

For the validation of the model, the identified risk factors associated with the high-impact users were applied to a new cohort of patients (the validation set). These patients were diagnosed with the same medical condition in the financial year before the original cohort was first diagnosed. They had the same duration of follow-up as the original cohort of patients. The significant covariates associated with the high-impact users identified through the original cohort were applied to the validation cohort to predict those patients with annual readmission rate of ≥ 2 for ≥ 3 years during the follow-up period. The cut-off was selected as the 90th percentile of the annual number of readmissions among the patient population. Receiver operator characteristic (ROC) curves were constructed with the area under the curve (AUC) calculated using the c statistic.(163)

3.5.2.3.2.1 Application of GBTM to validation cohort

The GBTM was also applied to the validation cohort. This was done to check if the best model fit to the new data showed the number of groups, their trends in readmission rate and predictors significantly associated with high-impact users similar to the original cohort.(163)

3.5.3 Technical application of sequence analysis

3.5.3.1 Statistical software

At first, the data was modified in SAS 9.4 software to establish each row representing one patient and several columns with information on the date and diagnostic coding of the diagnosis of hospital emergency admissions during the follow-up period. Then, the sequence analysis was conducted using *TraMineR* package (version 1.8-12) in R language statistical software (R 3.2.4).(42) The statistical software has been used in other studies to orient the data in chronological order, to identify the events and their sequences, and to calculate common sequences in the data.

3.5.3.2 Sequence analysis of causes of emergency readmissions

Each cause of readmission was labelled with a unique alphabet. According to the chronological date, as the emergency admissions occurred, the string of alphabets for each patient was created. The alphabets were also colour coded to visualise the changes in the causes of emergency admissions for patients in the group *(Figure 3).* The package can visually display all the sequences of events occurring in the data for each patient. It summarises the common sequences in the group and compares it to the other groups.(42) Also, the common causes of emergency admissions were also calculated for the whole patient population and its different groups. Chi-square test was used to compare the number of sub-sequences between the groups.

3.5.3.3 Sequence analysis of types of healthcare visits

The sequence analysis was also performed to assess sequences of types of healthcare visits for each patient and to identify common sequences of healthcare utilisation by different

groups of patients. The types of healthcare visit included: elective GP visit, emergency GP visit, elective hospital admission and emergency hospital admissions. The event of death was also coded to identify the group with a high mortality. Each type of healthcare visit was colour-coded, and a horizontal colour-coded strip was created for each patient depicting chronological sequence of different types of healthcare visits during the follow-up period. The horizontal strip for each patient is stacked over each other to form 'Lasagne' plot.

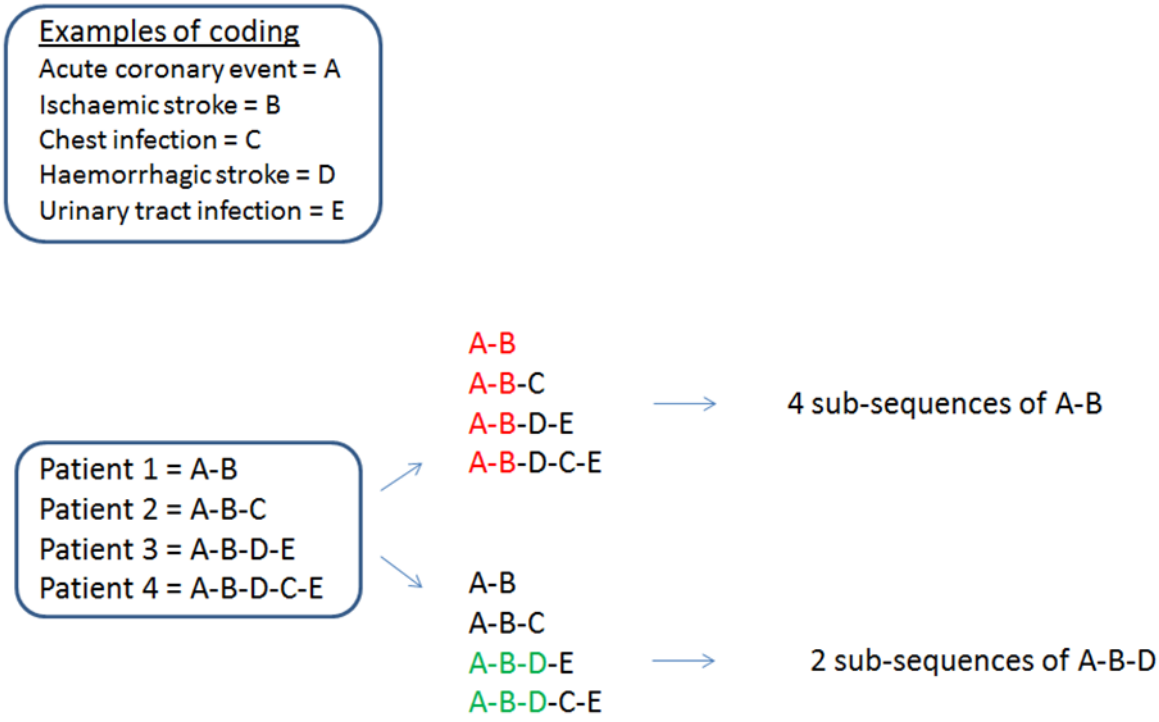


Figure 3. Example of mining of sequence data to identify common sub-sequences in the patient population.

Chapter 4. Results

4.1 Overview

This chapter demonstrates all the results from the studies conducted in the research. Trajectory and sequence analysis were successfully applied to different health datasets. Within each population cohort, discrete groups of patients with independent trends of hospital care use were identified. High-impact users accounted for a significant proportion of the patient populations studied. In most groups studied, they had persistently high readmission rates. Among HF patients, there were two types of high-impact users: chronic and short-term. Chronic users had persistently high readmission rates, whereas, short-term users had high initial readmission rates followed by a rapid decline due to high mortality. Certain patient populations had intermediate users who had the potential of becoming high-impact users later during the follow-up period. The trajectory model also identified significant predictors associated with high-impact users. It had good predictive ability and reliability when applied to a new cohort of patients with the same diagnosis. Although, high-impact users had similar common causes of readmissions. Compared with other groups, they had common discrete sequences of causes of readmissions, consisting of a few medical conditions, indicating that they undergo a repeated cycle of similar events during the follow-up period. Similarly, they had a constant series of emergency GP visits and elective and emergency hospital admissions as they approached the end of their life.

PATIENT POPULATION WITH ISCHAEMIC STROKE HAD 2 GROUPS: LOW- AND HIGH-IMPACT. HIGH IMPACT USERS (17.1%) WERE ASSOCIATED WITH THE PREVIOUS STROKE, LIVING ALONE, EPILEPSY, COMORBIDITY SCORE, POOR SOCIO-ECONOMIC STATUS, DIABETES, ADMISSION TO ITU/HDU, VISION LOSS, CHEST AND URINE INFECTION. THE DISTINCT COMMON SEQUENCES OF HOSPITAL ADMISSIONS CONSISTED OF CHEST INFECTION, URINE INFECTION AND EXTERNAL INJURIES.

4.2 Ischaemic stroke

4.2.1 Characteristics of general patient population

There were a total of 34208 patients diagnosed with an ischaemic stroke, who were recruited between 1st April 2009 and 31st March 2010. The mean age of the population at the time of diagnosis of ischaemic stroke was 72.17 (SD 13.37), with 51% males and 49% females. Within the patient population, 14.2% of them lived alone. 5.4% of the patients who had their first admission for ischaemic stroke were discharged to a nursing home; the mean length of stay was 15.35 days (SD 22.47). At the end of the follow-up period, 5.8% (n=4853) of the patients had in-hospital mortality. The main outcome was yearly total number of emergency hospital admissions during the follow-up period of 4 years.

Most of the patients were over the age of 65. A significant number of patients had non-Caucasian ethnicity. Ischaemic heart disease, previous stroke and atrial fibrillation were common co-morbidities associated with the patients. Characteristics of the patients are mentioned in *Table 6.* The proportion of patients with co-morbidity score ≥ 3 and socio-economic score ≥ 3 were 4830 (14.1%) and 21150 (61.7%) respectively. 30.2% of the patients had hospital-acquired complications including bleeding complications (129 [0.4%]), chest infection (1639 [4.7%]), urinary and faecal incontinence (1122 [3.2%]), and urinary tract infection (1748 [5.1%]). 708 patients (2.1%) had admission to intensive therapy unit, and 2118 patients (6.2%) had thrombolysis procedure carried out. 99 patients (0.3%) were fed through a nasogastric tube or percutaneous endoscopic gastrostomy. A significant number of patients (2442 [7.1%]) also had another thrombo-embolic event such as myocardial infarction and pulmonary embolism.

4.2.2 Trajectory model: classification of groups

The best-fit model by GBTM (BIC= -127547) classified patients into 2 groups: group 1 (low-impact users, n=28,358 [82.9%]) and group 2 (high-impact users, n=5849 [17.1%]) *(Figure 4).* Compared to the low-impact users, the covariates that were associated with the high-impact users are listed in *Table 7:* the 4-year in-patient mortality rate was significantly higher in the low-impact group versus the high-impact group (n=195 [3.2%] vs 1798 [6.4%], P < 0.001).

4.2.2.1 Results from validation of model

When the original patient cohort was analysed to identify patients with =>2 readmissions every year in ≥ 3 years during the follow-up period, the sensitivity and specificity of the

trajectory model to identify high-impact users in the original cohort of patients was 82.2% and 91.8% respectively.

The characteristics of the patients among validation cohort were similar to the original cohort *(Table 6).* The total number of patients in the validation cohort were 47641, of which 51% were females. The age distributions of the patients and their common past medical conditions were similar to original cohort. However, the proportion of patients with co-morbidity score ≥ 3 was higher among validation cohort compared with the original cohort. On the other hand, the proportion of patients living alone were higher in original cohort than validation cohort.

When the significant predictors associated with high-impact users were applied to the validation cohort of patients, the c statistics was 0.70, the sensitivity and specificity of the model to identify high-impact users in the validation cohort was 100.0% and 90.0% respectively. In the validation cohort (n=47641), the best-fit model (BIC=-160550) classified patient population into 2 groups: low-impact (81.3%) and high-impact (18.7%). The high-impact users identified in the validation cohort were significantly associated with the following co-variates: epilepsy (OR 1.80 [1.69-1.93], P < 0.001), living alone (OR 1.68[1.51-1.88], P < 0.001), ischaemic heart disease (OR 1.58 [1.51-1.66], P < 0.001), mental health disorder (1.55 [1.45-1.67], P < 0.001), diabetes (OR 1.52 [1.47-1.57], P < 0.001), socio-economic index (OR 1.15 [1.14-1.16], P < 0.001), history of stroke (OR 1.12 [1.06-1.17], P 0.026), co-morbidity score (1.01 [1.01-1.01], P < 0.001), prolonged length of stay (1.00 [1.00-1.00], P < 0.001), female sex (OR 0.92 [0.90-0.95], P 0.003), atrial fibrillation (OR 0.89 [0.86-0.91], P < 0.001), non-Caucasian ethnicity (OR 0.75 [0.72-0.78], P < 0.001), hearing loss (0.74 [0.64-0.86], P 0.045), discharge to nursing home (OR 0.73 [0.69-0.78], P < 0.001), renal failure (OR 0.69 [0.62-0.77], P 0.001), thrombo-embolic event (OR 0.59 [0.52-0.67], P < 0.001), chest infection (OR 0.39 [0.36-0.43], P < 0.001), and dementia (OR 0.35 [0.32-0.38], P < 0.001). These factors were similar to those found among high-impact users in original cohort.

4.2.3 Sequence analysis of causes of emergency readmissions

Common causes of emergency admissions in the patient population were similar in low and high-impact users; the causes were external injuries and fractures (n=3287, 16.6%), ischaemic stroke (n=3277, 16.5%), respiratory tract infection (n=2632, 13.3%), urine infection and urological conditions (n=2455, 12.5%), and ambulatory conditions (n=1816, 9.2%). The common distinct sequences of emergency admissions in the subgroups are mentioned in *Table 8.*

Co-variates	Original cohort (n=34208)	Validation cohort (n=47641)
Patient demographics		
Age < 45	1245 (3.6%)	1423 (2.9%)
45-54	2492 (7.2%)	2564 (5.3%)
55-64	5013 (14.6%)	5407 (11.3%)
65-74	8397 (24.5%)	10176 (21.3%)
75-84	11068 (32.3%)	15993 (33.5%)
≥85	6042 (17.6%)	12078 (25.3%
Female sex	16762 (49.0%)	24454 (51.3%)
Non-Caucasian ethnicity	4695 (13.6%)	6191 (13.0%)
Living alone	4856 (14.2%)	448 (1.2%)
Socio-economic index =>3	21150 (61.7%)	29444 (61.8%)
Discharge to nursing home	1842 (5.4%)	3233 (6.8%)
Past medical history		
Charlson co-morbidity score =>3	4830 (14.1%)	26316 (55.2%)
Ischaemic heart disease	2191 (6.4%)	3355 (7.0%)
Hypotension	285 (0.8%)	426 (0.9%)
Atrial fibrillation	7957 (23.2%)	13181 (27.7%)
Anaemia	762 (2.2%)	1488 (3.1%)
Dementia	1265 (3.7%)	2881 (6.1%)
Mental health disorders	1487 (4.3%)	1343 (2.8%)
Epilepsy	938 (2.7%)	1573 (3.3%)
Vision loss	513 (1.5%)	555 (1.6%)
Disorders of speech and swallowing	848 (2.5%)	976 (2.1%)
Cranial nerve palsy	390 (1.1%)	344 (0.7%)
Amnesia	401 (1.2%)	613 (1.3%)
Stroke	3955 (11.5%)	4705 (9.9%)
Paralysis	1171 (3.4%)	1762 (3.7%)
Diabetes	6748 (18.8%)	8847 (18.6%)
Hypertension	20616 (57.5%)	26464 (55.5%)

Table 6. Characteristics of patients with ischaemic stroke.

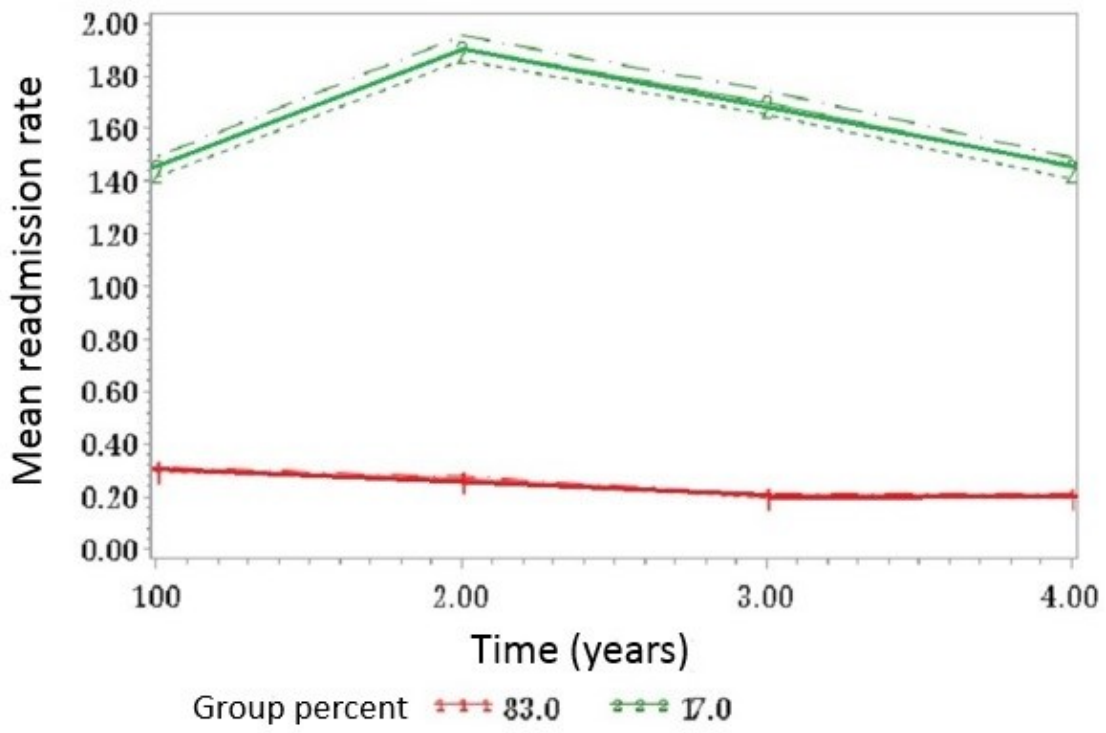


Figure 4. Trajectory pathways of subgroups of patients with ischaemic stroke (the horizontal axis starts at annual readmission rate at year one, and the dotted lines represent 95% confidence intervals for each subgroup).

Co-variates	Low-impact (n [%] or mean [SD])	High-impact (n [%] or mean [SD])	OR (95% CI)	P value
Patient characteristics				
Age	71.4 [13.6]	75.4 [11.6]	0.97 (0.92-1.02)	0.46
Female sex	13287 [47.4]	3078 [49.7]	0.95 (0.92-1.03)	0.12
Non-Caucasian ethnicity	3897 [13.9]	743 [11.9]	0.94 (0.93-0.95)	**< 0.001**
Socio-economic index	3.0 [1.4]	3.3 [1.4]	1.20 (1.19-1.21)	**< 0.001**
Living alone	3719 [13.3]	1134 [18.3]	1.25 (1.20-1.30)	**< 0.001**
Past medical history				
Charlson co-morbidity score	1.5 [0.8]	1.9 [1.1]	1.36 (1.34-1.39)	**< 0.001**
History of stroke	2615 [9.3]	1339 [21.6]	2.18 (2.10-2.27)	**< 0.001**
Ischaemic heart disease	1532 [5.5]	659 [10.6]	1.84 (0.90-3.78)	0.39
Anxiety/Depression	1114 [3.9]	373 [6.0]	1.63 (1.52-1.75)	**< 0.001**
Diabetes	4679 [16.7]	1694 [27.3]	1.23 (1.16-1.31)	**0.001**
Anaemia	576 [2.1]	183 [2.9]	1.12 (1.00-1.25)	0.29
Hypertension	15770 [56.3]	3837 [61.9]	1.06 (1.00-1.09)	0.09
Atrial Fibrillation	6267 [22.4]	1681 [27.1]	1.05 (1.00-1.09)	0.18
Renal failure	252 [0.9]	93 [1.5]	0.90 (0.78-1.05)	0.49
Dementia	1052 [3.8]	210 [3.4]	0.59 (0.54-0.65)	**< 0.001**
Stroke management factors				
Procedural complication	440 [1.6]	168 [2.7]	1.43 (1.27-1.62)	**0.002**
Admission to ITU/HDU	460 [1.6]	248 [4.0]	1.42 (1.27-1.58)	**0.001**
Length of stay	20.8 [30.7]	26.7 [35.1]	1.00 [1.00-1.01]	**< 0.001**
Discharge to nursing home	1522 [5.4]	319 [5.2]	0.61 (0.56-0.66)	**< 0.001**
Stroke associated adverse conditions				
Epilepsy	620 [2.2]	314 [5.1]	2.29 (2.10-2.51)	**< 0.001**
Vision loss	361 [1.3]	149 [2.4]	1.32 (1.17-1.49)	**0.02**
Amnesia	297 [1.1]	104 [1.7]	1.17 (1.00-1.35)	0.26
Speech and swallowing disorders	660 [2.4]	186 [3.0]	1.08 (0.97-1.21)	0.45
Cranial nerve palsy	304 [1.1]	84 [1.4]	1.08 (0.92-1.27)	0.61
Hearing loss	475 [1.7]	145 [2.3]	1.06 (0.94-1.20)	0.58
Incontinence	857 [3.1]	264 [4.3]	1.05 (0.96-1.15)	0.58
Thrombolysis	1779 [6.3]	338 [5.5]	1.01 (0.94-1.08)	0.92
Thrombo-embolic event	1758 [6.3]	684 [11.0]	0.85 (0.41-1.75)	0.82
Paralysis	1025 [3.7]	342 [5.5]	0.68 (0.62-0.74)	**< 0.001**
Hospital acquired conditions				
Urinary tract infection	1283 [4.6]	463 [7.5]	1.32 (1.22-1.43)	**0.009**
Chest infection	1184 [4.2]	451 [7.3]	1.25 (1.14-1.36)	**0.01**
Total number of hospital acquired complications	0.34 [0.62]	0.51 [0.71]	0.99 (0.94-1.04)	0.78
Pulmonary embolism/Deep vein thrombosis	236 [0.8]	27 [0.4]	0.58 (0.29-1.16)	0.43

Table 7. Association of various co-variates with high impact users in comparison to low-impact users in ischaemic stroke patients.

Ischaemic stroke				**TIA**			
Low-impact group		**High-impact group**		**Low-impact group**		**High-impact group**	
Common sequences	(n [%])	Common sequences	(n [%])	Common sequences	(n [%])	Common sequences	(n [%])
INJ-RTI	219 [1.9]	UTI-RTI	586 [8.2]	INJ-RTI	153 [1.9]	INJ-UTI	384 [10.4]
INJ-UTI	206 [1.8]	INJ-UTI	578 [8.1]	INJ-UTI	141 [1.8]	UTI-INJ	352 [9.6]
UTI-RTI	206 [1.8]	INJ-RTI	491 [6.9]	UTI-RTI	132 [1.7]	UTI-RTI	349 [9.5]
AMB-RTI	186 [1.6]	RTI-UTI	474 [6.6]	UTI-INJ	124 [1.6]	AMB-RTI	341 [9.3]
AMB-INJ	183 [1.6]	UTI-INJ	461 [6.5]	INJ-INJ-RTI	113 [1.4]	INJ-RTI	313 [8.5]

Table 8. Common sub-sequences of emergency admissions among groups of ischaemic stroke and TIA. (INJ, External injury or fracture; RTI, Respiratory tract infection; UTI, urinary tract infection and urological conditions; AMB, Ambulatory conditions).

PATIENTS WITH TIA HAD 2 GROUPS: LOW AND HIGH IMPACT. HIGH IMPACT USERS (20%) WERE ASSOCIATED WITH PREVIOUS STROKE, EPILEPSY, COMORBIDITY SCORE, DIABETES, POOR SOCIO-ECONOMIC STATUS, OLDER AGE, PROCEDURAL COMPLICATIONS, ADMISSION TO ITU/HDU, CHEST AND URINE INFECTION. THE COMMON DISTINCT SEQUENCES OF HOSPITAL ADMISSIONS AMONG HIGH IMPACT USERS WAS CHEST INFECTION, URINE INFECTION, AMBULATORY CONDITIONS.

4.3 Transient ischaemic attack (TIA)

4.3.1 Characteristics of general patient population

There were total of 20549 patients diagnosed with TIA, who were recruited between 1st April 2009 and 31st March 2010. The mean age of the population at the time of diagnosis of TIA was 72.25 (SD 13.63), with 49% males and 51% females. Within the patient population, 10.9% of them lived alone. 1.0% of the patients during their index admission for TIA were discharged to a nursing home; the mean length of stay was 2.96 days (SD 6.12). At the end of the follow-up period, 4.6% (n=945) of the patients had in-hospital mortality. The main outcome was yearly total number of emergency hospital admissions during the follow-up period of 4 years.

Most of the patients were over the age of 65, and a large proportion of patients were of the age bracket 75-84. A significant number of patients had non-Caucasian ethnicity. Previous stroke, atrial fibrillation, diabetes and hypertension were common co-morbidities associated with the patients. Other patient characteristics are mentioned in *Table 9.* The proportion of patients with co-morbidity score ≥ 3 and socio-economic score ≥ 3 were 2482 (12.1%) and 12301 (59.9%) respectively. 23.2% of the patients had hospital-acquired complications including bleeding complications (58 [0.2%]), chest infection (299 [1.4%]), urinary and faecal incontinence (186 [0.9%]) and gastrointestinal infection (110 [0.5%]). 258 patients (1.3%) had admission to intensive therapy unit, and 10 patients (0.02%) had thrombolysis procedure carried out. A significant number of patients (1470 [7.1%]) also had another thrombo-embolic event such as myocardial infarction and pulmonary embolism.

4.3.2 Trajectory model: classification of groups

The best-fit model by GBTM (BIC=-76497) classified patients into 2 groups: group 1, low-impact users, ([n=16439, 80.0%] and group 2, high-impact users [n=4110, 20.0%]) *(Figure 5).* Compared to the low-impact users, the covariates that were associated with the high-impact users are listed in *Table 10.* The 4-year in-patient mortality rate was significantly higher in high-impact group (n=328 [5.4%] vs. 617 [4.3%], P < 0.001) versus low-impact group.

4.3.2.1 Results from validation of model

When the original patient cohort was analysed to identify patients with =>2 readmissions every year in ≥ 3 years during the follow-up period, the sensitivity and specificity of the

trajectory model to identify high-impact users in the original cohort of patients was 82.7% and 94.3% respectively.

The characteristics of the patients among validation cohort were similar to the original cohort *(Table 9).* The total number of patients in the validation cohort were 47641, of which 51.3% were females. The age distributions of the patients and their common past medical conditions were similar to original cohort. However, the proportion of patients with co-morbidity score ≥ 3 were higher among validation cohort compared with the original cohort. On the other hand, the proportion of patients living alone were higher in original cohort than validation cohort.

When the significant predictors associated with high-impact users were applied to the validation cohort, the c statistics was 0.65. The sensitivity and specificity of the model to identify high-impact users in the validation cohort was 97.3% and 91.4% respectively. In the validation cohort, the best-fit model (BIC=-105157) classified patient population (n=26621) into 2 groups: low-impact (81.8%) and high-impact (18.2%). The high-impact users in the validation cohort were significantly associated with the following co-variates: epilepsy (OR 3.03 [2.77-3.32], P < 0.001), ischaemic heart disease (OR 1.93 [1.82-2.05], P < 0.001), diabetes (OR 1.67 [1.59-1.75], P < 0.001), paralysis (n=145 [3.9%] vs. 363 [2.1%], OR 1.60 [1.43-1.79], P < 0.001), hypotension (OR 1.58 [1.34-1.88], P 0.006), mental health disorder (OR 1.31 [1.17-1.46], P 0.01), socio-economic index (OR 1.23 [1.22-1.25], P < 0.001), atrial fibrillation (OR 1.15 [1.10-1.21], P 0.004), co-morbidity score (OR 1.03 [1.02-1.03], P < 0.001), older age (OR 1.02 [1.02-1.03], P < 0.001), non-Caucasian ethnicity (OR 0.65 [0.61-0.69], P < 0.001), thrombo-embolic event (OR 0.59 [0.46-0.76], P 0.034), and dementia (OR 0.50 [0.45-0.54], P < 0.001). These factors were similar to those found among high-impact users in original cohort.

4.3.3 Sequence analysis of causes of emergency readmissions

Common causes of emergency admissions in the patient population were similar in low and high-impact users; the causes were ischaemic stroke (n=1382, 19.4%), external injuries and fractures (n=1145, 16.1%), urine infection and urological conditions (n=892, 12.5%), respiratory tract infection (n=803, 11.3%) and ambulatory conditions (n=586, 8.2%). The common sequences of emergency admissions in the groups are mentioned in *Table 8.*

Co-variates	Original cohort (n=20549)	Validation cohort (n=26621)
Patient demographics		
Age < 45	763 (3.7%)	954 (3.5%)
45-54	1638 (7.9%)	2032 (7.6%)
55-64	2985 (14.5%)	3735 (14.0%)
65-74	4846 (23.5%)	6111 (22.9%)
75-84	6491 (31.5%)	8333 (31.3%)
≥85	3826 (18.6%)	5456 (20.5%)
Female sex	10473 (50.9%)	13660 (51.3%)
Non-Caucasian ethnicity	6144 (29.9%)	3338 (12.5%)
Living alone	2296 (10.9%)	168 (0.6%)
Socio-economic index =>3	12301 (59.9%)	15874 (59.7%)
Charlson co-morbidity score =>3	2482 (12.1%)	12948 (48.6%)
Ischaemic heart disease	1445 (7.0%)	1734 (6.5%)
Hypotension	183 (0.9%)	242 (0.9%)
Atrial fibrillation	3394 (16.5%)	4290 (16.1%)
Anaemia	444 (2.2%)	638 (2.7%)
Dementia	1054 (5.1%)	1331 (5.0%)
Mental health disorders	799 (3.9%)	690 (2.6%)
Epilepsy	464 (2.3%)	645 (2.4%)
Vision loss	269 (1.3%)	244 (0.9%)
Disorders of speech and swallowing	311 (1.5%)	369 (1.4%)
Cranial nerve palsy	113 (0.5%)	101 (0.4%)
Amnesia	192 (0.9%)	281 (1.1%)
Discharge to nursing home	229 (1.1%)	369 (1.5%)
Stroke	3172 (15.4%)	2766 (10.4%)
Paralysis	511 (2.5%)	168 (0.6%)
Thrombo-embolic event	1470 (7.1%)	151 (0.6%)
Hearing loss	310 (1.5%)	194 (0.7%)
Diabetes	3742 (18.2%)	4462 (16.8%)
Hypertension	10988 (53.5%)	13333 (50.1%)

Table 9. Characteristics of patients with TIA.

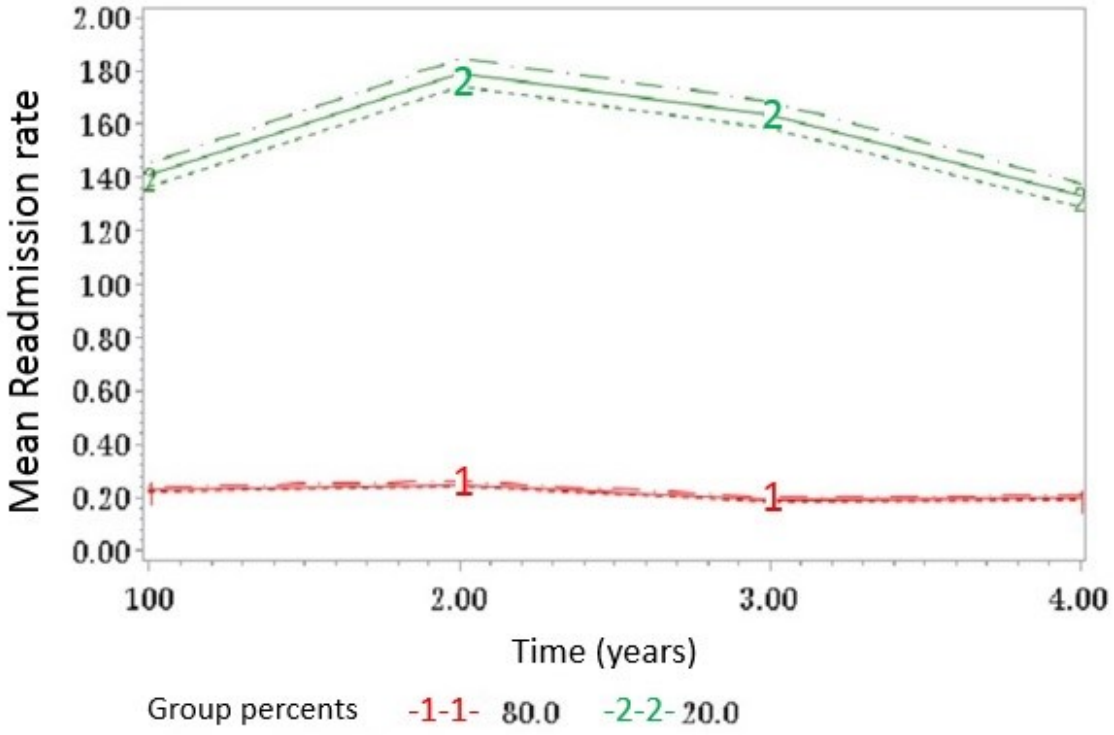


Figure 5. Trajectory pathways of subgroups of patients with TIA. (The horizontal axis starts at annual readmission rate at year one, and the dotted lines represent 95% confidence intervals for each subgroup).

Co-variates	**Low-impact (n [%] or mean [SD])**	**High-impact (n [%] or mean [SD])**	**OR (95% CI)**	**P value**
Patient characteristics				
Age	70.1 [13.8]	77.4 [11.6]	1.04 (1.04-1.04)	**< 0.001**
Female sex	7120 [49.2]	3353 [55.2]	1.05 (1.00-1.09)	0.23
Non-Caucasian ethnicity	5753 [39.7]	391 [6.1]	0.11 (0.10-0.12)	**< 0.001**
Socio-economic index	2.9 [1.4]	3.2 [1.3]	1.13 (1.12-1.14)	**< 0.001**
Living alone	1297 [8.9]	955 [15.7]	1.25 (1.16-1.34)	**0.001**
Past medical history				
Charlson co-morbidity score	1.4 [0.7]	1.8 [1.0]	1.39 (1.35-1.43)	**< 0.001**
History of stroke	1477 [10.2]	1695 [27.9]	2.51 (2.36-2.66)	**< 0.001**
Hypotension	85 [0.6]	98 [1.6]	1.86 (1.49-2.32)	**0.004**
Anxiety/Depression	503 [3.5]	296 [4.9]	1.63 (1.46-1.82)	**< 0.001**
Diabetes	2146 [14.8]	1596 [26.3]	1.58 (1.42-1.77)	**< 0.001**
Anaemia	231 [1.6]	213 [3.5]	1.55 (1.35-1.79)	**0.002**
Atrial fibrillation	1969 [13.6]	1425 [23.5]	1.27 (1.20-1.35)	**< 0.001**
Hypertension	7491 [51.7]	3497 [57.6]	0.94 (0.90-1.04)	0.13
Dementia	627 [4.3]	427 [7.0]	0.92 (0.84-1.02)	0.39
Ischaemic heart disease	736 [5.1]	709 [11.7]	0.46 (0.25-1.84)	0.19
Stroke management factors				
Procedural complications	124 [0.9]	80 [1.3]	1.40 (1.13-1.75)	**0.002**
Length of stay	2.6 [6.1]	4.8 [10.3]	1.02 (1.01-1.02)	**< 0.001**
Stroke associated adverse conditions				
Thrombo-embolic event	747 [5.2]	723 [11.9]	3.67 (2.01-6.69)	**0.03**
Epilepsy	235 [1.6]	229 [3.8]	2.25 (1.95-2.59)	**< 0.001**
Amnesia	95 [0.7]	97 [1.6]	1.62 (1.31-1.99)	**0.02**
Speech and swallowing disorders	182 [1.3]	129 [2.1]	1.36 (1.01-1.62)	0.06
Hearing loss	164 [1.1]	146 [2.4]	1.25 (1.05-1.48)	0.18
Cranial nerve palsy	72 [0.5]	41 [0.7]	1.23 (0.92-1.65)	0.47
Vision loss	154 [1.1]	115 [1.9]	1.13 (0.94-1.35)	0.49
Paralysis	267 [1.8]	241 [3.9]	1.02 (0.89-1.17)	0.87
Incontinence	111 [0.8]	75 [1.2]	0.92 (0.75-1.14)	0.69
Hospital acquired conditions				
Urinary tract infection	257 [1.8]	274 [4.5]	1.95 (1.67-2.29)	**< 0.001**
Chest infection	156 [1.1]	143 [2.3]	1.63 (1.32-2.01)	**0.02**
Total number of hospital acquired complications	0.21 [0.41]	0.36 [0.57]	0.84 (0.76-0.92)	0.06

Table 10. Association of various covariates with the high impact users as compared to the low-impact users in TIA patients.

PATIENT POPULATION WITH INTRA-CRANIAL HAEMORRHAGE HAD 5 GROUPS. THERE WAS ONE GROUP EACH OF LOW AND HIGH IMPACT USERS AND 3 GROUPS OF INTERMEDIATE USERS WITH DIFFERENT TRAJECTORIES. HIGH IMPACT USERS (0.5%) WERE ASSOCIATED WITH THROMBO-EMBOLIC EVENTS AND YOUNGER AGE. THEY DID NOT HAVE ANY DISTINCT SEQUENCE OF CAUSES OF HOSPITAL ADMISSIONS.

4.4 Non-traumatic intra-cranial haemorrhage

4.4.1 Characteristics of general patient population

There were total of 2605 patients diagnosed with non-traumatic intra-cranial haemorrhage, who were recruited between 1st April 2009 and 31st March 2010. The mean age of the population at the time of diagnosis of intra-cranial haemorrhage was 72.25 (SD 13.63), with 63% males and 37% females. Within the patient population, 11.1% of them lived alone. 3.3% of the patients during their index admission for intra-cranial haemorrhage were discharged to a nursing home: the mean length of stay was 10.82 days (SD 17.62). At the end of the follow-up period, 5.6% (n=145) of the patients had in-hospital mortality. The main outcome was yearly total number of emergency hospital admissions during the follow-up period of 4 years.

A large proportion of patients were over the age of 75 (53.4%) and non-Caucasian ethnicity (981 [37.7%]). Common past medical conditions were atrial fibrillation (430 [16.5%]), diabetes (424 [16.3%]), and hypertension (1108 [42.5%]). The proportion of patients with co-morbidity score ≥ 3 and socio-economic score ≥ 3 were 385 (14.8%) and 1590 (61.1%), respectively. A significant number of patients underwent interventions for central nervous system (n=453 [17.4%]). However, only 73 (2.8%) patients were diagnosed with hydrocephalus. 33.6% of the patients had hospital-acquired complications including urinary and faecal incontinence (71 [2.7%]), thrombo-embolic event (136 [5.2%]), and urine and chest infection (245 [9.4%]). 53 patients (2.0%) had admission to intensive therapy unit.

4.4.2 Trajectory model: classification of the groups

The best-fit model by GBTM (BIC= -2704) classified patients into 5 groups: group 1 (low-impact users) (n=1391, 53.4%), group 2 (n=745, 28.6%), group 3 (4.9%), group 4 (n=328, 12.6%), and group 5 (high-impact group, n=13, 0.5%) *(Figure 6).*

Group 1 were labelled as low-impact users because they had majority of the patients with least readmission rate in the follow-up period. The association of the co-variates with the other groups was calculated in comparison to low-impact users. Group 2, 3 and 4 were intermediate users because they had moderate annual readmission rate. Group 2 had slightly higher annual readmission rate than low-impact group. They were significantly associated with non-Caucasian ethnicity (n=731 [92.9%] vs. 180 [12.6%], OR 39.2 [29.4-52.5], P < 0.001), stroke length of stay (mean 14.8 [SD 22.6] days vs. 23.5 [SD 40.2], OR 0.99 [0.99-0.99], P 0.003), socio-economic index (mean 2.9 [SD 1.5] vs. 3.0 [SD 1.4] OR 0.78 [0.73-0.83], P < 0.001), epilepsy (n=38 [4.8%] vs. 94 [6.6%], OR 0.45 [0.31-0.66], P 0.03), and hypertension (n=285 [36.2%] vs. 653 [45.6%], OR 0.66 [0.55-0.80], P 0.03). Group 3 had

persistent intermediate readmission rate and was significantly associated with history of stroke (n=35 [20.6%] vs. 165 [11.5%], OR 1.82 [1.40-2.36], P 0.02) and epilepsy (n=21 [12.3%] vs. 94 [6.6%], OR 1.80 [1.32-2.46], P 0.05). Group 4 initially had intermediate readmission rate with progressive decline in the following years. They were associated with anxiety and depression (n=44 [22.2%] vs. 152 [10.6%], OR 1.92 [1.43-2.56], P 0.02), number of hospital acquired complications (mean=0.9 [SD 0.9] vs. 0.4 [SD 0.7], OR 1.67 [1.40-1.97], P 0.002), and socio-economic index (mean 3.4 [SD 1.3] vs. 3.0 [SD 1.4], OR 1.20 [1.11-1.30], P 0.02). Group 5 was the high-impact group with significantly higher readmission rate compared to other groups. The annual readmission rate declined during the follow-up period. They were significantly associated with thrombo-embolic event (n=6 [35.3%] vs 87 [6.1%], OR 20.3 [9.6-42.9], P < 0.001) and age (mean=60.0 [SD 18.6] vs. 68.6 [SD 17.7], OR 0.58 [0.46-0.73], P 0.01). The overall in-hospital mortality was lowest in high-impact group (n=0) compared to other groups (group 4 [n=37 18.7%], low-impact group [n=81 [5.6%], group 2 [n=27, 3.4%], group 3 [n=0], P < 0.001).

4.4.2.1 Results from validation of model

When the original patient cohort was analysed to identify patients with =>2 readmissions every year in ≥ 3 years during the follow-up period, the sensitivity and specificity of the trajectory model to identify high-impact users in the original cohort of patients was 100% and 80.5% respectively.

The characteristics of the patients among validation cohort were similar to original cohort. The total number of patients in the validation cohort were 17979, of which 50.3% were females. The age distributions of the patients and their common past medical conditions were similar to original cohort. However, the proportion of patients with socio-economic score ≥ 3 were lower among validation cohort compared with the original cohort. When the significant predictors associated with high-impact users were applied to the validation cohort of patients, the c statistics was 0.70. The sensitivity and specificity of the model to identify high-impact users in the validation cohort was 93.0% and 99.9% respectively. In the validation cohort, the best-fit model (BIC=-45270) classified patient population (n=17979) into 4 groups: low-impact group (Group 1, 58.3%), 2 intermediate groups (40.2%) and high-impact group (Group 4, 1.5%). The high-impact users were significantly associated with the following co-variates: epilepsy (OR 3.67 [2.97-4.53], P < 0.001), diabetes (OR 1.99 [1.65-2.41], P < 0.001), atrial fibrillation (OR 1.95 [1.60-2.39], P < 0.001), socio-economic index (OR 1.18 [1.12-1.24], p 0.001), co-morbidity score (OR 1.02 [1.01-1.03], P 0.05), and older age (OR 0.98 [0.98-0.98], P < 0.001).

4.4.3 Sequence analysis of causes of emergency readmissions

The common causes of emergency admissions among patients with non-traumatic intra-cranial haemorrhage were external injury and fracture (n=283, 20.2%), respiratory tract infection (n=199, 14.2%), urine infection and urological conditions (n=168, 11.9%), ambulatory conditions (n=115, 8.2%) and non-traumatic intra-cranial haemorrhage (n=111, 7.9%). The common causes of emergency admissions in group 1 (low-impact users) and group 2 (intermediate users) were similar to the general patient population. The common causes among group 3 were respiratory tract infection (n=14, 12.7%), dementia (n=13,

11.8%), epilepsy and seizure (n=11, 10.0%) and urine infection and urological conditions (n=11, 10.0%). The common causes of emergency admissions in group 4 were respiratory tract infection (n=45, 13.8%), external injury and fracture (n=42, 12.9%), urine infection and urological conditions (n=42, 12.9%), non-traumatic intra-cranial haemorrhage (n=35, 10.7%), epilepsy and seizure (n=27, 8.3%). The common causes of emergency admissions in high-impact users were respiratory tract infection (n=59, 21.3%), ambulatory conditions (n=55, 19.9%), epilepsy and seizure (n=43, 15.5%), gastro-intestinal bleeding (n=32, 11.5%), and non-traumatic intra-cranial haemorrhage (n=25, 9.0%). No distinct sequences of causes of readmissions were identified among low- and high-impact groups. The common sequences of readmissions among intermediate groups are mentioned in *Table 11*.

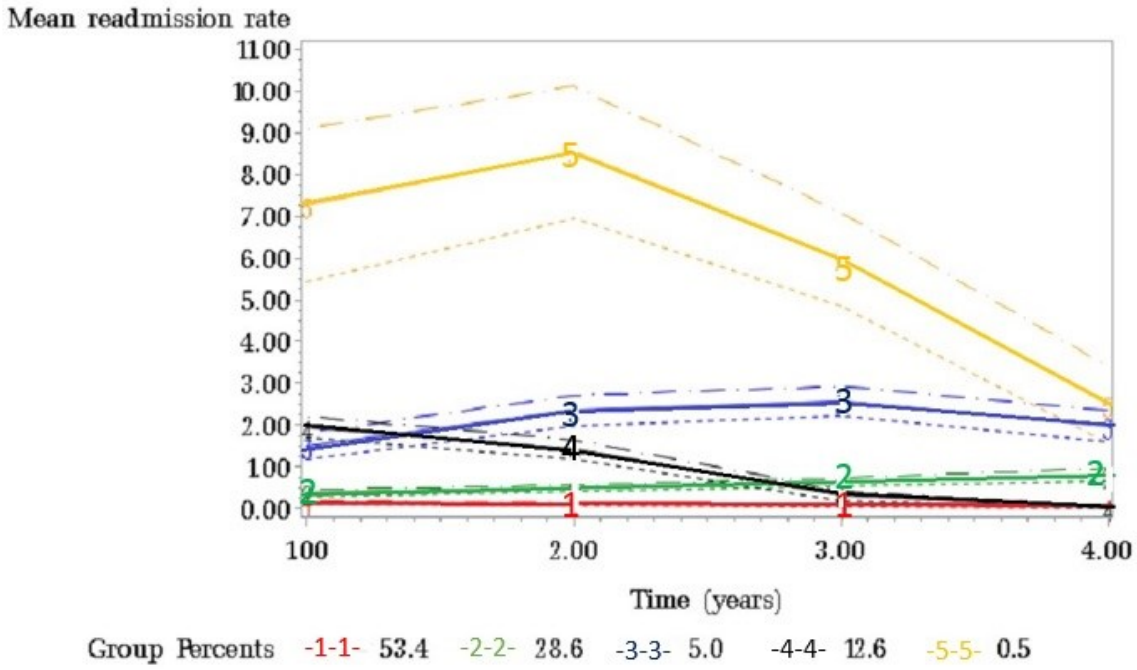


Figure 6. Trajectory pathways of subgroups of patients with intracranial haemorrhage. (The horizontal axis starts at annual readmission rate at year one, and the dotted lines represent 95% confidence intervals for each subgroup).

Group 2 (slight increase in readmission rate compared to low-impact group)		**Group 3 (moderately high and persistent readmission rate)**		**Group 4 (gradually declining readmission rate)**	
Common sequences	(n [%])	Common sequences	(n [%])	Common sequences	(n [%])
INJ-UTI	30 [4.9]	INJ-UTI	22 [20.0]	UTI-RTI	22 [6.7]
INJ-RTI	29 [4.8]	INJ-RTI	19 [17.2]	INJ-RTI	19 [5.8]
UTI-RTI	25 [4.1]	UTI-RTI	17 [15.4]	DEM-INJ	18 [5.5]
UTI-INJ	24 [3.9]	RTI-UTI	12 [10.9]	INJ-UTI	17 [5.2]
RTI-UTI	20 [3.3]	UTI-INJ	12 [10.9]	INJ-DEM	15 [4.6]

Table 11. Common sub-sequences of emergency admissions among intermediate groups of ischaemic stroke and TIA. (INJ, External injury or fracture; RTI, Respiratory tract infection; UTI, urinary tract infection and urological conditions; AMB, Ambulatory conditions; DEM, Dementia.

PATIENT POPULATION WITH ELECTIVE AAA REPAIR HAD 2 GROUPS: LOW AND HIGH IMPACT. HIGH IMPACT USERS (17.3%) WERE ASSOCIATED WITH FEMALE SEX, OTHER VASCULAR PROCEDURES, POOR SOCIO-ECONOMIC STATUS, OLDER AGE AND CO-MORBIDITY SCORE. THE DISTINCT COMMON SEQUENCES OF HOSPITAL ADMISSIONS CONSISTED OF CHEST INFECTION, ISCHAEMIC HEART DISEASE, AND COPD.

4.5 Elective AAA repair

4.5.1 Characteristics of general patient population

There were 16,973 patients in the original study population, who were recruited between 1st April 2006 to 31st March 2009. 83.3% of the patients were males *(Table 12).* Majority of the patients were between age 65 and 85. A relatively large number of patients were non-Caucasian (n=2378 [14.0%]) and had co-morbidity score =>3 (n=8502 [50.1%]). A small number of patients lived alone (n=73 [0.4%]) and were discharged to nursing home (n=65 [0.3%]) after being admitted for AAA repair. The main outcome was yearly total number of emergency hospital admissions during the follow-up period of 5 years.

Common past medical conditions were diabetes, hypertension, and ischaemic heart disease. Most of the patients underwent open repair for AAA (n=10801 [63.6%]) and a large of patients also had associated other vascular procedure (5009 [29.5%]). Revision procedures were performed in 41 patients. It was estimated that 21.8% of the patients had general hospital associated complications such as chest infection (n=1311 [7.7%]), urine infection (n=351 [2.1%]), gastro-intestinal complications (n=728 [4.3%]), and renal failure (n=623 [3.7%]). 396 (2.3%) and 722 (4.2%) had wound infection and dehiscence, respectively. Graft infection and other graft complications were present in 67 (0.4%) and 376 (2.2%) patients, respectively.

4.5.2 Trajectory model: classification of the groups

The best-fit model (BIC -61509) classified the patient population (n=16,973) into 2 groups based on their non-elective readmissions: Group 1 (82.0%) and Group 2 (18.0%) *(Figure 7).* Group 1 had persistently low rate of readmission and therefore, was classified as low-impact; while, group 2 had constant high rate of readmission and was labelled as high-impact. Various co-variates were associated with group 2 as compared to group 1 as mentioned in *Table 13.* The co-variates with positive and significant association with high-impact users (group 2) were female sex (OR 1.23 [1.15-1.32], P=0.001), undergoing other vascular procedures (OR 1.21 [1.14-1.28], P 0.003), poor socio-economic status (OR 1.13 [1.11-1.15], P < 0.001), older age (OR 1.04 [1.04-1.04], P < 0.001), and higher co-morbidity score (OR 1.04 [1.04-1.05], P < 0.001). The co-variates with lower odds to be related to high-impact users were chronic peripheral vascular disease (OR 0.80 [0.72-0.90], P=0.05), renal failure (OR 0.72 [0.63 -0.82], P=0.01), open repair (OR 0.61 [0.58-0.65], P < 0.001), non-Caucasian ethnicity (OR 0.61 [0.57-0.66], P < 0.001), heart failure (OR 0.59 [0.51 -0.68], P < 0.001), and cardiac arrest (OR 0.26 [0.17-0.39], P < 0.001). The 5-year mortality among high-impact users was 27.0% (n=768) vs. 23.7% (n=3354) for low-impact users (P < 0.001). The high-impact users had increased number of elective admissions during the follow-up period (mean 4.4 [SD 5.4]) compared to low-impact users (mean 2.5 [SD 3.9], P < 0.001). They had higher number of elective vascular procedures (mean 0.23 [SD 0.64]) compared to low-impact users (0.13 [SD 0.47], P < 0.001). Similarly, the high-impact group had higher number of patients undergoing revision of procedure (n=151, 5.3%) as compared to low-impact group (n=354, 2.5%, P < 0.001).

4.5.2.1 Results from validation of model

When the original patient cohort was analysed to identify patients with =>2 readmissions every year in ≥ 3 years during the follow-up period, the sensitivity and specificity of the model to detect high-impact users was 100% and 89.2% respectively.

The validation cohort (n=7210) had similar age and sex distribution to the original cohort *(Table 12).* Compared to original cohort, the validation cohort had a higher proportion of patients with non-Caucasian ethnicity and open AAA repair. However, they had a lower proportion of patients with co-morbidity score ≥ 3.

The predictors that were significantly associated with high-impact users were applied to a different cohort of patients, validation set, who were diagnosed in the year 2003-2004 for validation of the model. The AUC for c-statistics was 0.84. The sensitivity and specificity of the model to predict high-impact users in the validation cohort was 100.0% and 85.4% respectively. The trajectory analysis of the validation cohort showed that the best-fit model (BIC -26232) classified the population (n=7210) into 2 groups: group 1 (low-impact, 82.7%) and group 2 (high-impact, 17.3%). The co-variates associated with group 2 in the validation set were female sex (OR 1.23 [1.11-1.36], P=0.05), poor socio-economic index (OR 1.15 [1.12-1.18], P < 0.001), older age (OR 1.03 [1.02-1.03], P < 0.001), co-morbidity score (OR 1.03 [1.02-1.04], P=0.002), prolonged length of stay (OR 1.01 [1.01-1.01], P=0.001), other procedures (OR 0.76 [0.65-0.87, P=0.046), renal failure (OR 0.63 [0.50-0.78], P=0.033), wound dehiscence (OR 0.62 [0.50-0.77], P=0.028), admission to ITU (OR 0.40 [0.26-0.63],

P=0.047), and cardiac arrest (OR 0.15 [0.07-0.33], P=0.015). These risk factors were similar to those found among high-impact users in the original cohort.

4.5.3 Sequence analysis of causes of emergency readmissions

Within the patient population, the common causes of non-elective readmissions over 5-year period were respiratory tract infection (n=748, 7.7%), chest pain (n=543, 5.6%), iatrogenic injuries (n=465, 4.7%), haemorrhage (n=462, 4.7%), and external injuries (n=461, 4.7%). Of the total population, 57.6% had emergency readmission (n=9791). Within low-impact users, 49.7% of them had emergency readmission (n=6918), none of these patients had multiple readmissions but had similar common causes of emergency readmissions. Of the high-impact users, 82.8% of them had emergency readmissions (n=2531). The common causes and sequences of readmissions are mentioned in *Table 14.*

Co-variates	Original cohort (n=16973)	Validation cohort (n=7210)
Age < 45	21 (0.1%)	12 (0.2%)
45-54	122 (0.7%)	69 (0.9%)
55-64	1774 (10.4%)	807 (11.2%)
65-74	6950 (40.9%)	3159 (43.8%)
75-84	7238 (42.6%)	2956 (41.0%)
≥85	868 (5.1%)	207 (2.8%)
Female sex	2338 (13.7%)	953 (13.2%)
Non-Caucasian ethnicity	2378 (14.0%)	1695 (23.5%)
Charlson co-morbidity score =>3	8502 (50.1%)	2711 (37.6%)
Ischaemic heart disease	1892 (11.1%)	781 (10.8%)
Hypotension	291 (1.7%)	95 (1.3%)
Chronic peripheral vascular disease	832 (4.9%)	297 (4.1%)
Diabetes	1886 (11.1%)	484 (6.7%)
Hypertension	9201 (54.2%)	2698 (37.4%)
Anaemia	455 (2.6%)	153 (2.1%)
Living alone	73 (0.4%)	73 (1.0%)
Socio-economic index =>3	9669 (57.0%)	4131 (57.3%)
Discharge to nursing home	65 (0.3%)	53 (0.7%)
Revision procedure	41 (0.2%}	32 (0.4%)
Other vascular procedures	5009 (29.5%)	506 (7.0%)
Renal failure	623 (3.7%)	273 (3.8%)
Acute peripheral vascular condition	415 (2.4%)	117 (1.6%)
Open procedure technique	10801 (63.6%)	6822 (94.6%)

Table 12. Characteristics of patients with elective AAA repair.

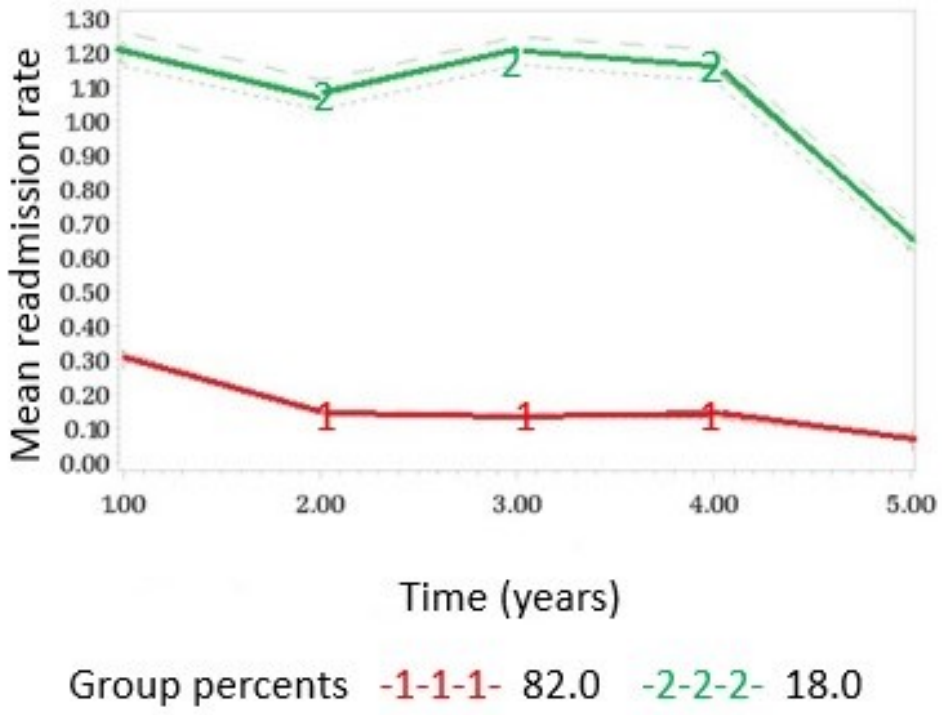


Figure 7. Trajectory pathways of subgroups of patients with elective AAA repair. (The horizontal axis starts at annual readmission rate at year one, and the dotted lines represent 95% confidence intervals for each subgroup).

Risk factors	Low-impact users	High-impact users	Odds ratio (95% CI)	P value
Patient demographics				
Age	73.1 (SD 7.3)	75.6 (SD 7.1)	1.04 (1.04-1.04)	**< 0.001**
Female sex	1829 (13.1)	509 (16.9)	1.23 (1.15-1.32)	**0.001**
Socio-economic index	2.8 (1.3)	3.1 (1.3)	1.13 (1.11-1.15)	**< 0.001**
Non-Caucasian ethnicity	2081 (14.9)	297 (9.9)	0.61 (0.57-0.66)	**< 0.001**
Living alone	49 (0.3)	24 (0.8)	1.65 (1.21-2.25)	0.11
Past medical history				
Diabetes	1477 (10.6)	409 (13.6)	1.22 (1.00 -1.39)	0.11
Anaemia	350 (2.5)	105 (3.5)	1.21 (1.04 -1.37)	0.17
Ischaemic heart disease	1478 (10.6)	414 (13.8)	1.15 (1.07 -1.23)	0.06
Mental health disorders	169 (1.2)	55 (1.8)	1.12 (0.91-1.36)	0.57
Hypotension	232 (1.7)	59 (1.9)	1.05 (0.88 -1.26)	0.76
Co-morbidity score	3.9 (SD 5.7)	5.6 (SD 6.6)	1.04 (1.04-1.05)	**< 0.001**
Stroke	202 (1.4)	85 (2.8)	0.98 (0.83 -1.16)	0.92
Hypertension	7556 (64.1)	1645 (54.7)	0.97 (0.92 -1.02)	0.47
Chronic peripheral vascular disease	671 (4.8)	161 (5.4)	0.80 (0.72-0.90)	**0.05**
Heart failure	435 (3.1)	125 (4.2)	0.59 (0.51 -0.68)	**< 0.001**
Management factors				
Procedure based				
Type of AAA repair- Open	9292 (66.5)	1509 (50.2)	0.61 (0.58-0.65)	**< 0.001**
Other vascular procedures	3842 (27.5)	1167 (38.8)	1.21 (1.14-1.28)	**0.003**
Other procedures	733 (5.2)	135 (4.5)	0.87 (0.77-0.98)	0.23
Prolonged length of stay	10.6 (SD 11.6)	11.5 (SD 12.7)	1.00 (1.00-1.01)	**< 0.001**
Procedure-related complications				
Revision of graft	32 (0.2)	9 (0.3)	1.21 (0.81-1.80)	0.67
Graft infection	56 (0.4)	11 (0.4)	0.73 (0.49 -1.11)	0.44
Other graft complications	287 (2.1)	89 (2.9)	1.12 (0.96 -1.30)	0.46
Wound dehiscence	589 (4.2)	133 (4.4)	0.97 (0.86 -1.09)	0.75
Wound infection	316 (2.3)	80 (2.7)	1.22 (1.04-1.42)	0.19
Other procedural complications	150 (1.1)	27 (0.9)	0.78 (0.60 -1.01)	0.31
Other complications				
Gastro-intestinal complications	571 (4.1)	106 (3.5)	0.83 (0.73 -0.94)	0.13
Acute peripheral vascular disease	337 (2.4)	78 (2.6)	0.92 (0.79-1.07)	0.59
Pulmonary embolism/Deep venous thrombosis	56 (0.4)	7 (0.2)	0.87 (0.52-1.45)	0.78
Urinary tract infection	272 (1.9)	79 (2.6)	1.31 (1.07 -1.58)	0.17
Respiratory tract infection	1083 (7.7)	228 (7.6)	1.01 (0.87 -1.17)	0.94
Total number of HACs	0.24 (0.51)	0.27 (0.53)	0.92 (0.83-1.03)	0.42
Renal failure	508 (3.6)	115 (3.8)	0.72 (0.63 -0.82)	**0.01**
Discharge to nursing home	53 (0.4)	12 (0.4)	0.76 (0.52-1.12)	0.47
Cardiac arrest	148 (1.1)	9 (0.3)	0.26 (0.17-0.39)	**< 0.001**

Table 13. Co-variates associated with high-impact users compared to low-impact users.

High-impact group		
Common causes	**Common sequences of readmissions**	**N [%]**
RTI (n=207, 7.3%)	COPD→RTI	135 [4.7]
Iatrogenic injuries (n=171, 6.0%)	RTI→COPD	133 [4.7]
Chest pain (n=165, 5.8%)	Ischaemic heart disease→chest pain	93 [3.3]
Haemorrhage (n=137, 4.8%)	Chest pain→ischaemic heart disease	83 [2.9]
COPD (n=136, 4.8%)	Urinary tract infection→RTI	74 [2.6]
External injuries (n=126, 4.7%)	RTI→COPD→COPD→RTI	67 [2.4]
Ischaemic heart disease (n=123, 4.3%)	COPD→RTI→RTI→COPD	64 [2.2]
Urinary tract infection (n=111, 3.9%)	External injury→RTI	62 [2.1]
Hypotension (n=102, 3.6%)	Chest pain→RTI	60 [2.1]
Heart failure (n=96, 3.4%)	RTI→heart failure	58 [2.0]

Table 14. Common causes of emergency readmissions and their sequence among subgroups of patient populations (RTI: respiratory tract infection, COPD: Chronic obstructive pulmonary disease).

PATIENT POPULATION FOLLOWING RAAA REPAIR HAD 3 GROUPS: LOW IMPACT (82.7%), CHRONIC HIGH IMPACT (10.1%) AND SHORT-TERM HIGH IMPACT (7.2%). CHRONIC HIGH IMPACT USERS WERE ASSOCIATED WITH HEART FAILURE, FEMALE SEX, PERIPHERAL VASCULAR DISEASE, UNDERGOING OPEN ANEURYSM REPAIR AND OTHER PROCEDURES, RENAL FAILURE, GASTROINTESTINAL COMPLICATIONS AND GENERAL HOSPITAL-ACQUIRED COMPLICATIONS. DISTINCT COMMON SEQUENCES OF READMISSIONS CONSISTED OF CHEST INFECTION AND COPD AMONG CHRONIC HIGH IMPACT USERS.

4.6 Ruptured AAA repair

4.6.1 Characteristics of general patient population

There were 4144 patients in the original study population, who were recruited between 1st April 2006 and 31st March 2009. 84.0% of the patients were males *(Table 15).* Majority of the patients were between age 65 and 85. A relatively large number of patients were non-Caucasian (n=736 [17.7%]) and had co-morbidity score =>3 (n=1989 [48.5%]). A small number of patients lived alone (n=23 [0.5%]) and were discharged to nursing home (46 [1.1%]) after being admitted for AAA repair. The main outcome was yearly total number of emergency hospital admissions during the follow-up period of 5 years.

Common past medical conditions were ischaemic heart disease, hypertension and diabetes. Most of the patients underwent open repair for AAA (3877 [93.6%]), and a large portion of the patients had undertaken other vascular procedures (n=678 [16.4%]). Revision procedures were performed in 22 (0.5%) patients. It was estimated that 36.8% of the patients had general hospital associated complications such as chest infection (n=880 [21.2%]), urine infection (n=122 [2.9%]), gastrointestinal bleeding and infection (n=378 [9.1%]). 316 (7.6%) and 411 (9.9%) had wound infection and dehiscence respectively. Graft infection and other graft complications were present in 42 (1.0%) and 74 (1.7%) patients, respectively.

4.6.2 Trajectory model: classification of the groups

The best-fit model (BIC -9936, AIC -9895) classified the patient population (n=4144) into 3 subgroups based on their non-elective annual readmission rates: Group 1 (82.7%), Group 2 (10.1%) and Group 3 (7.2%) *(Figure 8).* Group 1 had a persistently low rate of readmission and, therefore, was classified as low-impact. Those with high readmission rates (high-impact users) were part of Group 2 and Group 3. Group 2 included chronic high-impact users because they had an annual increase in readmission rate. Group 3 were short-term high-impact Short-term high impact users that initially had high readmission rate but then had a rapid decline in readmission rate. Various risk factors were associated with chronic and short-term high-impact groups as compared to Group 1, mentioned in *Table 16* and *Table 17* respectively. The 5-year mortality rate among high-impact users, Group 2 (n=60, 15.0%) and Group 3 (n=157, 53.4%), was significantly lower than the low-impact group (n=1997, 57.9%, $P < 0.001$). The proportion of patients undergoing revision of procedure was higher in high-impact users, chronic (n=19, 4.8%) and short-term (n=8, 2.7%) as compared to low-impact users (n=23, 0.7%, $P < 0.001$). The mean number of elective vascular procedures during the

follow-up period was high among high-impact users, chronic (0.12 [SD 0.59]) and short-term (0.16 [SD 0.53]), compared to the low-impact users (0.03 [SD 0.21]). Similarly, the mean number of elective admissions during the follow-up period was increased among the high-impact users, chronic (3.5 [SD 5.3]) and short-term (3.0 [SD 5.7]) as compared to low-impact users (0.9 [SD 2.2], P < 0.001).

4.6.2.1 Results from validation of model

When the original patient cohort was analysed to identify patients with =>2 readmissions every year in ≥ 3 years during the follow-up period, the sensitivity and specificity of the model to detect chronic high-impact users in the original cohort of patients was 23.5% and 94.3% respectively.

The validation cohort (n=2330) had similar age and sex distribution to the original cohort *(Table 15).* Compared to original cohort, the validation cohort had a higher proportion of patients with non-Caucasian ethnicity and open AAA repair. However, they had a lower proportion of patients with co-morbidity score ≥ 3.

The predictors that were significantly associated with high-impact users were applied to a different cohort of patients, validation set, who were diagnosed in the year 2003-2004 for validation of the model. The AUC for c-statics was 0.71. The sensitivity and specificity of the model to predict high-impact users in the validation cohort was 52.1% and 99.6% respectively. The trajectory analysis on the validation cohort showed that the best-fit model (BIC -5278) classified the population (n=2330) into 3 groups: Group 1 (low-impact, 67.2%), Group 2 (30.3%) and Group 3 (chronic high-impact, 2.5%). The covariates associated with chronic high-impact users in the validation set were prolonged length of stay (OR 1.8 [1.60-2.03], P < 0.001) and co-morbidity score (OR 1.1 [1.05-1.10], P 0.05).

4.6.3 Sequence analysis of causes of emergency readmissions

Within patient population, the common causes of non-elective readmissions over 5-year period were respiratory tract infection (n=127, 8.4%), COPD (chronic obstructive pulmonary disease) (n=80, 5.3%), hypotension (n=77, 5.1%), haemorrhage (n=70, 4.6%), and chest pain (n=70, 4.6%). Within low-impact users, the common causes of readmissions were respiratory tract infection (n=66, 7.9%), chest pain (n=45, 5.4%), hypotension (n=45, 5.4%), haemorrhage (n=43, 5.2%), and external injury (n=41, 4.9%). No common sequences of multiple readmissions were identified among low-impact users. The common causes of readmissions and their distinct sequences among high-impact users are mentioned in *Table 18*.

Co-variates	Original cohort (n=4144)	Validation cohort (n=2330)
Age < 45	5 (0.1%)	2 (0.1%)
45-54	25 (0.6%)	27 (1.2%)
55-64	414 (9.9%)	299 (13.4%)
65-74	1559 (37.6%)	961 (43.0%)
75-84	1814 (43.7%)	946 (42.3%)
≥85	327 (7.8%)	95 (4.1%)
Female sex	663 (16.0%)	345 (14.8%)
Non-Caucasian ethnicity	736 (17.7%)	900 (38.6%)
Charlson co-morbidity score =>3	1989 (48.5%)	48.5%
Ischaemic heart disease	510 (12.3%)	276 (11.8%)
Hypotension	178 (4.3%)	65 (2.8%)
Chronic peripheral vascular disease	164 (3.9%)	85 (3.6%)
Diabetes	367 (8.8%)	110 (4.7%)
Stroke	87 (2.1%)	50 (2.1%)
Heart failure	238 (5.7%)	121 (5.2%)
Hypertension	1926 (46.5%)	698 (29.9%)
Anaemia	157 (3.7%)	51 (2.2%)
Dementia	29 (0.7%)	11 (0.5%)
Living alone	23 (0.5%)	17 (0.7%)
Socio-economic index =>3	1491 (36.3%)	1432 (61.0%)
Discharge to nursing home	46 (1.1%)	24 (1.0%)
Revision procedure	22 (0.5%)	10 (0.4%)
Other vascular procedures	678 (16.4%)	211 (9.1%)
Renal failure	613 (14.8%)	302 (12.9%)
Acute peripheral vascular condition	197 (4.7%)	83 (3.6%)
Open procedure technique	3877 (93.6%)	2321 (99.6%)

Table 15. Characteristics of patients who had ruptured AAA repaired.

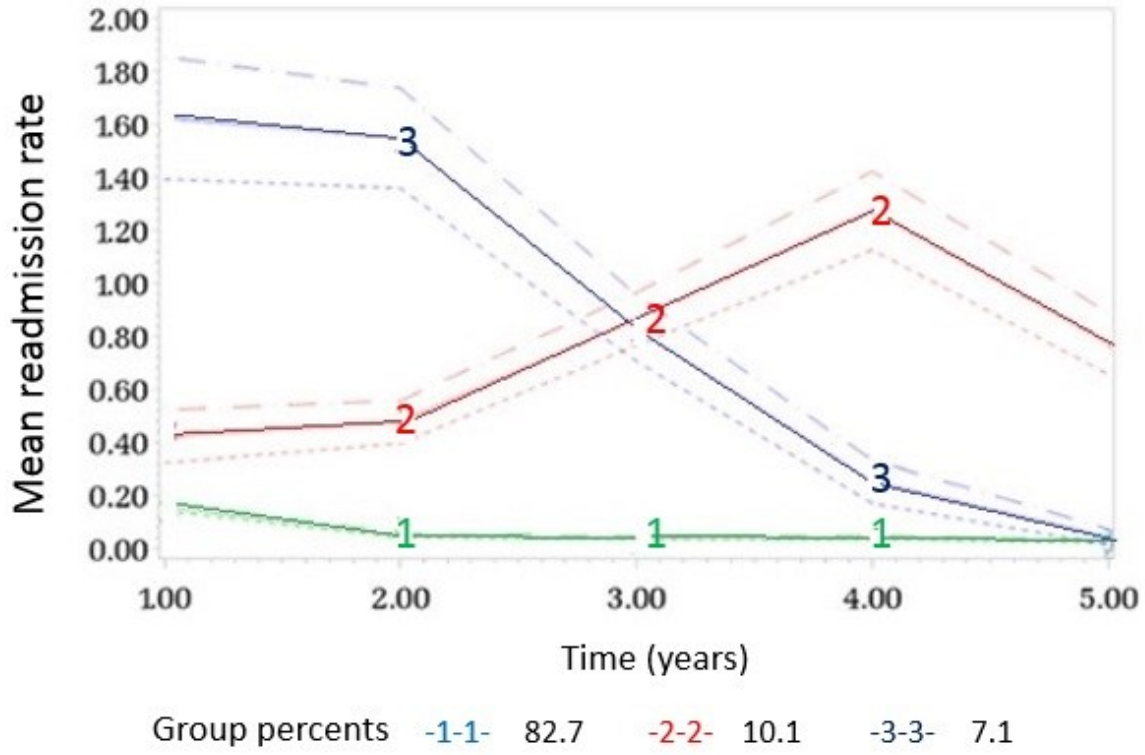


Figure 8. Trajectory pathways of subgroups of patients with ruptured AAA repair. (The horizontal axis starts at annual readmission rate at year one, and the dotted lines represent 95% confidence intervals for each subgroup).

Risk factors	Low-impact (n [%]) or mean [SD]	Chronic high-impact (n [%]) or mean [SD]	OR	CI (95%)	P value
Patient demographics					
Age	73.5 [SD 7.6]	75.5 [SD 7.5]	1.01	0.99-1.03	0.51
Female sex	283 [12.5]	91 [19.4]	3.03	2.05-4.48	**0.005**
Non-Caucasian ethnicity	332 [14.6]	326 [23.2]	1.58	1.09-2.29	0.21
Socio-economic index	2.9 [SD 1.3]	2.9 [SD 1.3]	0.98	0.88-1.10	0.88
Past medical history					
Co-morbidity score	4.1 [SD 6.1]	5.8 [SD 8.4]	0.98	0.96-1.00	0.58
Heart failure	92 [4.1]	120 [8.5]	7.77	3.39-17.81	**0.01**
Peripheral vascular disease	164 [7.2]	143 [10.2]	7.24	4.06-12.94	**< 0.001**
Mental health disorders	37 [1.6]	22 [1.6]	1.19	0.32-4.44	0.89
Diabetes	177 [7.8]	147 [10.5]	1.15	0.63-2.09	0.82
Ischaemic heart disease	293 [12.9]	169 [12.0]	1.06	0.68-1.65	0.88
Hypertension	1127 [49.7]	567 [40.3]	0.73	0.54-0.97	0.26
Procedural characteristics					
Open repair	2095 [92.4]	1358 [96.6]	7.85	4.41-13.96	**< 0.001**
Other vascular procedures	394 [17.4]	187 [13.3]	0.47	0.31-0.71	0.07
Other procedures	340 [13.9]	261 [18.6]	2.64	1.62-4.31	**0.05**
Admission to ITU	82 [8.9]	126 [3.0]	1.93	1.06-3.53	0.27
Length of stay	23.7 [SD 21.7]	3.4 [SD 4.2]	0.59	0.55-0.62	**< 0.001**
Procedure-related complications					
Renal failure	298 [13.1]	261 [18.6]	11.59	6.89-19.49	**< 0.001**
Gastro-intestinal complications	233 [10.3]	103 [7.3]	3.32	1.79-6.17	**0.05**
Graft complications	73 [3.2]	25 [1.8]	2.01	0.48-8.41	0.62
Wound complications	371 [16.4]	234 [16.6]	1.86	1.19-2.92	0.17
Hypotension	83 [3.7]	85 [6.0]	1.27	0.61-2.66	0.74
Anaemia	100 [4.4]	35 [2.5]	0.88	0.34-2.27	0.88
Hospital acquired complications					
Total number of HACs	0.51 [SD 0.75]	0.42 [SD 0.64]	2.56	1.77-3.71	**0.01**
Respiratory tract infection	544 [23.9]	217 [15.4]	1.86	1.02-3.39	0.29
Urinary tract infection	89 [3.9]	10 [0.7]	0.84	0.24-3.00	0.89

Table 16. Co-variates associated with Group 1 (chronic high-impact) as compared to low-impact users.

Risk factors	Low-impact (n [%]) or mean [SD]	Short-term (n [%]) or mean [SD]	OR	CI (95%)	P value
Patient characteristics					
Age	73.5 [SD 7.6]	75.2 [SD 7.5]	1.02	1.02-1.03	**0.005**
Female sex	283 [12.5]	91 [19.4]	1.48	1.26-1.73	**0.02**
Non-Caucasian ethnicity	332 [14.6]	78 [16.6]	1.13	0.96-1.33	0.46
Socio-economic index	2.9 [SD 1.3]	3.2 [SD 1.3]	1.16	1.11-1.22	**0.001**
Past medical history					
Co-morbidity score	4.1 [SD 6.1]	4.8 [SD 6.9]	1.02	1.00-1.03	0.06
Peripheral vascular disease	164 [7.2]	43 [9.1]	1.16	0.92-1.46	0.53
Diabetes	177 [7.8]	43 [9.1]	1.13	0.87-1.46	0.65
Hypertension	1127 [49.7]	232 [49.4]	0.94	0.83-1.07	0.63
Heart failure	92 [4.1]	26 [5.5]	0.76	0.53-1.07	0.41
Ischaemic heart disease	293 [12.9]	48 [10.2]	0.73	0.60-0.89	0.10
Mental health disorders	37 [1.6]	7 [1.5]	0.67	0.41-1.10	0.42
Stroke	41 [1.8]	6 [1.3]	0.51	0.28-0.94	0.26
Procedural characteristics					
Other vascular procedures	394 [17.4]	97 [20.6]	1.07	0.90-1.29	0.69
Length of stay	23.7 [SD 21.7]	26.5 [SD 24.5]	1.01	1.00-1.01	**0.02**
Other procedures	340 [13.9]	58 [12.3]	0.89	0.73-1.08	0.54
Open repair	2095 [92.4]	424 [90.2]	0.78	0.61-0.99	0.29
Admission to ITU	82 [8.9]	11 [2.3]	0.71	0.49-1.04	0.37
Procedure-related complications					
Anaemia	100 [4.4]	22 [4.7]	1.08	0.82-1.43	0.77
Graft complications	73 [3.2]	15 [3.2]	0.98	0.70-1.38	0.95
Gastro-intestinal complications	233 [10.3]	42 [8.9]	0.83	0.67-1.02	0.38
Wound complications	371 [16.4]	57 [12.1]	0.71	0.59-0.86	0.07
Renal failure	298 [13.1]	54 [11.5]	0.69	0.56-0.84	0.06
Hospital acquired complications					
Urinary tract infection	89 [3.9]	23 [4.9]	1.38	0.98-1.93	0.34
Respiratory tract infection	544 [23.9]	119 [25.3]	1.12	0.89-1.41	0.62
Total number of HACs	0.51 [SD 0.75]	0.53 [SD 7.9]	0.95	0.82-1.11	0.74
Hypotension	83 [3.7]	10 [2.1]	0.56	0.37-0.84	0.16

Table 17. Co-variates associated with Group 3 (short-term high-impact) as compared to low-impact users.

Group 2 (chronic high-impact)			**Group 3 (short-term high-impact)**		
Common causes (N [%])	Common sequences	N [%]	Common causes (N [%])	Common sequences	N [%]
RTI (34 [8.6])	COPD>RTI	22 [5.6]	RTI (27 [9.2])	COPD>RTI	17 [5.8]
COPD (26 [6.6])	RTI>COPD	21 [5.3]	COPD (22 [7.5])	UTI>RTI	14 [4.7]
External injuries (21 [5.3])	COPD>RTI>RTI>COPD	16 [4.1]	Iatrogenic injury (18 [6.1])	COPD>COPD>RTI	10 [3.4]
Fractures (18 [4.5])	RTI>COPD>COPD>RTI	11 [2.8]	Hypotension (14 [4.7])	RTI>COPD	10 [3.4]
Iatrogenic injury (18 [4.6])	COPD>COPD>RTI	10 [2.5]	Haemorrhage (13 [4.4])	RTI>UTI	9 [3.1]
Hypotension (18 [4.5])	RTI>COPD>RTI>COPD	10 [2.5]	Myocardial infarction (11 [3.7])	Dementia>RTI	8 [2.7]
UTI (18 [4.5])	RTI>UTI	10 [2.5]	rAAA (9 [3.1])	RTI>COPD>COPD>RTI	6 [2.0]
External haemorrhage (14 [3.6])	RTI>hypotension	9 [2.3]	UTI (9 [3.1])		
Chest pain (13 [3.3])			Ischaemic heart disease (8 [2.7])		
Ischaemic heart disease (13 [3.3])			External injury (8 [2.7])		

Table 18. Common causes and their sequences of readmissions among Group 1 and Group 3. (RTI, respiratory tract infection; COPD, chronic obstructive pulmonary disease; UTI, urinary tract infection; rAAA, ruptured abdominal aortic aneurysm).

HF PATIENTS HAD 5 GROUPS. MOST PATIENTS WERE LOW IMPACT, AND THERE WERE 2 GROUPS WITH INTERMEDIATE READMISSION RATES OF DIFFERENT TRAJECTORIES. SHORT-TERM AND CHRONIC HIGH IMPACT USERS WERE 3.4% AND 2.3% OF THE POPULATION. CHRONIC HIGH IMPACT USERS WERE ASSOCIATED WITH MYOCARDIAL INFARCTION, CONGENITAL HEART DISEASE, ARRHYTHMIAS, DEMENTIA, MENTAL HEALTH CONDITIONS, OLDER AGE, RENAL FAILURE, RESPIRATORY CONDITIONS, ANAEMIA AND BEING DIAGNOSED WITH HF AS AN INPATIENT IN THE HOSPITAL. HIGH IMPACT USERS ALSO HAD A HIGHER NUMBER OF OUT-OF-HOURS GP VISITS. DISTINCT COMMON SEQUENCES OF READMISSIONS CONSISTED OF CHEST INFECTION, CARDIOPULMONARY SIGNS AND SYMPTOMS AND EXTERNAL INJURIES. THE PATTERN OF HEALTH CARE VISITS CONSISTED OF MULTIPLE ELECTIVE AND EMERGENCY HOSPITAL ADMISSIONS LEADING TO DEATH.

4.7 Heart failure

4.7.1 Characteristics of general patient population

10525 patients had a diagnosis of heart failure in total. The mean age of the population at the time of first diagnosis of heart failure was 76.2 (SD 14.3), and the proportion of females was 53.8% (n=3140) *(Table 19).* The patients were recruited between 1st April 2008 and 31st March 2009. 70% of the patients (n=4087) were primarily diagnosed with heart failure as an inpatient in the hospital. However, over half of the patients (n=5833, 55.4%) presented with signs and symptoms of heart failure in the community. Commonly recorded comorbidities in the 5 years preceding the diagnosis of heart failure were hypertension (n=4494, 77.0%), ischaemic heart disease (n=3477, 59.6%), atrial fibrillation (n=3174, 54.4%), diabetes (n=1570, 26.9%), cardiac valvular disease (n=1392, 23.9%), acute myocardial infarction (n=1338, 22.9%), stroke (n=1212, 20.8%), dementia (n=908, 15.6%), obesity (n=672, 11.5%), peripheral vascular disease (n=586, 10.1%), and myocarditis/cardiomyopathy (n=303, 5.2%). The main outcome was yearly total number of emergency hospital admissions during the follow-up period of 5 years. The secondary outcome was yearly total number of out-of-hours GP consultations during the follow-up period of 5 years.

4.7.2 Trajectory model: classification of the groups

The best-fitting model (BIC -45665) derived 5 subgroups *(Figure 9).* Group 1 (n=7000, 66.5%) was considered low-impact group because it had persistently low readmission rate. Group 2 (n=1526, 14.5%) and Group 3 (n=1358, 12.9%) had intermediate use of hospital care. Group 2 showed constant intermediate readmission rate, whereas Group 3 started with a moderate annual readmission rate that steadily declined. Group 4 and 5 had the highest readmission rate, hence, they were labelled as high-impact users. Group 4 (n=358, 3.3%) were termed as short-term high-impact because they had a rapid drop in the annual

readmission rate after a very high readmission rate in their first year of follow-up. Group 5 (n=242, 2.3%) had a relatively steady high readmission rate with only a gradual decline during the follow-up period, hence, they were labelled as chronic high-impact.

4.7.2.1 Co-variates associated with each group

The risk factors associated with the high-impact users, Group 4 and 5, are mentioned in *Table 20 and Table 21.* The risk factors associated with Group 3 (intermediate group with decline in readmission rate) were: dementia (n=359 [14.9] vs. 1 [0.2], OR 17.81 [4.57-69.41], P=0.03), HF diagnosed as an inpatient (n=1417 [58.8] vs. 6 [1.4], OR 13.20 [7.03-24.78], P < 0.001), stroke (529 [21.9] vs. 5 [1.2], OR 8.41 [4.31-16.44], P=0.001), renal function recorded for monitoring visit (n=1481 [61.5] vs. 33 [7.9], OR 5.58 [3.86-8.08], P < 0.001), chronic respiratory conditions (n=1024 [42.5] vs. 48 [11.5], OR 5.00 [3.71-6.25], P < 0.001), anaemia (n=672 [27.9] vs. 22 [5.2], OR 4.95 [3.29-7.46], P < 0.001), atrial fibrillation (n=1345 [55.8] vs. 75 [17.9], OR 4.71 [3.63-6.11], P < 0.001), hypertension (n=2067 [85.8] vs. 199 [47.5], OR 4.62 [3.67-5.81], P < 0.001), mental health disorders (n=345 [14.3] vs. 13 [3.1], OR 4.10 [2.39-7.03], P=0.009), cardiac arrhythmia (n=1019 [42.3] vs. 56 [13.4], OR 3.29 [2.46-4.39], P < 0.001), myocardial infarction (n=519 [21.5] vs. 52 [12.4], OR 2.16 [1.54-3.03], P=0.02), diabetes (n=759 [31.5] vs. 65 [16.5], OR 1.84 [1.42-2.41], P=0.03), age > 75 (n=1420 [58.9] vs. 184 [43.9], OR 1.35 [1.21-1.51], P=0.005), patients on medication for signs and symptoms of heart failure (n=1578 [65.5] vs. 289 [68.9], OR 0.54 [0.41-0.71], P=0.03), bereavement episode recorded for GP consultation (n=227 [9.4] vs. 48 [11.5], OR 0.50 [0.35-0.70], P=0.04), history of flu vaccination (n=822 [34.1] vs. 306 [73.0], OR 0.47 [0.36-0.60], P=0.002), and 3 or more readmissions (vs. <= 2) in the year preceding diagnosis of HF (n=94 [3.9] vs. 16 [3.8], OR 0.33 [0.19-0.59], P=0.05).

The risk factors associated with Group 2 (persistent moderate readmission rate) were HF diagnosed as an inpatient (n=119 [21.6] vs. 6 [1.4], OR 48.40 [25.28-92.76], P < 0.001), anaemia (n=136 [24.7] vs. 22 [5.2], OR 42.95 [10.91-169.02], P=0.006), renal failure (n=339 [61.5] vs. 5 [1.2], OR 15.64 [10.18-24.05], P < 0.001), respiratory diseases (n=383 [69.5] vs. 48 [11.5], OR 14.88 [10.70-20.70], P < 0.001), atrial fibrillation (n=205 [37.2] vs. 75 [17.9], OR 14.73 [7.39-29.37], P < 0.001), stroke (n=530 [96.2] vs. 5 [1.2], OR 12.30 [8.58-17.64], P < 0.001), relationship problems (n=182 [33.0] vs. 22 [5.2], OR 10.91 [6.23-19.11], P < 0.001), myocarditis/cardiomyopathy (n=379 [68.8] vs. 19 [4.5], OR 10.49 [7.61-14.44], P < 0.001), ischaemic heart disease (n=375 [68.1] vs. 177 [42.2], OR 8.17 [6.11-10.91], P < 0.001), renal function monitoring at primary care (n=387 [70.2] vs. 33 [7.9], OR 6.89 [4.57-10.38], P < 0.001), congenital heart disease (n=219 [39.7] vs. 173 [41.3], OR 3.74 [2.61 5.37], P < 0.001), and heavy alcohol intake (n=267 [48.5] vs. 88 [21.0], OR 2.77 [2.03-3.78], P < 0.001).

4.7.2.2 Outcomes associated with each group

The overall 5-year mortality was 53.8% (n=5662). The all-cause 5-year mortality was highest in the short-term high-impact group (n=185, 72.8%), followed by group 2 (intermediate users) (n=744, 58.8%), low-impact (n=4244, 56.9%), chronic high-impact (n=88, 37.6%) and group 1 (intermediate users) (n=401, 30.3%) (P < 0.01). During the follow-up period, various outcomes for each group are shown in *Table 22.* The trajectories of out-of-hours GP visits

1. CHRONIC HIGH IMPACT USERS: PERSISTENTLY HIGH READMISSION RATES EVERY YEAR
2. SHORT-TERM HIGH IMPACT USERS HAVE HIGH INITIAL HIGH READMISSION RATE FOLLOWED BY RAPID DECLINE.

among subgroups of HF patients are shown in *Figure 10.* The trend in annual out-of-hours GP visits was similar to the readmission rate among the groups of HF.

4.7.2.3 Results from validation of model

When the original patient cohort was analysed to identify patients with =>2 readmissions every year in ≥ 3 years during the follow-up period, the sensitivity and specificity of the model to detect chronic high-impact users was 81.3% and 98.8%, respectively.

There were 9492 patients in the validation cohort. Patient characteristics, demographics and social factors among validation cohort were similar to the original cohort *(Table 19).* 63.4% of the patients were over the age of 75, and 50.4% of them were females. The percentage of patients with chronic renal disease (15.3%), cardiac arrhythmia (20.8%), valvular heart disease (6.1%) and heavy alcohol intake (19.1%) were lower compared with original cohort.

When the significant predictors associated with high-impact users were applied to the validation cohort of patients (year 2008-2009), the c statistics was 0.87. The sensitivity and specificity of the model to predict chronic high-impact users in the validation cohort was 100% and 97.4% respectively. The trajectory analysis on the validation cohort showed that the best fit model (BIC -41153) classified the population (n=9492) into 5 groups, with the following proportion of patients in each group: low-impact (64.3%), 2 intermediate groups (29.3%), short-term high-impact (4.9%) and chronic high-impact (1.5%). The co-variates associated with chronic high-impact users in the validation set were 3 or more readmissions (vs. <= 2) in the year preceding diagnosis of HF (OR 36.60 [16.40-81.40], P 0.01), dementia (OR 33.10 [14.90-73.70], P < 0.001), peripheral vascular disease (OR 12.20 [5.50-27.10], P 0.002), renal failure (OR 4.10 [2.00-8.20], P < 0.001), GP visits for flu vaccination (OR 2.20 [1.80-2.70], P 0.001), cardiac arrhythmia (OR 1.80 [1.50-2.20], P 0.003), GP visit for blood pressure check (OR 1.65 [1.22-2.23], P 0.04), female sex (OR 1.65 [1.42-1.92], P 0.002), hypertension (OR 1.65 [1.35-2.01], P 0.008), GP visits for heart failure medication review (OR 1.65 [1.35-2.01], P 0.006), GP visit for exercise recommendation (OR 1.49 [1.22-1.82], P 0.005), older age (OR 0.55 [0.51-0.59], P < 0.001), number of previous GP visits (≥ 90th percentile) (OR 0.55 [0.50-0.61], P < 0.001), GP visit for renal functional monitoring (OR 0.55 [0.45-0.67], P < 0.001), anaemia (OR 0.50 [0.41-0.61], P < 0.001), stroke (OR 0.50 [0.41-0.61], P < 0.001), myocardial infarction (OR 0.48 [0.40-0.57], P < 0.001), atrial fibrillation (OR 0.47 [0.40-0.55], P < 0.001), out-of-hour GP visits in the preceding year (≥ 90th percentile) (OR 0.45 [0.37-0.55], P < 0.001), respiratory conditions (OR 0.30 [0.27-0.34, P < 0.001), diagnosis of HF as an inpatient (OR 0.09 [0.08-0.11, P < 0.001). The co-variates associated with short-term high-impact users were hypertension (OR 6.05 [4.53-8.08], P < 0.001), dementia (OR 4.48 [3.78-5.31], P < 0.001), cardiac congenital conditions (OR 3.67 [3.00-

4.48], P < 0.001), respiratory conditions (OR 3.32 [2.89-3.82], P < 0.001), anaemia (OR 3.00 [2.61-3.46], P < 0.001), renal failure (OR 3.00 [2.61-3.46], P < 0.001), atrial fibrillation (OR 2.77 [2.39-3.22], P < 0.001), stroke (OR 2.01 [0.50-8.17], P < 0.001), female sex (OR 1.82 [1.58-2.10], P < 0.001), peripheral vascular disease (OR 1.65 [1.42-1.92], P < 0.001), 3 or more readmissions (vs. <= 2) in the year preceding diagnosis of HF (OR 1.65 [1.35-2.01], P 0.02), diagnosis of heart failure as an inpatient (OR 0.61 [0.51-0.73], P 0.01), and GP visit for blood pressure monitoring (OR 0.45 [0.37-0.55], P < 0.001). These risk factors were similar those found among high-impact users in the original cohort.

4.7.3 Results from sequence analysis

4.7.3.1 Common sequences of emergency hospital admissions

Common causes of emergency admissions after the diagnosis of HF were heart failure (n=1896 [21.5%]), chest infection (n=1293 [14.7%]), myocardial infarction (n=658 [7.5%]), external injuries (n=442 [5.0%]), and atrial fibrillation (n=434 [4.9%]). The most common causes of emergency hospital admissions in all subgroups were heart failure, chest infection and myocardial infarction. The incidence of ischaemic stroke was commoner in group 1. Group 2 (intermediate users) had more admissions for cardio-respiratory signs and symptoms and atrial fibrillation. Short-term high-impact users had more admissions for cardio-respiratory signs and symptoms and ischaemic stroke. The common and distinct sequences of causes of admissions among high-impact patients with multiple readmissions are given in *Table 23.*

4.7.3.2 Lasagne plot: common sequences of types of health care use

The sequence analysis of the types of healthcare use and visits for all the heart failure patients over the 5 year period is shown in *Figure 11.* The sequence of healthcare visits in the subgroups of patients *(Figure 12)* showed an increased number of patients with multiple hospital admissions among high-impact users. The proportion of emergency hospital admissions and elective hospital admissions reduced during the period for all subgroups, but chronic high-impact users had a higher proportion of emergency and elective hospital admissions throughout the follow-up period *(Figure 13).* The common sequences of the types of healthcare visits among short-term high-impact users were predominantly emergency hospital admissions resulting in death. The number of consecutive hospital admissions, elective and emergency, was more common in chronic high-impact users. The short-term high-impact users had high sequences of emergency hospital admissions with an increased number of deaths *(Figure 14).* The frequency of transition from emergency GP visit to emergency hospital admission was higher among intermediate and high-impact users as compared with low-impact users. The repeated events of elective hospital admissions to emergency admissions were higher in high-impact users compared with other groups *(Table 24).*

Co-variates	**Original cohort (n=10525)**	**Validation cohort (n=9492)**
Age > 75	6242 (59.3%)	6112 (63.4%)
Female sex	3140 (53.8%)	4861 (50.4%)
Social and Lifestyle factors		
History of smoking	4274 (44.3%)	3976 (41.3%)
Heavy alcohol intake	6309 (65.4%)	1582 (16.4%)
Relationship problems	476 (94.9%)	414 (4.3%)
Bereavement episodes	933 (9.6%)	822 (8.5%)
Obesity	672 (11.5%)	799 (8.3%)
Past medical history		
Chronic renal disease	3491 (36.2%)	1480 (15.3%)
Cardiac arrhythmia	3299 (34.2%)	2009 (20.8%)
Myocarditis/Cardiomyopathy	303 (5.2%)	646 (6.7%)
Valvular heart disease	1392 (23.9%)	592 (6.1%)
Peripheral vascular disease	586 (10.1%)	1369 (14.2%)
Hypertension	4494 (77.0%)	7511 (78.0%)
Stroke	1883 (19.5%)	2287 (23.7%)
Atrial fibrillation	3174 (54.4%)	4875 (50.6%)
Diabetes	2518 (26.1%)	2509 (26.0%)
Dementia	908 (15.6%)	1359 (14.3%)
Anaemia	2661 (27.6%)	2561 (26.9%)
Mental health disorder	1175 (12.1%)	1106 (11.6%)
Respiratory diseases	3724 (38.6%)	4091 (42.4%)
Healthcare associated factors		
Renal function recorded at GP visit	6309 (65.4%)	5601 (58.2%)
History of flu vaccination	3000 (31.1%)	2941 (30.5%)
Exercise recommendation by GP	815 (49.9%)	4342 (45.1%)
Prescribed for medications for suggestive symptoms and signs of heart failure before diagnosis	6202 (64.3%)	5651 (58.6%)
3 or more readmissions (vs. <= 2) in the year preceding diagnosis of HF	323 (3.3%)	389 (4.0%)
Number of consultations by GP in preceding year (4th percentile)	1908 (19.7%)	1605 (16.6%)
Number of patients with increased out of hours' visits at primary care in preceding year (75th percentile and above for number of visits)	1180 (12.2%)	407 (4.2%)
Patients presenting with atypical signs and symptoms	5840 (60.5%)	5292 (54.9%)
HF diagnosed as an inpatient	7045 (73.0%)	6880 (71.4%)
Blood pressure recorded at GP visit	8718 (90.4%)	8016 (83.3%)

Table 19. Characteristics and medical background of patients with heart failure.

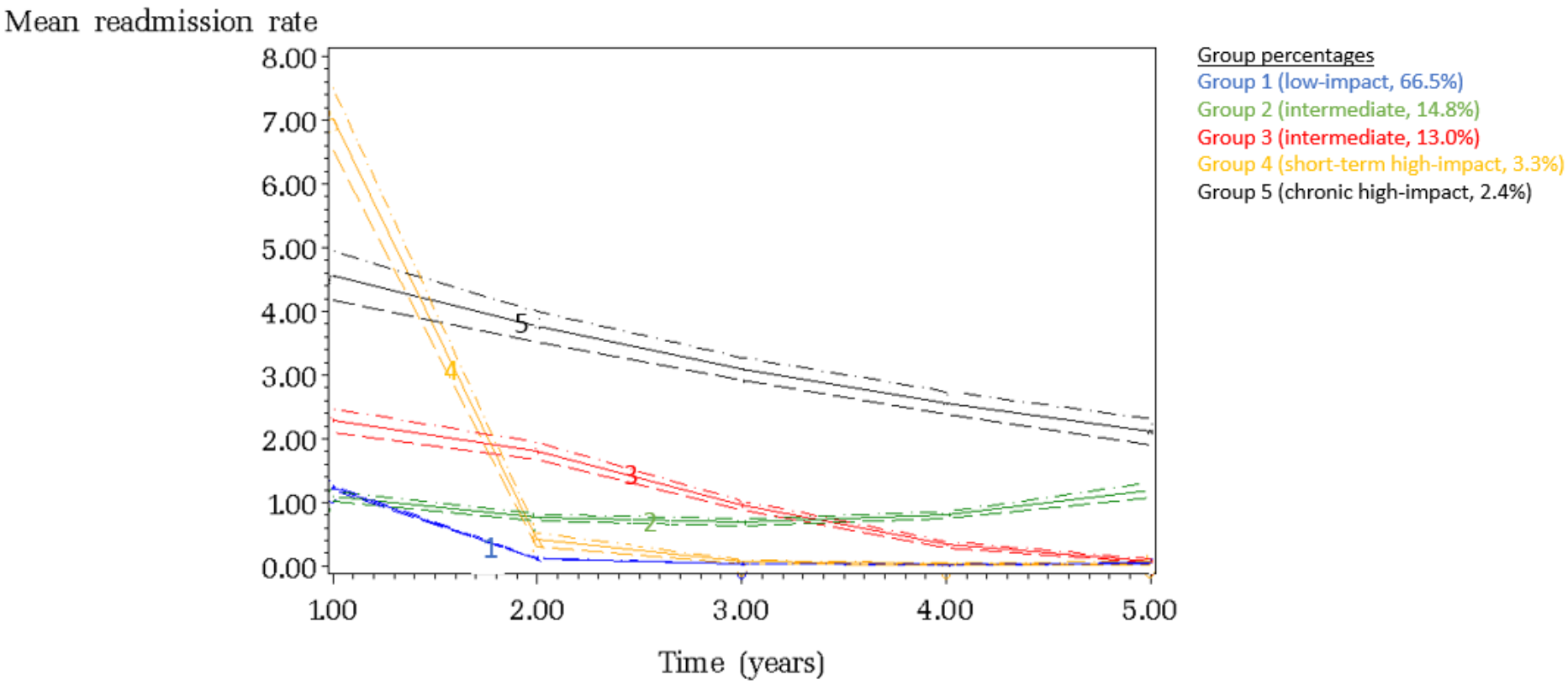


Figure 9. Trajectories of subgroups among HF patients (dotted lines represent 95% confidence intervals).

Risk factors	Low-impact N [%]	Chronic high-impact N [%]	OR CI (95%)	P value	Short-term high-impact N [%]	OR CI (95%)	P value
Patient demographics and social factors							
Age > 75	184 [43.9]	673 [70.8]	1.58 [1.40-1.79]	**< 0.001**	3555 [69.2]	2.03 [1.82-2.27]	**< 0.001**
Female sex	193 [46.1]	518 [54.5]	0.98 [0.77-1.25]	0.92	2674 [52.1]	0.80 [0.64-1.00]	0.31
History of smoking	183 [43.7]	359 [37.8]	0.91 [0.79-1.06]	0.52	2305 [44.9]	1.17 [1.03-1.34]	0.23
Heavy alcohol intake	88 [21.0]	163 [17.2]	1.32 [1.00-1.75]	0.32	997 [19.4]	1.36 [1.05-1.77]	0.22
Obesity	57 [13.6]	111 [11.7]	0.80 [0.57-1.14]	0.53	414 [8.1]	0.59 [0.43-0.82]	0.09
Bereavement episodes	48 [11.5]	114 [12.0]	0.52 [0.36-0.75]	0.07	473 [9.2]	0.41 [0.30-0.58]	**0.01**
Relationship problems	22 [5.2]	35 [3.7]	1.30 [0.76-2.23]	0.63	250 [4.9]	1.72 [1.05-2.80]	0.26
Past medical history							
Myocardial infarction	52 [12.4]	349 [36.7]	3.86 [2.69-5.53]	**< 0.001**	1082 [21.1]	2.61 [1.86-3.67]	**0.005**
Congenital heart disease	173 [41.3]	751 [79.1]	13.74 [3.67-51.42]	**0.05**	2417 [47.1]	1.48 [0.47-4.66]	0.73
Chronic renal disease	9 [2.1]	572 [60.2]	11.25 [3.90-32.46]	**0.02**	1490 [29.0]	3.03 [1.05-8.76]	0.29
Cardiac arrhythmia	56 [13.4]	508 [53.5]	5.42 [3.97-7.39]	**< 0.001**	1310 [25.5]	1.77 [1.31-2.38]	**0.05**
Myocarditis/Cardiomyopathy	19 [4.5]	44 [4.6]	0.93 [0.52-1.68]	0.91	273 [5.3]	0.76 [0.43-1.34]	0.61
Valvular heart disease	53 [12.6]	318 [33.5]	1.17 [0.86-1.60]	0.61	901 [17.5]	0.68 [0.50-0.91]	0.19
Peripheral vascular disease	17 [4.1]	148 [15.6]	1.15 [0.70-1.90]	0.77	393 [7.6]	0.82 [0.50-1.34]	0.68
Hypertension	199 [47.5]	869 [91.5]	5.81 [4.44-7.61]	**< 0.001**	3373 [65.6]	1.79 [1.43-2.23]	**0.009**
Stroke	5 [1.2]	296 [31.2]	10.38 [5.26-20.49]	**< 0.001**	820 [15.9]	5.70 [2.92-11.13]	**0.01**
Atrial fibrillation	75 [17.9]	629 [66.2]	6.17 [4.66-8.17]	**< 0.001**	2334 [45.4]	3.22 [2.48-4.18]	**< 0.001**
Ischaemic heart disease	177 [42.2]	755 [79.5]	7.17 [1.88-27.99]	0.14	2563 [49.9]	0.52 [0.16-1.68]	0.58
Diabetes	65 [16.5]	347 [36.5]	2.08 [1.55-2.77]	**0.01**	1049 [20.4]	1.31 [0.99-1.73]	0.33
Dementia	1 [0.2]	286 [30.1]	35.16 [8.94-138.38]	**0.009**	649 [12.6]	8.94 [2.29-34.81]	0.11
Anaemia	22 [5.2]	499 [52.5]	10.38 [6.82-15.80]	**< 0.001**	1096 [21.3]	3.46 [2.29-5.21]	**0.003**
Renal failure	5 [1.2]	518 [54.5]	2.92 [0.74-11.47]	0.43	1374 [26.7]	3.90 [0.99-15.33]	0.32
Mental health disorder	13 [3.1]	224 [23.6]	6.11 [3.49-10.70]	**0.001**	397 [7.7]	1.70 [0.98-2.94]	0.34
Respiratory diseases	48 [11.5]	539 [56.7]	8.41 [6.11-11.59]	**< 0.001**	1685 [32.8]	3.03 [2.23-4.14]	**< 0.001**

Table 20. Sociodemographic and past medical history associated with high-impact users compared with the low-impact users.

Risk factors	**Low-impact N [%]**	**Chronic high-impact N [%]**	**OR CI (95%)**	**P value**	**Short-term high-impact N [%]**	**OR CI (95%)**	**P value**
Renal function recorded at GP visit	33 [7.9]	672 [70.7]	7.46 [5.00-11.13]	**< 0.001**	3684 [71.7]	7.17 [4.90-10.49]	**< 0.001**
History of flu vaccination	306 [73.0]	264 [27.8]	0.43 [0.33-0.57]	**0.002**	1328 [25.9]	0.39 [0.30-0.51]	**< 0.001**
Exercise recommendation by GP	251 [59.9]	440 [46.3]	0.68 [0.54-0.87]	0.12	2505 [48.8]	0.65 [0.52-0.81]	**0.05**
Prescribed for medications for suggestive symptoms and signs of heart failure prior to diagnosis	289 [68.9]	618 [65.1]	0.47 [0.34-0.64]	**0.01**	3225 [62.8]	0.54 [0.41-0.73]	**0.03**
3 or more readmissions (vs. <= 2) in the year preceding diagnosis of HF	16 [3.8]	193 [20.3]	1.15 [0.64-2.05]	0.81	415 [8.1]	0.87 [0.49-1.54]	0.79
Number of consultations by GP in preceding year (4th percentile)	76 [18.1]	272 [28.6]	1.02 [0.90-1.15]	0.87	1022 [19.9]	1.01 [0.90-1.13]	0.93
Number of patients with increased out of hours' visits at primary care in preceding year (75^{th} percentile and above for number of visits)	14 [3.3]	78 [8.2]	1.14 [0.95-1.36]	0.46	325 [6.3]	1.14 [0.96-1.35]	0.45
Patients presenting with atypical signs and symptoms	237 [56.6]	622 [65.5]	1.19 [0.92-1.52]	0.49	3037 [59.1]	1.10 [0.87-1.39]	0.67
HF diagnosed as an inpatient	6 [1.4]	794 [83.6]	42.52 [22.20-81.45]	**< 0.001**	4312 [83.9]	45.60 [24.29-85.63]	**< 0.001**
Blood pressure recorded at GP visit	393 [93.8]	793 [83.4]	0.52 [0.32-0.84]	0.17	4794 [93.3]	0.96 [0.61-1.51]	0.93

Table 21. Management related factors associated with high-impact users compared with the low-impact users.

Subgroups	**Bereavement (n [per visits]) (p < 0.01)**	**GP visit for relationship difficulties (n [% per visits]) (p=0.05)**	**GP out-of-hours visits (n [% per visits]) (p < 0.01)**	**Visits for HF medication review (n [% per visits]) (p < 0.01)**	**GP visits for monitoring of blood pressure and renal function (n [% per visits]) (p < 0.01)**
Group 5 (chronic high-impact)	6 [2.6%]	4 [1.7%]	2223 [1.1%]	20010 [9.4%]	3763 [1.8%]
Group 4 (short-term high-impact)	1 [0.4%]	2 [0.8%]	1217 [1.5%]	7450 [9.1%]	1536 [1.9%]
Group 3 (intermediate use)	32 [2.5%]	15 [1.2%]	8926 [1.2%]	84517 [11.1%]	15416 [2.0%]
Group 2 (intermediate use)	48 [3.6%]	19 [1.4%]	8607 [0.8%]	123000 [11.4%]	23811 [2.2%]
Low-impact (group 1)	95 [1.3%]	53 [0.7%]	12266 [0.6%]	291942 [14.5%]	46334 [2.3%]

Table 22. The number of episodes of health care use and social events in the subgroups during the 5-year follow-up period. (The cardiac imaging included chest x-ray, echocardiogram, cardiac angiogram, computed tomography and magnetic resonance imaging of the heart).

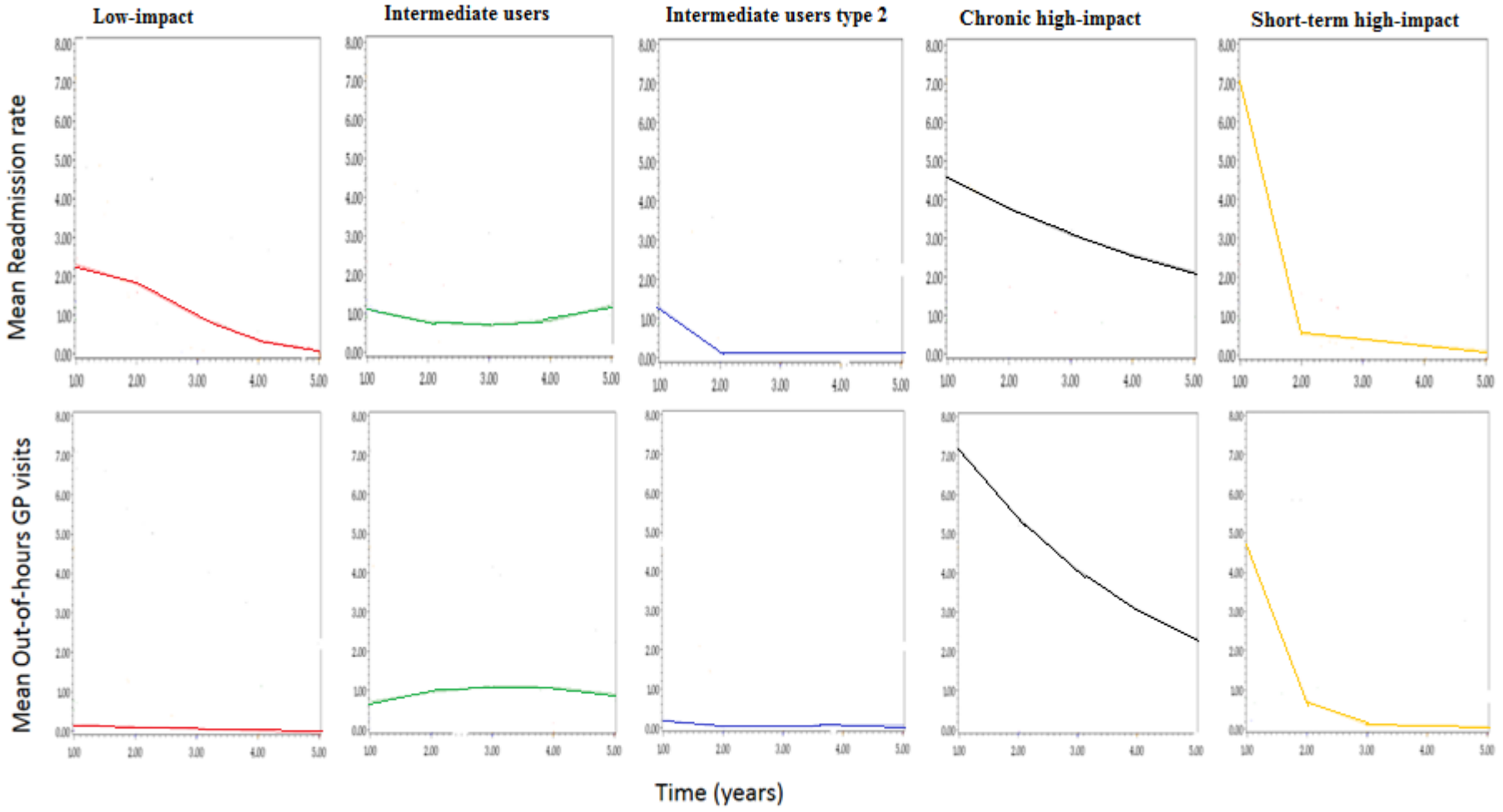


Figure 10. The trajectory of mean out-of-hours GP visits in comparison with mean annual readmission rate among subgroups in HF.

Common sub-sequences	**Low-impact (group 3) (n [%])**	**Group 1 (intermediate use) (n [%])**	**Group 2 (intermediate use) (n [%])**	**Group 4 (high-impact) (n [%])**	**Group 5 (high-impact) (n [%])**	**P value**
Cardio-respiratory symptoms/signs>Respiratory tract infection	34 [0.6]	59 [4.7]	47 [3.6]	20 [8.3]	35 [15.4]	< 0.001
Respiratory tract infection>Cardio-respiratory symptoms/signs	28 [0.5]	34 [2.7]	26 [2.0]	13 [5.5]	32 [14.1]	< 0.001
Ischaemic heart disease>Cardio-respiratory symptoms/signs	23 [0.4]	24 [1.9]	26 [2.0]	13 [5.5]	21 [9.4]	< 0.001
External injury>Respiratory tract infection	40 [0.7]	68 [5.4]	46 [3.5]	8 [3.5]	23 [10.3]	< 0.001
Respiratory tract infection>HF	40 [0.7]	37 [3.0]	31 [2.4]	11 [5.1]	24 [10.6]	< 0.001
Respiratory tract infection>External injury	28 [0.5]	44 [3.5]	48 [3.7]	11 [5.1]	14 [6.4]	< 0.001

Table 23. Common distinct sequences of causes of emergency admissions associated with various subgroups in the patient population.

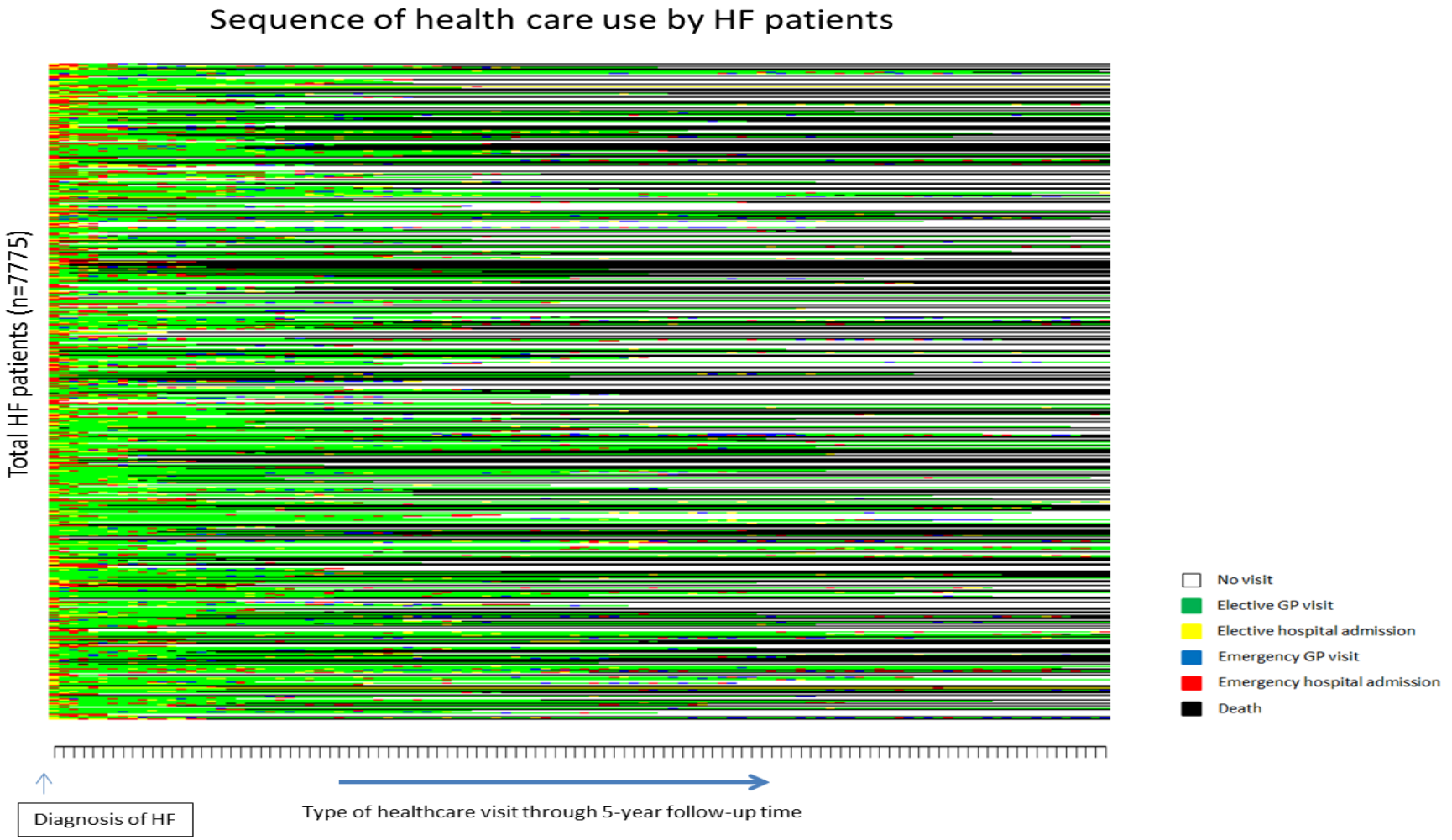


Figure 11. The sequence of healthcare visits for HF patients during their follow-up period since the time of diagnosis of HF.

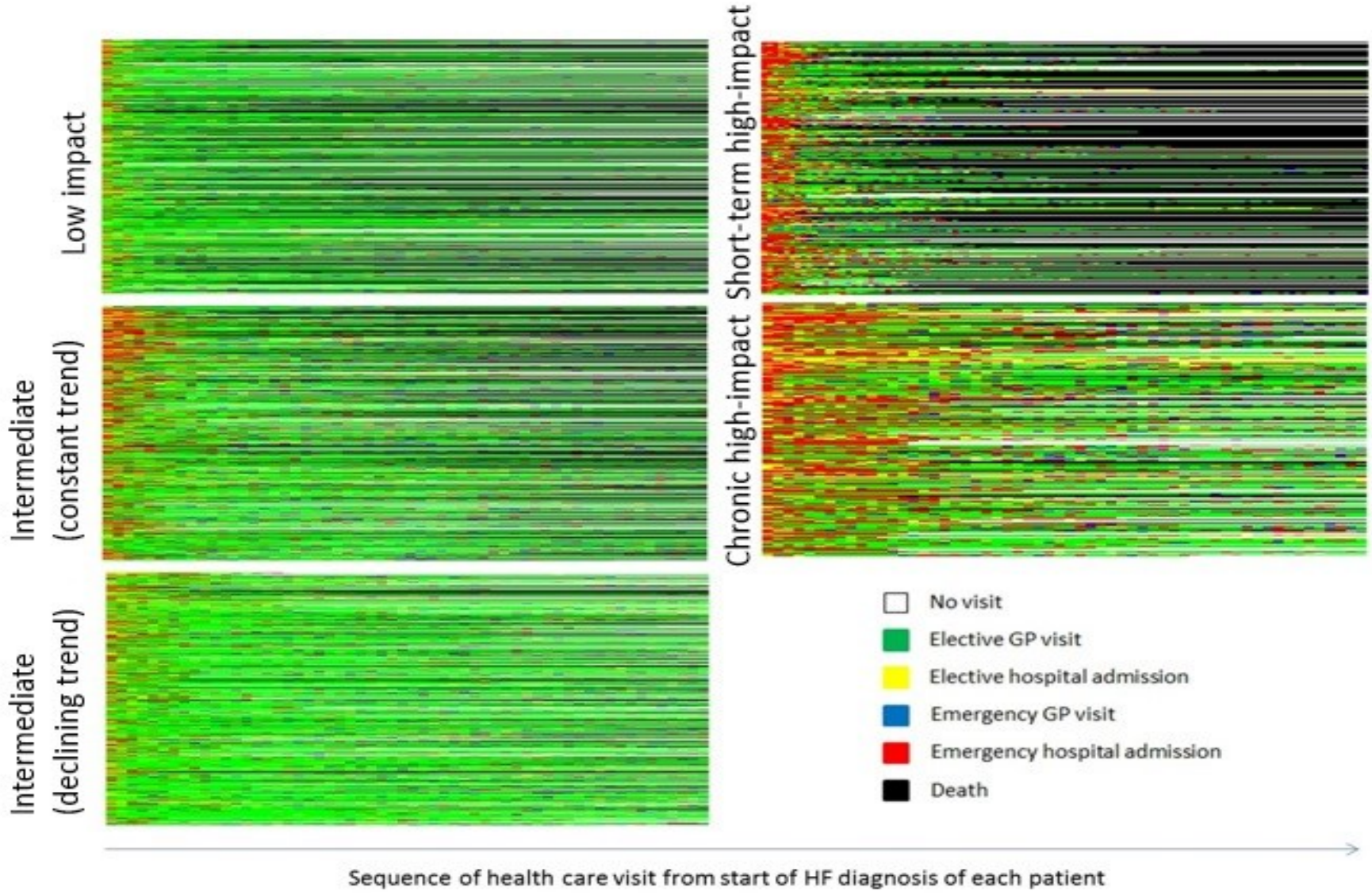


Figure 12. The sequence of healthcare visits in different subgroups of HF patients in the follow-up period.

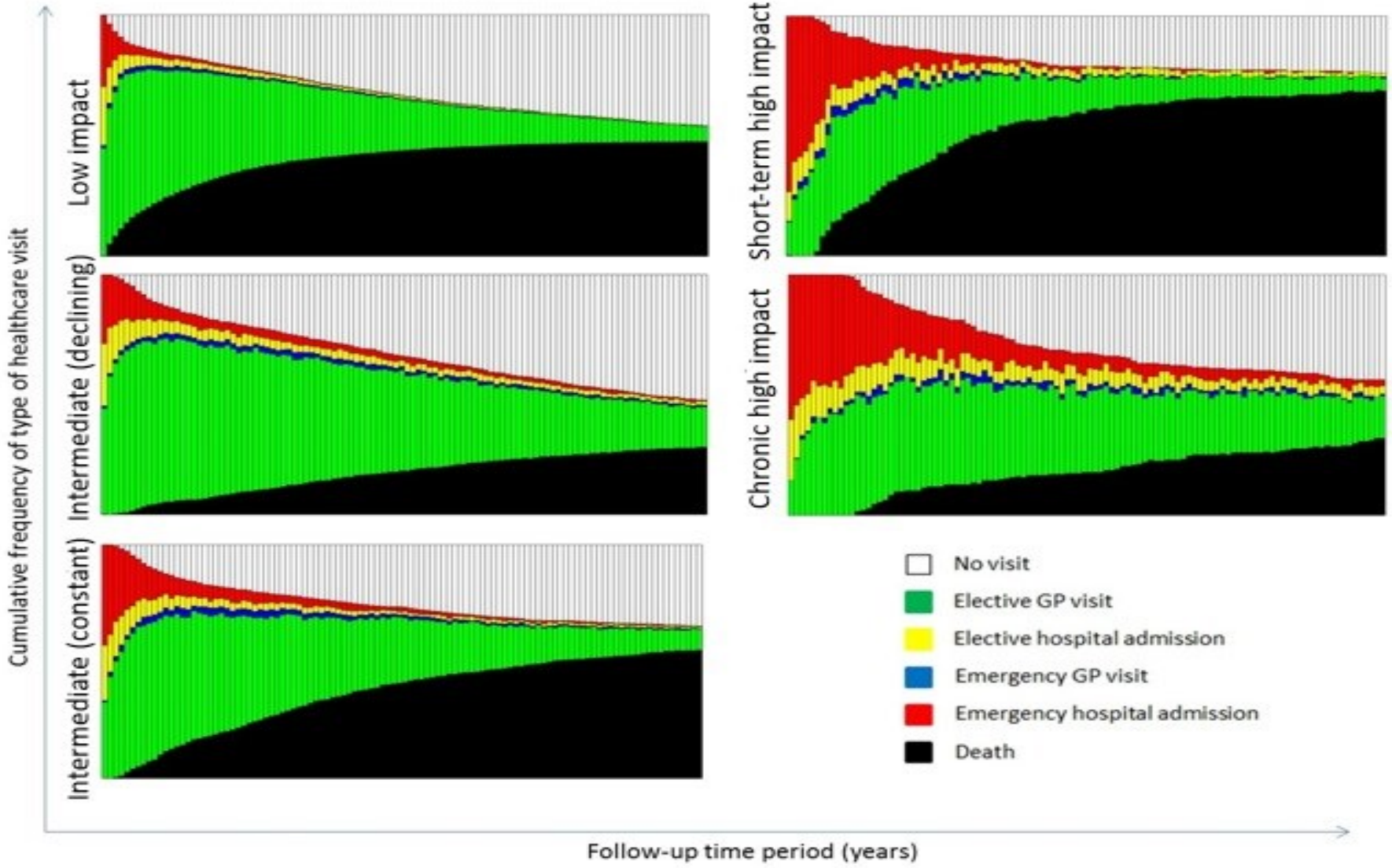


Figure 13. The proportion of the type of healthcare visits during each consecutive health care use among subgroups of HF patients.

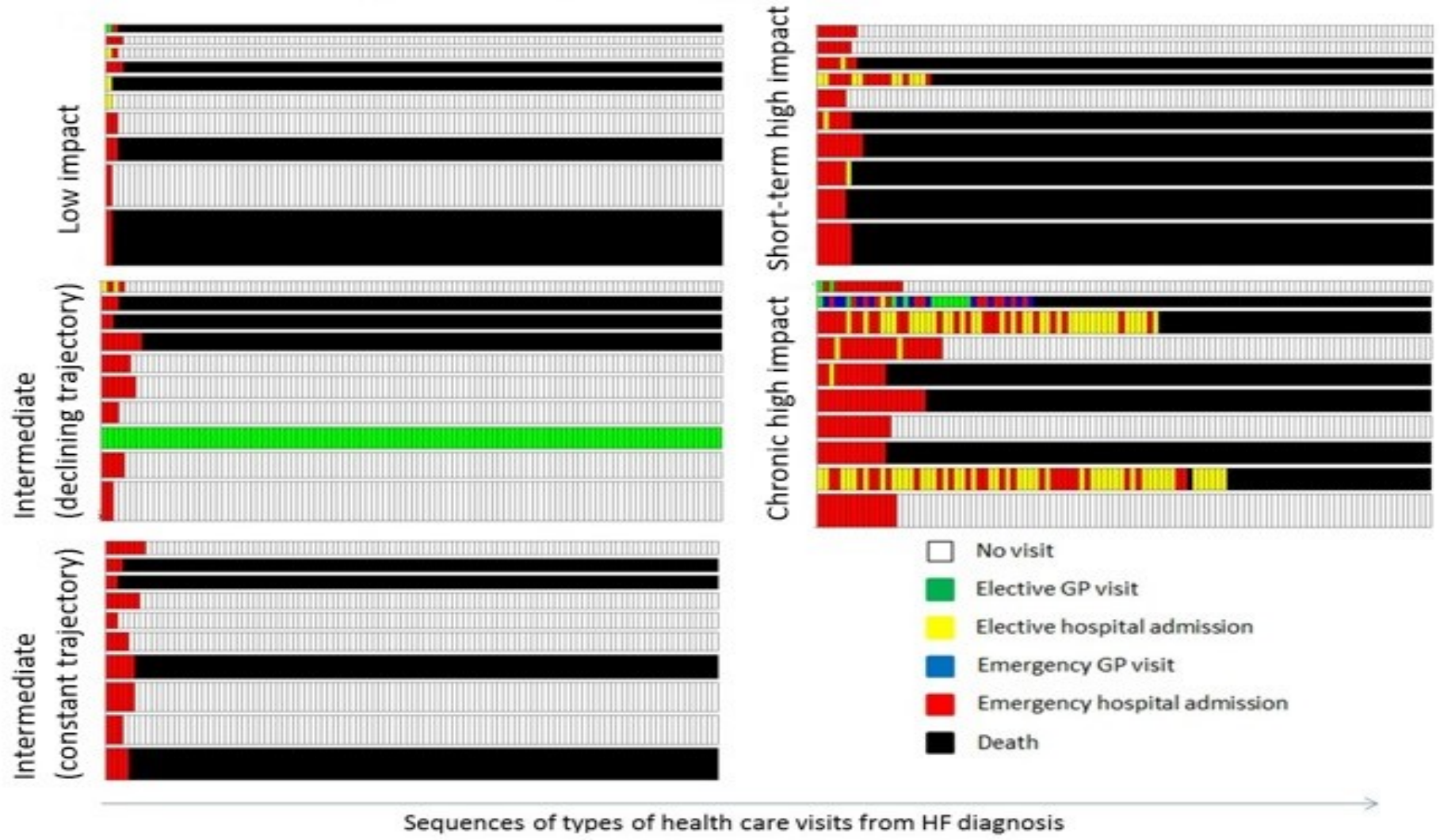


Figure 14. Common sequences of health visits among subgroups of HF patients.

Transition of events	Elective hospital admission to emergency hospital admission (n [%])	Emergency hospital admission to elective hospital admission (n [%])	Emergency GP visit to emergency hospital admission (n [%])	Emergency hospital admission to death (n [%])
Low-impact	1408 [29.9]	1205 [25.6]	630 [13.4]	2086 [44.4]
Intermediate impact	955 [72.1]	819 [61.8]	518 [39.1]	406 [30.6]
Short-term high-impact	143 [56.3]	149 [58.6]	68 [26.7]	185 [72.8]
Chronic high-impact	194 [82.9]	190 [81.2]	94 [40.2]	82 [35.0]

Table 24. The common transition of healthcare visits in subgroups of HF.

IN DIFFERENT REGIONS, THE PATIENT POPULATION HAD MORE THAN 2 GROUPS, AND THE MAJORITY OF THE PATIENTS WERE LOW IMPACT USERS. INTERMEDIATE USERS WERE THOSE WITH MODERATE READMISSION RATES. EACH REGION HAD 1 OR 2 INTERMEDIATE GROUPS. MOST REGIONS HAD SHORT-TERM HIGH IMPACT USERS, AND ALL REGIONS CONSISTED OF CHRONIC HIGH IMPACT USERS. PATIENT CHARACTERISTICS WERE SIGNIFICANTLY DIFFERENT AMONG DIFFERENT REGIONS. CARDIO-PULMONARY CONDITIONS WERE COMMONEST AMONG DISTINCT SEQUENCES OF READMISSIONS IN HIGH IMPACT USERS.

4.8 Regional analysis of HF patients

4.8.1 Patient characteristics in different regions

The population of HF patients was divided into 8 regions based on CPRD regional codes. The number of groups based on long-term readmission rate was more than 2 in every region: the patient characteristics among all regions are shown in *Table 25.* A significant variation was seen among patients from different regions based on their basic demographics and past medical history. The proportion of patients with a history of myocardial infarction was low in South-East, South-Central and South-West regions as compared to other regions. The proportion of patients with congenital heart disease was higher in London and North-West region. The number of patients with a background of hypertension and cardiac arrhythmia was higher in Southern and West Midlands regions, but there was a decrease in the number of renal failure and cardiomyopathy. The number of patients with drug prescription for heart failure and factors relating to their management significantly differed among patients from different regions *(Table 26).* The number of patients with GP visits for HF medication review and prescription were lower in Northern, East of England and West Midlands regions. The proportion of patients with increased hospital admissions before HF diagnosis was high in East of England, London and North-West region. Out-of-hours GP visits in a year preceding HF diagnosis were high in East of England, North-West and South-central region.

4.8.2 Trajectory modelling: classification of groups in different regions

In every region, multiple discrete groups were identified where the majority of the patients were part of a low-impact group and those with persistently low readmission rate, in all regions *(Table 27).* The group with initial high readmission rate followed by rapid decline in the rate was labelled as the short-term high-impact group. It was identified in all regions except South-West region: the proportion of these patients ranged from 2.5% to 11.3%. The group with constantly high readmission rate compared to other groups was labelled as the chronic high-impact group and was present in all regions: the proportion of patients in this group varied from 1.9% to 12.1%. The remaining groups with moderate readmission rate were classed as intermediate groups. In most regions, the number of intermediate groups was 2 except London and South-West region where there was only 1 intermediate group: the proportion of patients in this group was 11.5% to 40.1%. The pattern of change of

readmission rate of each group in different regions is shown in *Figure 15a and 15b.* The initial mean readmission rate among short-term high-impact users was the highest, between 6 and 9, in East of England, London and South-West regions. The initial mean readmission rate among chronic high-impact users was usually between 4 and 7 that gradually declined over time except in South-East region where it rose in the later part of the follow-up period. Of the regions with 2 intermediate groups, one intermediate group had a gradual decline in the readmission rate, while the readmission rate either remained constant or moderately increased in the other group. In the West-Midlands region, there was a sharp rise in the readmission rate among patients in the intermediate group. Of all the regions, South-West region had the lowest mean readmission rate, and it remained lowest throughout the following years.

4.8.3 Co-variates associated with high-impact users in different regions

The covariates with significant association with high-impact users are mentioned in *Table 28.* The covariates that were commonly found to have an association with short-term high-impact users among most of the regions were chronic respiratory disease, chronic renal disease, stroke, anaemia, mood disorder, and cardiac arrhythmia. Older age patients had lower odds of being associated with short-term high-impact users. Similar co-variates were found to be associated with chronic high-impact users. Among the intermediate users from all regions, hypertension was prominent predictor followed by atrial fibrillation and chronic renal disease *(Table 29).* Diagnosis of HF as an inpatient and history of GP visit for review of HF medications had lower odds of being associated with the intermediate group.

4.8.4 Sequence analysis of causes of emergency readmissions

Common causes of emergency admissions were similar in all regions, the top 5 causes of hospital admissions were heart failure, respiratory tract infection, myocardial infarction, atrial fibrillation and external injuries. Common sequences of causes of readmissions were identified among high-impact users *(Table 30).* These sequences were significantly lower in number among other groups. Respiratory tract infection, urinary infection, cardiopulmonary signs and symptoms and exacerbation of heart failure were common causes in the sequences of readmissions in all regions. North-East and North-West regions also had cancer as one of the common causes among the sequences of readmissions. South-Central and South-East regions had a common occurrence of external injuries in the sequences of readmissions. No common sequences of readmissions were identified among high-impact users in West-Midlands and South-West regions.

Patient characteristics N [%] or mean [SD]	East of England	London	North-East	North-West	South-east	South-west	South-central	West Midlands	P value
Age (mean [SD])	79.1 [11.9]	78.6 [11.5]	74.7 [15.0]	75.9 [12.5]	79.8 [11.2]	78.6 [11.4]	79.6 [11.2]	76.3 [13.9]	< 0.001
Female sex	404 [54.9]	317 [52.5]	484 [48.5]	530 [53.5]	395 [57.3]	386 [52.8]	380 [52.7]	624 [52.4]	0.04
Myocardial infarction	177 [24.0]	143 [23.7]	246 [24.7]	255 [25.7]	151 [21.9]	164 [22.4]	150 [20.8]	250 [21.2]	0.09
Congenital heart disease	414 [56.3]	378 [62.6]	569 [57.3]	641 [64.8]	377 [54.7]	419 [57.4]	367 [50.9]	650 [55.2]	< 0.001
Cardiac arrhythmia	222 [30.2]	200 [33.1]	318 [32.0]	339 [34.2]	257 [37.3]	262 [35.8]	343 [47.5]	377 [32.0]	< 0.001
Atrial fibrillation	424 [57.6]	327 [54.2]	479 [48.2]	509 [51.4]	423 [61.3]	382 [52.3]	392 [54.3]	626 [53.1]	< 0.001
Myocarditis/Cardiomyopathy	30 [4.0]	46 [7.6]	61 [6.1]	43 [4.3]	53 [7.6]	36 [4.9]	36 [4.9]	69 [5.8]	0.01
Hypertension	584 [79.4]	517 [85.7]	742 [74.7]	790 [79.8]	567 [82.2]	511 [70.0]	501 [69.4]	860 [73.0]	< 0.001
Diabetes	195 [26.5]	178 [29.5]	250 [25.1]	293 [29.6]	191 [27.7]	193 [26.4]	177 [24.5]	274 [23.2]	0.04
Anaemia	198 [26.9]	206 [34.1]	270 [27.1]	334 [33.7]	204 [29.6]	205 [28.0]	168 [23.3]	304 [25.8]	< 0.001
Valvular heart disease	162 [22.0]	150 [24.8]	225 [22.6]	276 [27.9]	181 [26.2]	168 [23.0]	166 [23.0]	270 [22.9]	0.04
Peripheral vascular disease	63 [8.5]	74 [12.2]	106 [10.6]	117 [11.8]	66 [9.5]	63 [8.6]	73 [10.1]	95 [8.0]	0.02
Respiratory diseases	285 [38.7]	255 [42.2]	397 [39.9]	452 [45.7]	257 [37.3]	281 [38.4]	273 [37.8]	440 [37.3]	0.003
Renal failure	263 [35.7]	239 [39.6]	313 [31.5]	356 [36.0]	264 [38.3]	241 [33.0]	216 [29.9]	365 [31.0]	< 0.001
Pulmonary embolism	20 [2.7]	24 [3.9]	47 [4.7]	35 [3.5]	33 [4.7]	30 [4.1]	45 [6.2]	61 [5.1]	0.04
Mental health disorder	87 [11.8]	88 [14.5]	142 [14.2]	153 [15.4]	97 [14.0]	75 [10.2]	98 [13.5]	126 [10.6]	0.004
Dementia	112 [15.2]	124 [20.5]	160 [16.1]	145 [14.6]	94 [13.6]	96 [13.1]	126 [17.4]	185 [15.7]	0.007
Heavy alcohol intake	159 [21.6]	113 [18.7]	190 [20.6]	247 [24.9]	154 [22.3]	128 [17.5]	152 [21.0]	205 [18.8]	0.004
History of smoking	340 [46.2]	297 [49.2]	493 [53.5]	489 [49.4]	269 [39.0]	343 [46.9]	298 [41.3]	493 [45.2]	< 0.001

Table 25. Patient characteristics among different regions in England.

Patient characteristics	East of England	London	North-East	North-West	South-East	South-West	South-Central	West Midlands	P value
Prescribed for medications for suggestive symptoms and signs of heart failure prior to diagnosis	616 [83.8]	499 [82.7]	554 [55.6]	820 [82.9]	596 [86.5]	619 [84.7]	607 [84.1]	704 [59.2]	< 0.001
GP visit for Bumetanide prescription a year preceding HF diagnosis	22 [2.9]	14 [2.3]	15 [1.5]	39 [3.9]	39 [5.6]	21 [2.8]	22 [3.0]	8 [0.6]	< 0.001
GP visit for digoxin prescription a year preceding HF diagnosis	97 [13.2]	61 [10.1]	56 [5.6]	83 [8.3]	77 [11.1]	95 [13.0]	102 [14.1]	83 [6.9]	< 0.001
GP visit for angiotensin II receptor blocker prescription a year preceding HF diagnosis	80 [10.8]	96 [15.9]	83 [8.3]	152 [15.3]	117 [16.9]	102 [13.9]	86 [11.9]	133 [11.1]	< 0.001
GP visit for beta-blocker prescription a year preceding HF diagnosis	240 [32.6]	185 [30.6]	219 [21.9]	298 [30.1]	216 [31.3]	225 [30.8]	210 [29.1]	262 [22.0]	< 0.001
GP visit for angiotensin converting enzyme inhibitor prescription a year preceding HF diagnosis	279 [37.9]	218 [36.1]	237 [23.8]	343 [34.6]	251 [36.4]	272 [37.2]	274 [38.0]	289 [24.3]	< 0.001
GP visit for diuretics prescription a year preceding HF diagnosis	436 [59.3]	349 [57.8]	393 [39.4]	591 [59.7]	426 [61.8]	463 [63.4]	447 [62.0]	487 [40.9]	< 0.001
Renal function recorded at GP visit	541 [73.6]	458 [75.9]	614 [66.6]	744 [75.2]	464 [67.3]	512 [70.1]	522 [72.4]	754 [69.2]	< 0.001
GP visit for monitoring of BNP (B-type natriuretic peptide)	18 [2.4]	40 [6.6]	48 [5.2]	3 [0.3]	18 [2.6]	1 [0.1]	29 [4.0]	9 [0.8]	< 0.001
Blood pressure recorded at GP visit	696 [94.6]	570 [94.5]	864 [93.8]	951 [96.1]	656 [95.2]	690 [94.5]	681 [94.4]	964 [88.5]	< 0.001
3 or more readmissions (vs. <= 2) in the year preceding diagnosis of HF	23 [3.1]	30 [4.9]	23 [2.3]	52 [5.2]	22 [3.1]	16 [2.1]	22 [3.0]	35 [2.9]	0.002
Number of patients with increased out of hours' visits at primary care in preceding year (75th percentile and above for number of visits)	153 [20.8]	63 [10.4]	123 [12.3]	168 [16.9]	79 [11.4]	107 [14.6]	130 [18.0]	138 [11.6]	< 0.001
HF diagnosed as an inpatient	548 [74.5]	430 [71.3]	743 [74.6]	658 [66.5]	493 [71.5]	504 [69.0]	532 [73.7]	887 [74.6]	< 0.001
Patients presenting with atypical signs and symptoms	638 [86.8]	536 [88.8]	598 [60.0]	870 [87.9]	597 [86.6]	635 [86.9]	636 [88.2]	705 [59.2]	< 0.001
Overall mortality	402 [54.6]	360 [59.7]	485 [48.6]	565 [57.1]	400 [58.0]	421 [57.6]	454 [62.9]	646 [54.3]	< 0.001
History of flu vaccination	288 [39.1]	241 [39.9]	303 [30.4]	416 [42.0]	238 [34.5]	259 [35.4]	210 [29.1]	299 [25.1]	< 0.001
Exercise recommendation by GP	417 [56.7]	319 [52.9]	504 [50.7]	585 [59.1]	332 [48.1]	393 [53.8]	406 [56.3]	586 [49.3]	< 0.001

Table 26. Management based factors associated with patient population in different regions.

Regions	BIC	Total No. of patients	No. of groups	Intermediate groups (n)	Proportion of intermediate users	High-impact groups (n)	Types of high-impact users	Proportion of high-impact users
London	-5553	1175	4	1	38.8%	2	Short-term	6.6%
							Chronic	6.2%
East of England	-5481	1249	5	2	29.5%	2	Short-term	2.5%
							Chronic	2.2%
North-East	-4613	996	5	2	21.9%	2	Short-term	11.3%
							Chronic	2.1%
North-West	-8101	1788	4	1	33.8%	2	Short-term	4.9%
							Chronic	10.2%
South-Central	-5398	1307	5	2	25.9%	2	Short-term	7.2%
							Chronic	1.9%
South-East	-5634	1238	5	2	40.1%	2	Short-term	6.2%
							Chronic	2.7%
West-Midlands	-5356	1189	5	2	23.4%	2	Short-term	8.6%
							Chronic	1.6%
South-West	-5462	1375	3	1	11.5%	1	Chronic	12.1%

Table 27. The modelling of HF patients into different groups in each region. (BIC: Bayesian Information criterion)

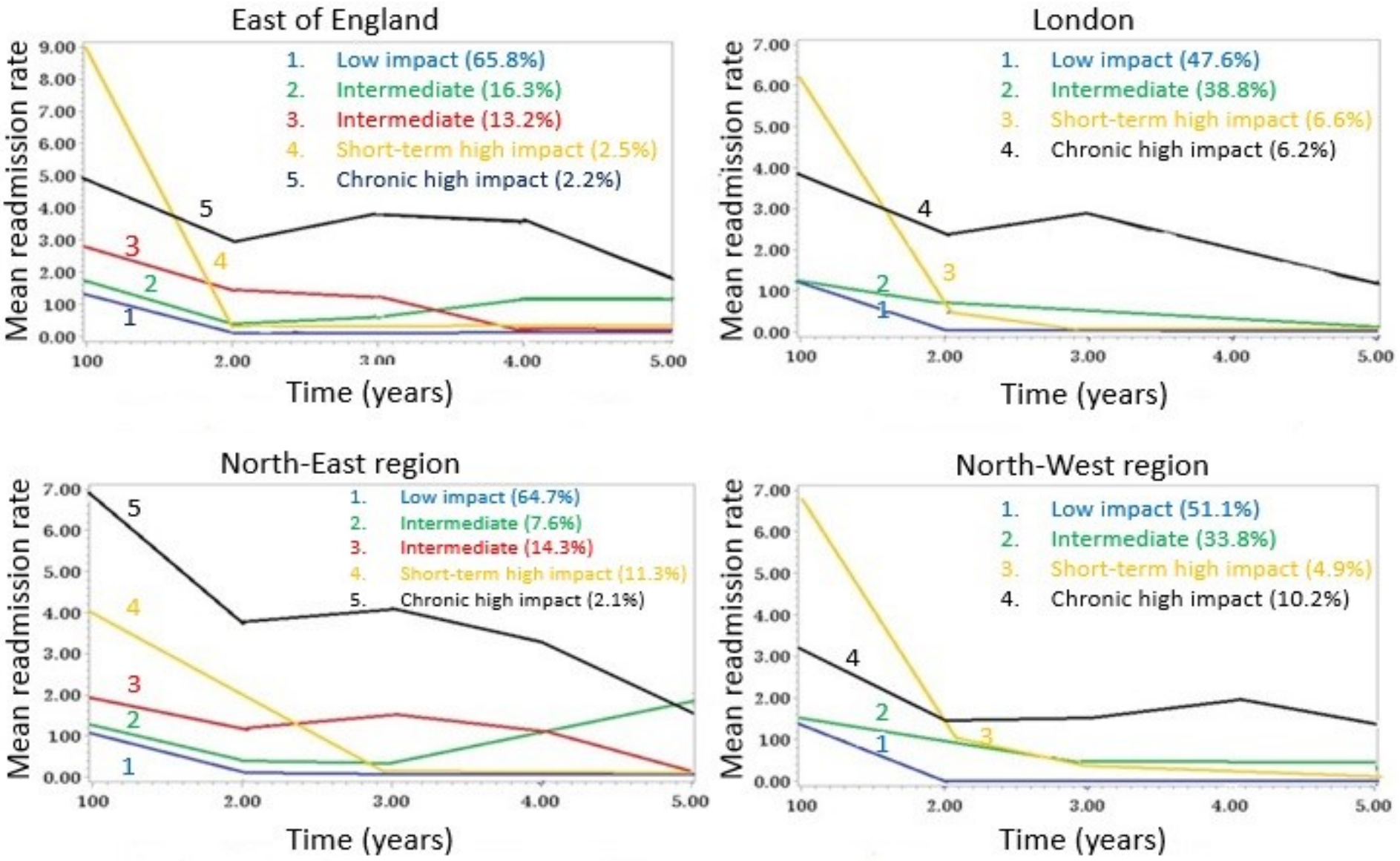


Figure 15 a. Trajectory of subgroups in different regions of England based on mean readmission rate.

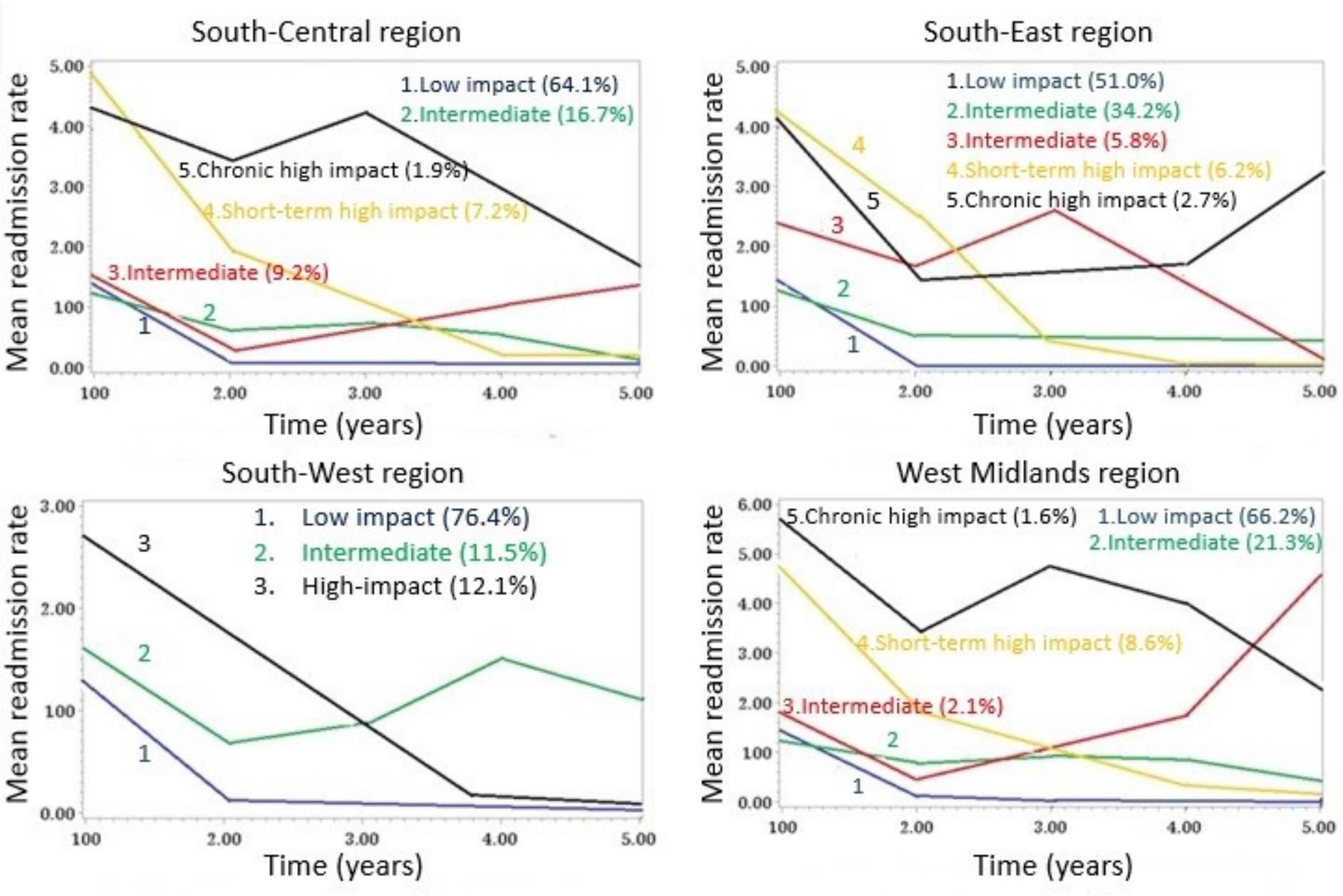


Figure 15 b. Trajectory of subgroups in different regions of England based on mean readmission rate.

Short-term high-impact	OR [95% CI]	Chronic high-impact	OR [95% CI]
London			
Stroke^	4.39 [2.51-7.69]	Chronic renal disease+	11.82 [6.05-23.10]
Anaemia^	4.26 [2.56-7.10]	Diabetes+	8.76 [5.05-15.18]
Chronic renal disease*	4.01 [2.23-7.24]	Valvular heart disease+	5.81 [3.39-9.97]
Valvular heart disease*	3.06 [1.84-5.10]	Stroke+	5.64 [3.16-10.07]
Chronic respiratory disease*	2.86 [1.75-4.66]	Chronic respiratory disease+	4.62 [2.64-8.08]
		Female sex*	2.89 [1.68-4.95]
		Anaemia*	2.75 [1.65-4.57]
East of England			
Anaemia*	8.33 [3.56-19.49]		
North-East			
Congenital heart disease*	3.74 [2.27-6.17]	Hypertension+	14.88 [8.00-27.66]
Chronic renal disease+	3.00 [2.64-3.42]	Cardiac arrhythmia+	6.17 [5.00-7.61]
Dementia+	2.86 [2.46-3.32]	Mood disorder+	5.81 [4.62-7.32]
Cardiac arrhythmia+	2.75 [2.41-3.13]	Chronic respiratory disease+	5.31 [4.18-6.75]
Hypertension+	2.59 [2.16-3.10]	Chronic renal disease+	4.90 [3.97-6.05]
Mood disorder+	2.51 [2.12-2.97]	Anaemia+	4.14 [3.39-5.05]
Chronic respiratory disease+	2.32 [2.03-2.64]	Dementia+	3.86 [2.97-5.00]
Anaemia+	2.23 [1.95-2.53]	Pulmonary embolism^	2.66 [1.86-3.82]
Valvular heart disease+	2.12 [1.84-2.44]	Diabetes+	2.44 [1.99-2.97]
Stroke+	1.65 [1.49-1.82]	Stroke+	2.29 [1.88-2.80]
Atrial fibrillation*	1.35 [1.22-1.49]	Atrial fibrillation+	2.18 [1.75-2.72]
Older age+	0.74 [0.69-0.79]	Marital problems*	2.18 [1.52-3.13]
HF diagnosis as an inpatient^	0.61 [0.51-0.72]	Valvular heart disease^	2.12 [1.73-2.59]
		Peripheral vascular disease*	1.82 [1.43-2.32]
		Ischaemic heart disease*	1.58 [1.28-1.95]
		Exercise recommendation by GP*	1.55 [1.25-1.93]
		History of flu vaccination+	1.52 [1.25-1.86]
		Older age+	0.41 [0.37-0.46]
North-West			
Hypertension+	5.64 [3.42-9.30]	Older age*	0.43 [0.31-0.59]
Mood disorder+	3.29 [2.32-4.66]	Number of patients with increased out-of-hours GP visits (>90th percentile) ^	0.34 [0.23-0.50]
Dementia^	3.13 [2.16-4.53]	GP visit for renal function monitoring*	0.31 [0.19-0.51]
Cardiac arrhythmia^	2.83 [2.10-3.82]	HF diagnosis as an inpatient+	0.19 [0.13-0.28]
Chronic renal disease^	2.46 [1.82-3.32]		
Anaemia^	2.39 [1.77-3.22]		
Chronic respiratory disease*	2.20 [1.63-2.97]		
History of flu vaccination*	2.12 [1.54-2.92]		
Older age*	0.48 [0.33-0.68]		
HF diagnosis as an inpatient*	0.41 [0.27-0.61]		
South-Central			
Chronic respiratory disease^	5.93 [3.63-9.68]	Hypertension^	0.31 [0.17-0.55]
Valvular heart disease+	5.75 [3.49-9.49]	Chronic renal disease*	0.22 [0.14-0.37]
Cardiac arrhythmia^	4.62 [2.64-8.08]	Older age*	0.23 [0.12-0.41]
Older age^	0.22 [0.13-0.39]	Dementia*	0.19 [0.10-0.37]
		HF diagnosis as an inpatient+	0.06 [0.03-0.11]
South-East			
Ischaemic heart disease+	17.64 [4.76-65.37]	Chronic renal disease*	4.35 [3.00-6.30]
Chronic renal disease^	8.76 [4.95-15.49]	Anaemia+	4.14 [2.89-5.93]
Chronic respiratory disease^	5.53 [3.06-9.97]	Dementia^	3.16 [2.05-4.85]
Cardiac arrhythmia*	5.16 [3.00-8.85]	Cardiac arrhythmia*	2.61 [1.80-3.78]
		Chronic respiratory disease+	2.23 [1.55-3.19]
		GP visit for HF medication review*	0.38 [0.24-0.62]
		Older age*	0.37 [0.23-0.58]
West-Midlands			
Cardiac arrhythmia+	5.47 [3.49-8.58]	Chronic renal disease+	9.97 [5.21-19.11]
Hypertension*	4.06 [2.10-7.85]	Cardiac arrhythmia*	5.70 [3.22-10.07]
Chronic respiratory disease^	3.32 [2.18-5.05]	Stroke^	5.16 [2.94-9.03]
Female sex*	2.75 [1.73-4.35]	Chronic respiratory disease^	4.62 [2.61-8.17]
Older age*	0.39 [0.25-0.63]	Older age*	0.26 [0.15-0.47]
South-West			
		History of flu vaccination*	9.03 [3.00-27.11]
		Chronic respiratory disease*	0.07 [0.02-0.25]
		Older age*	0.03 [0.01-0.11]
		HF diagnosis as an inpatient+	0.01 [0.00-0.04]

Table 28. Co-variates associated with short-term and chronic high-impact groups in different regions. (denotes P < 0.05, ^ denotes P < 0.01, + denotes P < 0.001)*

Intermediate group	OR [95% CI]	P value
London		
Hypertension	2.80 [1.95-4.01]	0.003
Chronic renal disease	1.65 [1.27-2.14]	0.05
Chronic respiratory disease	1.63 [1.27-2.10]	0.05
Number of patients with previous GP visit for HF medication review	0.51 [0.37-0.71]	0.04
Older age	0.35 [0.26-0.46]	0.002
East of England		
Diabetes	0.32 [0.18-0.54]	0.03
Chronic respiratory disease	0.32 [0.19-0.54]	0.03
Chronic renal disease	0.21 [0.12-0.37]	0.005
North-East		
Cardiac congenital conditions	4.31 [2.51-7.39]	0.007
Hypertension	3.90 [3.32-4.57]	< 0.001
Ischaemic heart disease	2.36 [1.79-3.13]	0.002
Mood disorders	2.32 [2.01-2.66]	< 0.001
Chronic renal diseases	2.03 [1.84-2.25]	< 0.001
Valvular heart disease	1.95 [1.73-2.20]	< 0.001
Cardiac arrhythmias	1.93 [1.75-2.14]	< 0.001
Dementia	1.80 [1.57-2.08]	< 0.001
Respiratory conditions	1.54 [1.39-1.70]	< 0.001
Anaemia	1.54 [1.38-1.72]	< 0.001
Stroke	1.35 [1.20-1.52]	0.012
Atrial fibrillation	1.31 [1.19-1.45]	0.0099
History of smoking	0.87 [0.81-0.93]	0.048
Number of patients with increased out-of-hours GP visits (>90th percentile)	0.64 [0.55-0.75]	0.0028
GP visit for renal monitoring	0.62 [0.53-0.72]	0.0016
Number of patients with previous GP visit for HF medication review	0.62 [0.51-0.76]	0.017
Older age	0.57 [0.53-0.60]	< 0.001
>3 hospital admissions in preceding year of diagnosis of HF vs. <=2)	0.34 [0.25-0.45]	< 0.001
HF diagnosis as an inpatient	0.32 [0.28-0.37]	< 0.001
North-West		
Hypertension	11.36 [5.53-23.34]	< 0.001
Chronic renal disease	5.81 [4.10-8.25]	< 0.001
Cardiac arrhythmias	4.26 [3.10-5.87]	< 0.001
Atrial fibrillation	2.72 [1.95-3.78]	0.003
Mood disorder	2.61 [1.79-3.82]	0.012
Number of patients with GP visit for flu vaccination	2.51 [1.80-3.49]	0.005
Anaemia	1.97 [1.46-2.66]	0.033
Presentation of atypical signs and symptoms before the diagnosis of HF	0.42 [0.28-0.64]	0.04
HF diagnosis as an inpatient	0.25 [0.16-0.38]	0.001
Older age	0.19 [0.13-0.27]	< 0.001
South-Central		
Chronic respiratory disease	0.36 [0.23-0.56]	0.024
Cardiac arrhythmia	0.25 [0.15-0.43]	0.011
Dementia	0.24 [0.14-0.44]	0.016
Hypertension	0.22 [0.13-0.37]	0.004
Chronic renal disease	0.17 [0.11-0.29]	< 0.001
South-East		
Hypertension	5.37 [2.97-9.68]	0.004
Older age	0.23 [0.16-0.35]	< 0.001
HF diagnosis as an inpatient	0.15 [0.11-0.21]	< 0.001
West-Midlands		
Hypertension	3.16 [2.25-4.44]	< 0.001
Chronic respiratory disease	2.01 [1.55-2.61]	0.007
Atrial fibrillation	1.86 [1.42-2.44]	0.023
Valvular heart disease	1.82 [1.36-2.44]	0.042
HF diagnosis as an inpatient	0.42 [0.32-0.57]	0.003
Older age	0.36 [0.27-0.48]	< 0.001
South-West		
Hypertension	4.81 [3.39-6.82]	< 0.001
Atrial fibrillation	1.80 [1.38-2.36]	0.03
HF diagnosis as an inpatient	0.39 [0.27-0.56]	0.01
Number of patients with previous GP visit for HF medication review	0.28 [0.19-0.41]	< 0.001

Table 29. Significant Co-variates associated with intermediate groups in different regions.

Sequences	Low-impact (%)	Intermediate (%)	Short-term high-impact (%)	Chronic high-impact (%)
London (N=1175)				
UTI-RTI	0.4	1.9	4.4	17.5
Chest s/s-Abdo s/s	0.01	4.7	4.4	7.5
RTI-HF	0.4	1.8	8.8	10.0
RTI-UTI	0.4	3.3	8.8	10.0
RTI-Chest s/s	0.01	1.4	4.4	10.0
East of England (N=1249)				
IHD-chest s/s	6.0	0.3	1.9	17.3
RTI-Chest s/s	3.0	0.3	1.9	17.4
Chest s/s-IHD	0.9	0.01	0.9	13.0
Chest s/s-RTI	3.0	0.3	8.8	17.4
MI-IHD	6.0	0.3	6.8	4.3
North-East (N=996)				
HF-Chest s/s	10.4	3.1	0.9	15.4
UTI-RTI	6.8	0.8	0.6	11.5
Chest s/s-HF	6.5	5.5	0.6	11.5
RTI-Cancer	3.4	4.7	0.01	3.8
North-West (N=1788)				
Chest s/s-RTI	1.2	9.0	9.6	1.1
RTI-INJ	0.3	6.5	2.4	0.4
RTI-cancer	0.6	1.6	4.8	0.01
RT-Chest s/s	0.6	4.1	5.6	0.6
RTI-IHD	0.3	2.4	0.01	4.0
South-Central (N=1307)				
INJ-RTI	2.1	0.01	0.01	12.5
Chest s/s-RTI	0.01	0.01	1.6	6.3
INJ-INJ-RTI	2.1	0.01	0.01	6.3
RTI-INJ	0.7	0.01	0.8	6.3
HF-Chest s/s	1.4	0.01	2.3	6.3
South-East (N=1238)				
UTI-RTI	0.3	0.7	14.3	5.6
RTI-INJ	0.0	3.4	5.7	5.6
INJ-RTI	1.2	2.7	14.3	3.4
INJ-SALT	0.3	1.3	5.7	5.6
SALT-INJ	0.6	0.9	2.8	6.7

Table 30. Sequences commonly found among high-impact users as compared to other groups (P < 0.001, [UTI, urinary tract infection; RTI, respiratory tract infection; Chest s/s, cardiopulmonary signs and symptoms; Abdo s/s, abdominal signs and symptoms; INJ, external injuries; SALT, speech and swallowing disorders; HF, heart failure]).

Chapter 5. Discussion

5.1 Overview

This chapter summarises the main findings from the application of trajectory and sequence analysis to different patient populations. It compares the findings from this study with the results obtained from previous studies. It then attempts to provide pragmatic and clinical oriented explanations for the main findings of the study, and evaluates the potential clinical impact of the results of the research. This chapter highlights the strengths of the statistical techniques used in the study and limitations of this research. It also identifies research gaps in further topics and suggests possible future research projects.

TRAJECTORY AND SEQUENCE ANALYSIS WERE SUCCESSFULLY APPLIED TO DIFFERENT PATIENT POPULATIONS OF VARIABLE SIZE. EACH POPULATION HAD DISTINCT GROUPS WITH DISSIMILAR TRENDS OF OUTCOMES. HIGH IMPACT USERS HAD DISTINCT SEQUENCES OF CAUSES OF READMISSIONS AND TYPES OF HEALTHCARE USE. THEY WERE ASSOCIATED WITH OTHER POOR OUTCOMES AND INCREASED USE OF OTHER HEALTHCARE SERVICES.

5.2 Summary of results

Overall, I successfully applied trajectory and sequence analysis to different health datasets. I identified different groups with distinct patterns of long-term readmission rates within each patient population. High-impact users accounted for a significant proportion of the patient populations studied. They had persistently high readmission rates. Among HF patients, there were two types of high-impact users: chronic and short-term. Chronic users had persistently high readmission rates, whereas short-term users had high initial readmission rates followed by a rapid decline due to high mortality. Certain patient populations also had intermediate users who had the potential of becoming high-impact users later during the follow-up period. The trajectory model also identified significant predictors associated with high-impact users. It had good predictive ability and reliability when applied to a new cohort of patients with the same diagnosis. High-impact users had similar common causes of readmissions. Compared with other groups, they had common discrete sequences of causes of readmissions, consisting of a few medical conditions, indicating that they undergo a repeated cycle of similar events during the follow-up period. Similarly, they had a repetitive series of emergency GP visits and elective and emergency hospital admissions as they approached the end of their life.

5.2.1 Patients with cerebrovascular conditions

Ischaemic stroke (n=34208) and TIA (n=20549) were shown to have two subgroups, while patients with intracranial haemorrhage had five subgroups (n=2605). Even though low-impact users constituted the majority of the patient population, high-impact users were also found to exist in significant proportions: 17% and 20% of patients were high-impact users among ischaemic stroke and TIA, respectively. High impact users had persistently high readmission rates throughout the follow-up period. Certain risk factors had a significant association with ischaemic stroke and TIA such as old age, cardiovascular conditions, increased co-morbidity burden, poor socio-economic status, prolonged length of stay, mental health conditions, epilepsy and living alone. High impact users among intra-cranial haemorrhage formed a small group (0.5%). They had a significant association with relatively young age and thrombo-embolic event. Intermediate users among intra-cranial haemorrhage were of 2 subtypes, those with a rapid decline in readmission rate (Group 4) and those with a rise in readmission rate (Group 3). The cause of an initial high readmission rate followed by a decline in group 4 patients may be credited to an increased number of HACs resulting in higher mortality. Group 3 had a strong association with the history of stroke and epilepsy, which may have aggravated its readmission rate.

High-impact users among ischaemic stroke and TIA patients had similar common causes of emergency admissions as low-impact users, but they had a higher proportion of patients with multiple readmissions and distinct sequences of causes of emergency admissions.

TRAJECTORY MODEL HAD GOOD PREDICTABILITY. WHEN APPLIED TO VALIDATION COHORT, IT PRODUCED SIMILAR NUMBER OF GROUPS WITH SAME TRAJECTORIES AND PROPORTION OF PATIENTS IN EACH GROUP. THE COVARIATES FOUND TO BE ASSOCIATED WITH HIGH IMPACT USERS IN VALIDATION COHORT WERE ALSO SIMILAR TO THOSE FOUND IN ORIGINAL COHORT.

Common sequences of readmissions mainly consisted of only a few causes of emergency admissions due to respiratory infection, urinary tract infection, external injuries and exacerbation of ambulatory conditions that repeatedly occurred among high-impact users suggesting the formation of a vicious cycle of similar events during their follow-up course.

5.2.2 Patients with elective AAA repair

Following elective AAA repair, analysis of both patient cohorts - original and validation set indicated that the patient population consisted of 2 groups: low and high-impact users. Elderly female patients with poor socio-economic status and increased co-morbidities who had undergone endovascular elective repair with prolonged length of stay as well as other vascular procedures seem to be the ones with persistently high long-term readmission rate. The trajectory model had increased predictive power. During the follow-up period, high-impact users followed a distinct pathway of persistently high hospital care use. Compared with low-impact users, they were associated with higher mortality, increased elective vascular procedures, increased number of elective admissions and a higher proportion of patients undergoing revision of AAA repair during the follow-up period. Of all the causes of emergency readmissions, cardiopulmonary conditions were commoner than other conditions among high-impact patients, with distinct sequences of multiple hospital admissions.

5.2.3 Patients with rAAA repair

Based on the modelling of long-term readmission rates, the patient population following ruptured AAA repair had three distinct groups. The majority of patients were low-impact users with a persistently low readmission rate. There were two kinds of high-impact users, one with constantly high readmission rates, chronic high-impact, and the other was short-term high-impact, who had a high readmission rate initially and then a sharp decline. Compared with other patients, high-impact users had a significant association with renal failure, gastrointestinal complications, heart failure, peripheral vascular disease, the number of hospital-acquired complications, female sex and undergoing other related procedures. They had an association with higher rates of elective procedures, vascular procedures and revision procedures. The majority of the causes of multiple readmissions among high-impact users were exacerbations of COPD and respiratory tract infections.

5.2.4 Patients with HF

Heart failure population had five subgroups, among which we importantly distinguished between chronic and short-term high-impact users. The analysis of primary care data included other lifestyle and social risk factors that were not available in hospital dataset. It also included information on other health services used by the patients. Certain risk factors had a strong association with all high-impact users, such as having a first-time diagnosis of

PREVIOUS STROKE AND EPILEPSY HAD STRONG ASSOCIATION WITH HIGH IMPACT USERS AMONG ISCHAEMIC STROKE AND TIA PATIENTS.

HF as an inpatient in a hospital, old age and a background of stroke, anaemia, myocardial infarction, atrial fibrillation, respiratory disease, and hypertension. GP visits for flu vaccination, exercise recommendation by GP, and initiation of HF medication in the community have had an association with lower odds of being a high-impact user. During the follow-up period, the proportion of visits for bereavement episodes, relationship difficulties, and out-of-hours GP visits increased significantly among high-impact users. However, they had a significantly smaller proportion of visits for HF medications, blood pressure and renal function monitoring. High-impact users had a distinct set of sequences for emergency readmissions consisting mainly of cardiopulmonary conditions and also had a higher proportion of patients with multiple readmissions. Chronic high-impact users had significant associations with mental health disorders and dementia, which was not found among short-term high-impact users. Short-term high-impact users had the highest mortality rate among all other groups. However, the sequence of readmissions was similar to chronic high-impact users. High readmission rates among both chronic and short-term high-impact users may imply that high-impact users begin with an increased readmission rates, but chronic high-impact users survive and continue to have high readmission rates and the other group labelled as short-term high-impact users suffer high mortality.

5.2.5 Regional analysis of HF patients

Regional analysis of heart failure patients showed that all 8 English regions had more than two groups. The number of subgroups and their trends of readmission rates was similar to the analysis of the national HF patient population. The high-impact users had two subgroups: chronic high-impact with constantly high readmission rates and short-term high-impact with initial high readmission rates followed by a rapid immediate decline. A significant number of patients were intermediate users who had the potential of becoming high-impact users, as one of its subgroups had a gradually increasing readmission rate. Certain risk factors had a common association with high-impact users in most of the regions. These factors included chronic respiratory disease, chronic renal disease, stroke, anaemia, mood disorder, and cardiac arrhythmia. There were a high proportion of patients among the high-impact group that had multiple readmissions, with similar repeated common causes consisting of respiratory tract infection, urine infection, exacerbation of heart failure, ischaemic heart disease and external injuries.

5.3 Interpretation of results and comparison with previous studies

5.3.1 Cerebrovascular conditions

5.3.1.1 Significant co-variates associated with high-impact users

The risk factors associated with increased short-term readmission rates in previous studies were similar to long-term readmission rates among high-impact users in this analysis - these factors include cardiovascular risk factors, history of stroke and mental health disorders.(44) One of the stronger risk factors associated with ischaemic stroke and TIA were a history of stroke and epilepsy. Among ischaemic stroke patients, other risk factors associated with

CARDIOPULMONARY CONDITIONS AND FALLS AND FRACTURES FORMED VICIOUS CYCLE OF REPEATED HOSPITAL ADMISSIONS AMONG HIGH IMPACT USERS OF CEREBROVASCULAR CONDITIONS.

high-impact users were older age, vision loss, diabetes, mental health disorders, increased co-morbidity, prolonged length of stay for stroke, admission to HDU/ITU, procedural complications and infections. For instance, if an elderly stroke patient with cardiovascular conditions and mental health disorders has multiple complications during their stay in the hospital; this can be detrimental to one's physiological and psychological state resulting in long-term readmissions.(67) Thrombo-embolic event had strongest correlations with high-impact users who were TIA patients: a condition with significantly higher risk than other risk factors. The condition of TIA puts one at a risk of a thromboembolic event, and multiple anti-platelet and anticoagulation therapy are prescribed in these patients as a secondary prevention.(164) Despite the efforts, if they suffer a thrombo-embolic event, it leads to a subsequent detrimental chain of emergency admissions.(164) Among patients with intracranial haemorrhage, specific risk factors were associated with certain subgroups and accounted for their pattern of readmission rate. For example, the group with intermediate readmission rate followed by rapid decline had the worse mortality rate. These patients had an association with increased HACs which may have contributed to high readmission rate and increased mortality later on. Another group with rising readmission rates were young patients who had a thromboembolic event. However, this group did not have a high mortality rate. These patients may have survived the acute vascular event but suffered repetitive cycles of emergency admissions.

5.3.1.2 Co-variates are interlinked and initiate series of adverse events

The risk factors associated with high-impact users seem to be inter-linked. One of the important risk factors for high readmission rate is history of stroke as it has been shown that recurrent stroke is common in cerebrovascular patients.(43,164) A second stroke results in multiple cerebral lesions causing progressive cognitive decline and poor functional health.(165) In addition to this, it has also been linked to epilepsy which may be related to the severity of stroke due to the effect on the hippocampus region and cortex from involvement of multiple sites and larger lesions.(166) These events lead to poor mobility which can make one prone to chest infection, including aspiration pneumonia, and catheter-related urine infection.(43,167) Furthermore, multiple medical conditions can be detrimental to mental health; incidence of depression is high among stroke patients. Stroke causes depression either directly due to damage to neural circuit of mood regulation or, indirectly through cognitive impairment and suffering from other medical conditions.(168) All these factors prolong the length of stay in the hospital by causing dehydration, malnutrition and further functional decline.(7)

5.3.1.3 Co-variates that had lower odds of association with high-impact users

Old age, dementia and paralysis are some risk factors which affect mortality and morbidity according to previous studies. However, these factors had lower odds of being associated with high-impact patients. Elderly patients with dementia and poor mobility may be those

COMMON CAUSES OF READMISSIONS WERE SIMILAR IN ALL GROUPS BUT HIGH IMPACT USERS HAD DISTINCT SEQUENCES OF CAUSES OF READMISSIONS. HIGH IMPACT USERS ALSO HAD HIGHER NUMBER OF PATIENTS WITH MULTIPLE READMISSIONS AS COMPARED WITH OTHER GROUPS.

dying patients who had a stroke, and a cerebrovascular event may have increased their mortality.(169) By no means is this an indicator of a higher readmission due to an early demise and they will remain a part of the low-impact group. Similarly, non-Caucasian ethnicity has lower odds of being associated with high-impact group, but in earlier studies, there were linked with increased risk of cardiovascular events in the future.(170-172) However, among these ethnic groups there is a gap in knowledge and awareness of conditions with regards to which they seek healthcare assistance, hence nothing conclusive may be assumed.(173-175)

5.3.1.4 Similar common causes of readmission among all subgroups

The common causes of long-term emergency admissions were the same in different groups of patients with cerebrovascular conditions. However, the high-impact users among ischaemic stroke and TIA had distinct sequences of causes of emergency admissions. The proportion of patients with multiple hospital admissions was higher among high-impact users as compared with low-impact users. Low- and high-impact groups among patients with intracranial haemorrhage had no sequences of emergency admissions. Patients in the low-impact group did not have many repeated hospital admissions, and there were very few patients in the high-impact group to identify a common distinct sequence. The common causes identified in this study were similar to ones documented earlier for patients with short-term readmission rate.(176,177)

5.3.1.5 Comparison with earlier studies of common causes of readmission

Most previous studies have evaluated causes of emergency admissions in ischaemic stroke patients. Recurrent stroke, diabetic complications, heart failure, infections, fractures/falls and cardiovascular conditions were found to be common causes of readmissions.(43)(178) Distinct from ischaemic stroke, dementia was one of the most common causes of emergency admissions among patients with intracranial haemorrhage. In certain cases, ischaemic stroke patients were also readmitted for dementia, but it was not one of the top 5 conditions. Clinical studies have observed that the risk of dementia is higher in the first year following stroke.(42,179,180) Furthermore, dementia was more common among patients with intracranial haemorrhage because the patient population had a high prevalence of pre-existing dementia and cognitive impairment as well as those patients who have undergone the intra-cranial procedure.(165,179,180) Patients with intracranial haemorrhage can present with general symptoms which may mimic cognitive impairment such as a headache, memory loss, and conscious level alteration.(181) As a result, clinicians may also have a low threshold to admit these patients for possible dementia.

ASSOCIATION OF COVARIATES WITH HIGH IMPACT USERS WAS BASED ON THEIR LONG TERM FOLLOW UP WHICH WAS THE CASE IN EARLIER STUDIES. HENCE, IDENTIFIED COVARIATES WITH SIGNIFICANT ASSOCIATION WITH HIGH IMPACT USERS DIFFERED FROM EARLIER STUDIES. OPEN REPAIR HAD LOWER ODDS OF BEING ASSOCIATED WITH HIGH IMPACT USERS.

5.3.1.6 Common sequences of readmissions are repetition of few medical conditions among high-impact users

A few medical conditions were prominent and contributed the most to distinct sequences of causes of emergency admissions among high-impact patients with multiple admissions. Of the causes of admissions, urinary and respiratory tract infection, ambulatory conditions and external injuries started the series of events leading to multiple admissions. These are potentially preventable and curbing them in the community can help health trusts to improve patient care and be cost-effective, for example, recommendation for flu vaccination to prevent chest infection, prophylactic antibiotics for stroke patients with high risk of urine infection based on evidence-based anti-microbial therapy, regular diabetic checks and community rehabilitation programs to prevent falls and external injuries. Similar conditions were identified in intermediate users among intra-cranial haemorrhage with multiple readmissions. The proportion of intermediate users was particularly high in patient populations with maximum mortality. This shows that these conditions may also be related to the prognosis of these patients. There were very few high-impact users to identify common sequences among patients with intracranial haemorrhage. Further studies with more high-impact users among these patients are required to evaluate sequences of hospital admissions.

5.3.2 Elective AAA repair

5.3.2.1 Types of co-variates assessed in the study

With the primary focus on the patients with aneurysm repair and observing them with systematic and long-term follow-up, various significant predictors associated with high-impact users were identified which were not shown to have any significant effect on the readmission rate in the earlier studies.(182-185) It was important to include various types of risk factors in the model and identifying factors with strong predictive ability. Certain risk factors which may be assumed to cause an increase in the readmission rate had lower odds of being associated with high-impact users like patients with a history of cardiac arrest, heart failure and renal failure. These factors may be related to early mortality in these patients, hence, limiting the number of readmissions during their lifetime. Very few studies have assessed predictors and causes of increased readmission rate, especially those related to high-impact users among vascular patients.(59) In earlier studies, the most powerful predictors of readmissions in general surgical population were postoperative complications, polypharmacy, and co-morbidity score. In addition, diabetes and heart failure were significantly associated with vascular surgery patients.(59) But the patients were followed up for a limited time and no effort was made to identify and select high-impact users.(66)

5.3.2.2 Characteristics of high-impact users

The model tends to select elderly patients with relatively moderate health status as high-impact users. Patients with heart failure or chronic vascular conditions have an inverse relationship to high-impact usage, because these patients may not even survive to receive multiple hospital admissions. Patients who have moderate health status, but still suffer other co-morbidities, are discharged to the community but keep returning to the hospital for cardio-pulmonary conditions. The results of the study showed that ischaemic heart disease, COPD and chest infection were not significant risk factors to become a high-impact user, but high-impact users seem to have multiple hospital admissions due to these conditions after their AAA repair. It seems that these conditions were stable in these patients pre-operatively and were exacerbated following AAA repair. After major operation for AAA repair, the body physiological reserves decrease in patients, making them more prone to conditions, such as angina, chest pain, exacerbation of COPD, that were dormant in earlier prognosis.(186) Endovascular repair of AAA was common among high-impact group; however, the AAA repair is shown to exert stress on cardiopulmonary function while endoscopic procedure is going on.

5.3.2.3 How do we define potentially preventable readmissions?

There has been a debate about the proportion of emergency readmission that can be prevented in the community. The implementation of penalty for hospitals with higher than expected 30-day all-cause readmission rate among medical patients sparked research into preventative measures for causes of readmission. However, it was found that most of the readmissions were due to the conditions that warranted hospital admission and, hence, not preventable.(187,188) This study has shown that patients with multiple hospital admissions mainly suffer from cardiopulmonary and iatrogenic conditions which can be potentially avoidable. Furthermore, 30-day readmission is routinely assessed in clinical practice following this policy and most research is conducted on it. It is based on earlier studies which showed that most of the readmissions occur within 30 days of discharge from the hospital. However, long-term follow-up of the patients indicates that patients continue to have high readmission rates beyond 30 days and readmissions can occur even after one year. What happens to the readmission rate of high-impact users among vascular surgery patients? Is it different from the rest of the patients? Do they continue to have high readmission rate in the long-term? These questions are important and the study attempted to answer them for better personalised care of the patients and possible role of management program among these patients.

5.3.2.4 Prevalence of cardiopulmonary conditions among sequences of readmissions

Since cardiopulmonary conditions are prevalent among sequences of multiple readmissions in high-impact users, a need for improved care to prevent exacerbation and progression of chronic cardiopulmonary conditions and infections in the community may be required to prevent multiple readmissions in high-impact users following AAA repair. The sequence analysis identified that multiple readmissions mainly consisted of a vicious cycle of COPD, chest infection and ischaemic heart disease. It may suggest that the primary care team should be vigilant to assess patients once they are discharged back to the community after AAA repair. Meticulous preventative measures such as regular flu vaccination to prevent chest infection, secondary preventative medical therapy for ischaemic heart disease, and regular follow-up for COPD should be followed in these patients to prevent them from becoming high-impact. Moreover, the high-impact users had higher readmissions for

CHRONIC HIGH IMPACT USERS AMONG RAAA WERE ELDERLY FEMALE PATIENTS WITH MULTIPLE ORGAN FAILURE AND COMPLICATIONS DURING THE HOSPITAL STAY AS COMPARED WITH SHORT TERM HIGH IMPACT USERS. HIGH IMPACT USERS HAD VERY RATES OF CHEST INFECTION AND COPD IN THEIR SEQUENCES OF READMISSIONS, HINTING TOWARDS POLICY IMPLEMENTATION TO AVOID THESE CONDITIONS IN THE COMMUNITY.

iatrogenic injuries than the other group. In contrast, majority of low-impact users did not have any multiple readmissions.

5.3.3 Ruptured AAA repair

5.3.3.1 Comparison of trajectory analysis to previous models among AAA patients

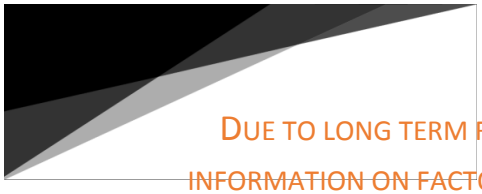
The trajectory analysis used in the study had strong predictive power and increased specificity to identify high-impact users. The methodology to classify high-impact users was different from the ones in previously conducted studies. The model used in this study estimated a pattern of annual readmission for each patient and grouped patients with similar trends. The narrow confidence interval for each group showed that they were discrete. Very few earlier studies have made an effort to identify high-impact users and assess their pattern of readmission following repair for rAAA.(189) In most studies, the readmission rate was measured as a secondary outcome and only for a period of 30 days to 1 year.(189) It is important to observe these patients for a long period because a significant number of emergency readmissions occur after 30 days.(189)

5.3.3.2 Two subtypes of high-impact users: chronic and short-term

Unlike previous studies, our analysis indicated that the high-impact users consisted of two subgroups. This was further validated when the model was applied to another cohort of patients where 3 groups were recognised in the population. The elderly female patients belonging to poor socio-economic class who had prolonged length of stay had higher readmission rate after discharge but they became low-impact users later on. On the other hand, female patients with renal and heart failure, who had undergone open AAA repair with multiple complications continue to have high readmission rates. These patients can be recognised immediately post-operatively however, an active monitoring policy is required for these patients. For both subtypes of high-impact users, exacerbation of COPD, chest infection and urine infection were linked together in multiple readmissions. It seems that these conditions are not directly related to surgery. These conditions can be avoided in the community with simple preventative measures in the primary care. On the other hand, the involvement of specialised cardio-pulmonary rehabilitation centres may reduce the readmission rate in these patients.(189)

5.3.3.3 Comparison of common causes of readmissions with earlier studies

All causes of emergency admissions during the 5-year period following rAAA repair were examined. Common causes of readmissions were cardiopulmonary conditions, iatrogenic injuries, and external injuries – these were common in all subgroups. Earlier studies evaluating causes of short-term readmissions following AAA repair had similar causes of readmission, but most of them are based on patients with elective repair.(183) The common



DUE TO LONG TERM FOLLOW UP AND INFORMATION ON FACTORS RELATED TO SOCIAL AND PRIMARY CARE, ADDITIONAL COVARIATES WITH SIGNIFICANT ASSOCIATION WITH HIGH IMPACT USERS WERE IDENTIFIED THAT IMPROVED THE PREDICTABILITY OF THE MODEL.

causes of readmission after elective repair were wound complication, chest infection, sepsis, and myocardial infarction.(190) There was a higher rate of graft complications and re-intervention with EVAR use, but bowel obstruction, hernia repair, and gastrointestinal conditions were more common with open repair.(190)

All subgroups had similar common causes of readmissions, but high-impact users had a significantly higher proportion of patients with multiple readmissions compared with other groups. The common sequences of causes of multiple readmissions in these patients consisted of exacerbation of COPD and chest infections. Identification of common sequences of readmissions was particularly important since it indicated that mere observation of common causes of readmission was similar in all subgroups. However, sequence analysis identified distinct sequences of readmissions that can be targeted by policymakers to prevent patients from having multiple readmissions.

5.3.4 Heart failure

5.3.4.1 Use of trajectory modelling in earlier studies

In a previous study, trajectory analysis of monthly change in co-morbidity status was conducted to assess prognosis in subgroups among HF patients.(126,191). The number of subgroups and their co-morbidity pattern was similar to the trajectory analysis of readmission rates in this study. However, in the previous study, neither the predictors of worse prognosis status were measured nor was the model validated using a different cohort of patients. In this study, internal validation was attempted by dividing CPRD data on HF patients into regions and conducting trajectory analysis on each region. In our study, significant predictors associated with chronic high-impact users were identified. These risk factors were dementia, anaemia, stroke, renal failure, respiratory diseases, congenital heart disease and atrial fibrillation. It seems that high-impact users were elderly patients with dementia, mental health disorders and other organ failure, which led to multiple readmissions without high mortality. In contrast, short-term high-impact users were those elderly patients, with increased co-morbidity, who were often near the end of their lives. Intermediate users were relatively young patients with greater prevalence of diabetes, who had difficulties in their social life like heavy alcohol intake and relationship problems.

5.3.4.2 Co-variates associated with high-impact users compared with those identified in earlier studies

Previous studies of single readmissions differed in their sets of predictors.(60) The most commonly tested factors were diabetes, HT, ischaemic heart disease, HF, AF (atrial fibrillation), and COPD (chronic obstructive pulmonary disease), along with patients' age and sex. Among the clinical factors, renal function and BNP (B-type natriuretic peptide) were commonly assessed.(60) In this study, similar factors were identified to be associated with high-impact users. However, more factors were found to be linked with these users which

THE MAJORITY OF THE CAUSES OF READMISSIONS ARE NOT RELATED TO HF CONDITIONS. HENCE, HF PATIENTS REQUIRE HOLISTIC APPROACH TOWARDS THEIR CARE IN THE COMMUNITY TO AVOID MULTIPLE HOSPITAL ADMISSIONS.

were not recognised before. This was because the modelling was based on repeated measurement of series of readmission rate and comparison of different subgroups unlike earlier studies. Furthermore, earlier studies have not included variables from primary care data to assess its association with higher readmission rates. In this study, factors relating to regular monitoring of HF patients in the community were also assessed, such as, blood pressure and renal function monitoring. HF patients use anti-hypertensive medications which require regular checks on kidney function. Measurement of blood pressure in the community did not affect readmission rates; however, renal functional monitoring was linked with high readmission rates, which may suggest that high-impact users had underlying renal disease and renal function was regularly monitored to check the effect of the use of HF medications on kidney function.

5.3.4.3 Common causes of readmissions among HF patients

The common causes of readmissions were similar between low- and high-impact users among patients with HF. In the previous studies, the common causes of readmission were similar. During 18 months' follow-up, it was shown that one-third of the HF patients had readmissions due to HF-related complications, another one-third readmissions were due to other cardiovascular conditions, and the rest of the readmissions were due to non-cardiovascular conditions, like renal impairment and anaemia.(65,192) Similarly, the common causes of 30-day readmissions were recurrent heart failure, renal conditions, pneumonia, arrhythmias, septicaemia, COPD, and ischaemic heart disease.(193) However, high-impact users frequently had multiple readmissions and distinct sub-sequences of causes of readmissions. The sequences of readmissions mainly consisted of 3 primary causes: respiratory tract infections, cardiopulmonary signs and symptoms, and ischaemic heart disease.

5.3.4.4 Potential clinical measures that can modify risk factors in different subgroups

Based on the results of the study, simple clinical tactics can improve management of patients. With the inclusion of risk factors based on community factors, the predictive model had better sensitivity and specificity as compared with previous models. This model can be applied to the patient at a bedside to predict individual morbidity as well as implemented at a hospital level to study trends in the larger population. In principle, patient profiling from risk stratification models can be used for focused interventions and to save resources for the medical and social services team.(80) Enrolment of high-risk patients in pro-active management programs has been able to reduce hospitalisation costs and improve quality of life in HF patients.(194) The interventions that have led to a reduced readmission rate, like patient education and disease management, can be tailored to high-impact users as higher intensity programs are found to be more effective.(195) The use of primary care data provided the opportunity to study the impact of several other domains of the social environment not commonly included in studies. Examples of these factors are financial problems, relationship breakdown, being a carer for someone, bereavement due to

HIGH IMPACT USERS AMONG HF PATIENTS WERE ASSOCIATED WITH PERSONAL, SOCIAL AND LIFESTYLE RELATED ISSUES, WHICH MAKES THE ROLE OF SOCIAL CARE PARTICULARLY IMPORTANT TO MANAGE THEM IN THE COMMUNITY.

loss of family member, etc.(192) The high-impact users were shown to have a higher incidence of bereavement and relationship difficulties, which may have led to the delay in seeking help for their medical condition.(194) These patients may benefit from social services and persistent GP review to identify problems in their personal life. Furthermore, patients with multiple readmissions mainly consisted of selected conditions which can potentially be prevented in the community via interventions such as flu vaccination in HF patients, regular GP review for secondary prevention of ischaemic heart disease and to prevent the acute onset of HF with exercise recommendations, and compliance with HF medications.(196,197) It has been shown that influenza vaccination in the community reduced hospitalisation rate in the elderly patients.(196,198) The new guidelines in the management of heart failure patients have also suggested regular flu vaccination as a part of lifestyle recommendations.(196)

5.3.5 Regional analysis: high-impact users among HF patients

5.3.5.1 Regional variation in patients' characteristics and medical management

The proportion of high-impact users varied from 4% to 15% in different regions: the proportion of high-impact users and their annual readmission rate was lower in Southern regions. Variation in the proportion of high-impact users could be attributed to both variations in medical management and background characteristics of the patients. GP visits for all types of HF medication review and prescriptions were significantly lower in Northern, West Midlands and East of England regions. These regions had an association with a higher number of patients with hospital admissions and out-of-hours GP visits preceding the diagnosis of HF. Increased healthcare contacts may be suggestive of poor monitoring of pharmacological interventions for HF patients who require a regular update of their HF medical therapy.(199) Regular planned follow-up helps in prevention of acute decline in health status necessitating an urgent review by the GP or emergency hospital admission. Recent data on hospitals in the UK showed marked variation in the discharge outcomes of the patients. The proportion of patients with HF medication prescription, follow-up imaging, discharge planning and referral to a specialist nurse, cardiologist and cardiac rehabilitation was variable.(200) The hospital with higher volume of HF patients had lower readmission rates, while those places with generally high overall readmission rate had higher readmissions following HF.(199)

INTERMEDIATE USERS FORM A GROUP WITH SIGNIFICANT NUMBER OF PATIENTS AND HAVE THE POTENTIAL TO BECOME HIGH IMPACT USERS IN THE FUTURE. SECONDARY PREVENTATIVE MEASURES ARE IMPORTANT TO REDUCE THEIR READMISSION RATE.

5.3.5.2 Intermediate users among HF patients

COMMON CAUSES OF READMISSIONS ARE SIMILAR IN ALL REGIONS WHICH SUGGESTS IMPLEMENTATION OF A SINGLE NATIONAL PROGRAM TO PREVENT THEM.

In every region, intermediate users were a sizable group with the potential to become high-impact users. They were more likely than other groups to have hypertension, which was suggestive of the fact that they were prone to get further cardiovascular complications.(201,202) They also had smaller odds of being associated with regular GP visits for HF medications. It may be the case that these patients had lack of compliance with their medication, resulting in vascular morbidities in the future.(201) The association of hypertension with intermediate users further emphasises the findings from previous clinical trials on the importance of managing hypertension in the community as a secondary prevention of cardiovascular conditions leading to heart failure.(150,203)

5.3.5.3 Results of the study compared with previous regional analysis

This study is an initial step towards the demonstration of regional variation in the readmission pathways that different groups take and the general pattern of long-term readmission rate. Most of the previous data on regional variation is obtained from multi-centre clinical trials that have assessed the clinical effect of variation in the use of medical therapy for the treatment of heart failure.(204,205) For most studies, the primary outcome has been the overall mortality and readmission for exacerbation of heart failure condition, whereas some studies have evaluated overall readmission rate as a secondary measure.(205,206) High-impact users were found to be of 2 types: short-term and chronic. The short-term high-impact users were terminally ill patients, and after an initial high readmission rate, they died. In contrast to this, chronic high-impact users were those who had multiple readmissions throughout the follow-up period. Both subtypes of high-impact groups had a different set of predictors associated with them. This study identified Intermediate users that was not categorised in earlier studies. In some regions, intermediate users had a progressively rising readmission rate and had the potential to become high-impact, and they constitute a significantly high number of patients. However, further research is required to understand their characteristics and the factors relating to a rise in their readmission rate.

5.3.5.4 Difference in case-mix in different regions

We also found differences in the proportion of patients with relevant cardiovascular and other medical conditions in different regions. The Southern regions had a lower number of patients with a background of myocardial infarction, cardiomyopathy, and renal failure. In an earlier study, the difference in case-mix only accounted for 2.6% of the variation in readmission among HF patients in a global comparison of different countries, but it is difficult to estimate prevalence and patient's past medical characteristics even with the inclusion of the information from clinical registries.(199). These differences in patient case-mix and management of HF also exist at the global level as well as between different countries.(206,207)

REGIONAL VARIATION AMONG HIGH IMPACT USERS IS DUE TO DIFFERENCES IN PATIENT CHARACTERISTICS AND MANAGEMENT PROVIDED TO THEM IN DIFFERENT REGIONS.

5.3.5.5 Common sequences of readmissions in different regions

Despite variation in co-morbidities of the patients in different regions, the common causes of hospital admissions and their sequences were similar among high-impact patients with multiple hospital readmissions. These patients underwent a vicious cycle of admissions for cardiopulmonary signs and symptoms, chest and urine infections, ischaemic heart disease and external injuries. Exacerbation of HF is one of the common causes of readmissions. However, these patients get admitted to hospital for various other reasons as well. Multiple causes of hospital admissions among HF patients show that the medical management of HF alone cannot yield better care for them.(199,208) The reduction in readmission rate will require improvement of holistic care of these patients, such as the promotion of secondary preventative measures for ischaemic heart disease, regular flu vaccination, exercise recommendation and prevention of falls and fractures.(197,199,208,209) Since the trends in readmissions and the causes of hospital admissions are similar across regions, it provides an opportunity to policymakers to create a single and uniform program for high-impact users across all regions to reduce their readmission rate.

5.3.5.6 Significance of risk factors associated with different subgroups of HF patients

Heart failure on top of a history of other organ failures had an association with poor prognosis among short-term high-impact users for HF, which is common in all regions. Risk factors for chronic high-impact users have been variable; in elderly patients, multiple organ failures lead to high mortality whereas they tend to be younger patients relative to other groups. In each region, there is one prominent risk factor that has increased odds of association with the group and one particular condition can trigger multiple hospital admissions once patients develop HF. Intermediate users in each region have similar risk factors as short-term high-impact users, but they are a relatively young population. Their conditions of hypertension, chronic renal and respiratory diseases are stable. We need to explore other factors that prevent them from becoming high-impact users. It is possible that they may have less severe heart failure or the cause of heart failure is different from high-impact users. In any case, a combination of clinical data with administrative data can help answer these questions.

5.4 Trajectory and sequence analysis

5.4.1 Limitations of methodologies used for classification of high-impact users in earlier studies

The classification of the patient population into different subgroups based on hospital care use has been arbitrary and variable with no standard methodology.(22,23) Most of the previous studies have focused on the identification of high-impact users of emergency care department. When classifying high-impact users for a particular condition, like HF, the sample size of the studies was small.(94) The categorisation was based on a single observation made at the end of the follow-up period, which has been one year in most cases.(94) Earlier studies measured the effect of an intervention to reduce patient visits to the hospital by using the control group for comparison consisting of the same patient cohort

PREVIOUS MODELS TO STUDY TRENDS IN LONG-TERM OUTCOMES WERE HIERARCHICAL MODELLING, LATENT CURVE GROWTH ANALYSIS AND GROWTH MIXTURE MODELLING.

before the intervention.(95) Precaution should be taken to interpret effectiveness of these interventions as the reduction of hospital care use could be due to a natural regression in healthcare use.(95,210) It has been suggested that more than half of the high-risk users decreased their healthcare visits after one year and a smaller proportion of the high-risk patients persistently and increasingly use healthcare services throughout the four-year follow-up.(111) There is an indication that subgroups may exist within broad categories of high- and low-impact users.(112) Hence, it is critical to study, model and visualise changes in the frequency of health care use over time to accurately classify the patients.(111) This has been missing in many of the studies done previously.

In addition to this, in various previous studies patients have been broadly categorised into two groups: high- and low-impact users.(13) High-impact users were defined as those requiring 3 or more unplanned hospital admissions in a year.(13) The main focus of the previous studies was to identify predictive factors associated with the high-impact users by conducting logistic regression analysis (1,13,23). The statistical model only measured change over two-time points and had limited ability to assess dynamic developmental changes over time.(26) On the other hand, methods such as cluster analysis categorise population into subgroups based on similar properties but do not focus on the identifying risk factors associated with the patient subgroups.(27,28)

5.4.2 Previous predictive models used for long-term clinical outcomes

There has been a continuous effort to predict long-term outcomes, but the previous predictive models lack validity, generalisability and accuracy, at least for stroke.(211) Most of the previous studies aiming to formulate a prediction model for the outcomes were not adequately validated, and a small cohort of patients was used to test them.(211) Crude analysis or use of one type of statistical modelling, such as logistic regression, was used to assess the association of prognostic factors with the outcome of interest.(211) The most common outcome measures for stroke were the quality of life, mortality and functional capacity.(212) Not many studies adjusted for case-mix factors, such as severity of the condition, demographics and co-morbidity status that were important to compare the outcome in different subgroups.(212) Other studies with longer follow-up and specific outcomes of interest had limited predictive ability.(213) Many previous studies have mainly focused on predictors based on patient characteristics and past medical history, whereas the inclusion of social and psychological factors in the adjusted analysis is yet to be thoroughly assessed. Many of the studies' follow-up period did not exceed more than one year. Half of the studies used administrative data and some studies extracted secondary information from randomised controlled trials, which have a different primary aim.

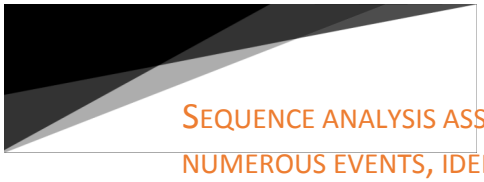
5.4.3 Previous models used to visualise trends of outcomes in subgroups

The characteristics of other established models used to study the trajectory of subgroups in non-medical studies follow assumptions which may not make it as competent a model as

PREVIOUS PREDICTIVE MODELS TO ASSESS READMISSIONS WERE NOT ADEQUATELY VALIDATED, AND TESTED ON SMALL NUMBER OF PATIENTS. THEY WERE BASED ON LOGISTIC REGRESSION TO EVALUATE ASSOCIATION OF RISK FACTORS WITH OUTCOME OF INTEREST.

GBTM to study the long-term clinical outcomes.(21) Growth curve models consist of hierarchical modelling and latent curve growth analysis.(21) Although these models are different, they still share certain common properties.(21) They assume that the outcome follows a normal distribution and they estimate average trends in the development for the whole population. All individuals follow similar trends, and the subgroups are formed based on variation from the average trend. Some studies have used growth mixture modelling, which assumes that the population consists of 2 or more distinct groups.(21) The outcome for each group is calculated as a separate component of the model, and each group has its own mean and variation. In all these models, the number of subgroups are finite and based on some pre-determined hypothesis of the study.(21) In contrast, GBTM assumes that different trajectories in a population exist due to inter-individual variation within the same population.(40) Hence, the number of groups is not finite, and their trajectories are based on actual observation of the outcome.(108) It is particularly beneficial for trajectories of unknown shapes and in cases where some subgroups and their trends of outcomes are uncertain. The individuals within the group are more homogenous in characteristics, and comparison of groups, rather than the individuals, is used to assess the variability. It provides the advantage of quantifying probability of an individual to be associated with the group by measuring group membership probability score.(108)

In life course epidemiology, growth trajectories in early childhood have been studied to elucidate its relation to risk of chronic diseases later in life.(214,215) However, previous methodologies have limitations for its application to medical outcomes. One way to evaluate trajectories was the use of z-scores in illustrative datasets and approaches based on conditioning.(214,215) The use of z-scores involves the difference of individual's measure of outcome with the average of the group and standard deviation. The procedure works by taking the cross-sectional and simple analysis of the outcome at different time intervals, rather than average continuous trajectory. It is beneficial for assessing the period when there is a significant relationship between outcome measurement and adverse event, but when the outcome is measured in the next time phase, it may show a completely different relationship with the adverse event and hence using z-score may cause problems. The measurement of the outcome has to be done at the same time in all time periods for all individuals in the group. There are no confidence intervals for the trajectories. The



SEQUENCE ANALYSIS ASSESS TIMINGS OF NUMEROUS EVENTS, IDENTIFY COMMON PATTERN AMONG THEM AND THEN EVALUATES ITS EFFECT ON THE PROGNOSIS

conditioning approach is based on finding the relationship between independent variable and dependent variable for a particular observation of outcome while adjusting for measurement of the outcome at a different period.(214) The potential limitation of this approach is that the estimated trajectory is based on collinearity among the series of measurements of the outcome: the shorter the time interval between the measurements, the more co-related they are. The method produces wide confidence intervals which makes identification of subgroups in the population rather difficult.

5.4.4 Recent use of trajectory analysis in medical research

Trajectory analysis is a robust methodology to model and visualise changes in the frequency of healthcare use in different subgroups in the patient population so that interventions aiming to reduce readmission rate are cost-effective, parsimonious and have long-lasting impacts.(11,21) In a recent clinical study using trajectory analysis, five subgroups of patients were identified based on the pattern of recovery following stroke, each with distinct prognosis as well as the risk of mortality.(216) Similar observations are present in patients with other conditions like surgery and heart failure.(126,217) The methodology for classification should assess the patient population for a long period because it is still unclear as to what proportion of these patients continue to remain high-impact and how many of the low-impact users turn high-impact in the long-term.

5.4.5 Identification of risk factors based on long-term outcomes

High-impact users among AAA repair had an association with heart failure and renal failure, peripheral vascular disease, and hospital-acquired complications. One may consider that the information on risk factors associated with high-impact users is not new and one would expect an elderly patient with multiple organ conditions to have high readmission rate. The information about the risk factors is similar to what was found in earlier studies.(218) However, previous studies do not provide a complete overview of the outcome of high-impact users following AAA repair.(219) Only heart failure and diabetes had a significant association with high readmission rates.(219) In the analysis, renal failure and hospital-acquired complications were important predictors of long-term outcome. Other cardiovascular risk factors – like hypertension, diabetes and ischaemic heart disease – that may seem to impact the outcome of patients did not have any effect on the readmission rate.

5.4.6 Advantages of sequence analysis over other techniques

Sequence analysis provides multiple benefits when applied to hospital administrative data. Instead of a crude analysis that reveals common causes of readmissions, for example within the usual 30-day post-discharge window, it provides additional information with regards to the timing of the occurrence of events.(41) Use of sequence analysis identifies a common pattern of readmissions as well as explores the further interpretation of transition from particular event to another.(41) Most readmission studies only assessed the sequence of 2 events and its impact on the outcome. The patient population was divided into two groups based on the timing of occurrence of events, and their outcomes were compared.(19,35) Sequence analysis assess timings of numerous events, identify common pattern among them and then evaluates its effect on the prognosis.(42)

For all the patients who had emergency readmissions, the categories of causes of readmission are colour-coded, and all sequences of readmissions can be visualised.(42) The program also measures the rate of movement of a patient from one event to another, and it

HIGH IMPACT USERS REQUIRE DIFFERENT MANAGEMENT PATHWAY AS COMPARED WITH OTHER PATIENTS, MANAGEMENT PROGRAMS SHOULD BE TARGETED TOWARDS THEM AND THEY REQUIRE LONG-TERM SURVEILLANCE.

can be used to compare transition rates and mean time spent within each category of the cause of readmission.(42) It can also run various common statistical tests between groups to assess the association of various patient factors.(42) Sequence analysis can demarcate groups based on independent variables like gender, age, socioeconomic index etc.(42) For a given time-frame, the common causes of readmission and their sub-sequences can be investigated.(42) The program can run analysis on a large data sample and for a greater number of coded categories of readmissions.(42)

5.4.7 Use of Lasagne plot to visualise sequence of adverse events

Population-based administrative data was converted to patient-centred longitudinal data to assess one's chronological order of healthcare interactions.(220) The order of events was displayed on a 'Lasagne plot' to show the type of care visits leading to patient's death. This plot is a new way of depicting the patient's continuous outcomes, and it is popularly used in the genomic literature.(221) In the 'Lasagne plot,' the pathway of a patient in a population is displayed as a horizontal layer. Colour marks each event, and each horizontal line shows a change in the colour pattern if there is a change of event from one category to another. Data of other patients in a population are stacked over each other.(220,221) Furthermore, it can also measure the frequency of change from one particular event to another. The technique can be applied to other types of outcome measures, categorical or continuous. It can also measure the rate of change of severity of a clinical status, outcome or indicator.

5.5 Clinical implications

5.5.1 Different care pathway for high-impact users

Our study showed that chronic high-impact users continued to have high readmission rate during the long-term follow-up period. It is important to recognise them early and assess the option of different care pathway to allow easy transition of care. Further studies are required to build a predictive model to identify potential high-impact users by the clinical team. These patients may benefit from closer surveillance. For example, more aggressive pre- or post-operative cardiopulmonary work-up or rehabilitation to avoid iatrogenic complications may be of benefit following AAA repair. An early and aggressive mobility and cardiopulmonary rehabilitation program for patients in ITU and colonic surgery patients has already shown to reduce readmission

LASAGNE PLOT VISUALISES PATHWAY OF PATIENTS AND EACH EVENT IS COLOUR CODED SO THAT CHANGES AND FREQUENCIES OF EVENTS ARE DISPLAYED IN LONGITUDINAL PATTERN

rates.(222,223)

5.5.2 Sequences of readmissions may contain potentially preventable causes of hospital admissions

The identification of distinct sequences of causes of emergency readmissions may help on focusing on potentially preventable admissions. Although it is hard to define a preventable readmission, previous studies suggest all emergency readmissions are potentially avoidable, especially those due to medical conditions rather than surgical interventions.(224) My analysis suggested that common sub-sequences of readmissions in high-impact group mainly contained medical conditions. From the hospital administrative data alone, it is not possible to isolate information on community factors associated with the cause of admissions e.g. whether or not the urinary infection was catheter-related. However, it can provide enough information to concentrate on certain conditions that lead to further readmissions like chest infection as shown in my data.

5.5.3 Possible role of management programs targeted only towards high-impact users

This study distinguishes various subgroups with distinct pathways based on readmission rate. The model has a good ability to predict high-impact users. The results of the study suggest that there is a probable role of trial of different management strategy for high-impact users. Predictors associated with high-impact users help clinicians to identify those who tend to become high-impact users. Only then health policymakers and clinical teams can introduce strategies to reduce the number of long-term high-impact users, guided by the knowledge of common sequences of readmission cause. This way, clinicians can concentrate on the management of specific subgroups with higher readmission rates and limit elaborate spending of resources on a large group of patients that are well and will continue to be so.

Identification and prediction of high-impact users may improve the efficacy and cost-effectiveness of disease management programs. Hospital admissions following heart failure are very common and account for more than half of the cost used to manage these patients.(225) It was estimated that hospital admissions related to heart failure cost around £500 million to NHS UK.(225) Disease management programs have certain key features: patient education, trained nursing or medical staff for early follow-up and patients' access to trained staff.(203,226) The cost-benefit of these programs was questionable due to limited evidence on cost evaluation. However, the majority of these programs have been able to reduce all-cause and heart failure related readmission rate in patients with different age groups as well as the severity of heart failure.(203,227) This will also allow clinical deterioration within patients to be noticed earlier and enable alteration of medication appropriately and accordingly.

5.5.4 Further assessment of markers of readmission rates to evaluate quality of service

Earlier studies found high readmission rates immediately after the vascular procedure with a marked reduction after 30 days. Therefore, Centre for Medicare standardised 30-day readmission rate as a marker of quality of service.(98,228) However, the trajectory of high-impact users shows that they had persistently high readmission rate throughout the

postoperative 5-year period. Thus, high-impact users require closer observation for a longer period.

5.5.5 Future research models for HF patients

In the light of this study, two policy changes may improve the care of heart failure patients. The corresponding out-of-hours GP visits among subgroups match the trends in readmission rate, indicating that these patients repeatedly call for help in the community during out-of-hours. When the GP attends them, they have a low threshold of referring them to hospital care given their history of heart failure.(229) The differential diagnosis of these patients, as shown by the causes of admissions in our results, will be worsening of heart failure, chest infection, and acute ischaemic coronary event. All these conditions have severe consequences if misdiagnosed.(230) Hence, the GP attending these patients can end up referring them to a hospital in most cases. Recent instruments have been developed for prompt measurement of troponin and inflammatory markers.(231,232) However, further research is required to assess if these point of care devices can make the decision-making process as well as treatment easier for the GPs if they encounter a patient with cardio-pulmonary sign or symptom. If it indicates chest infection rather than an acute ischaemic event, they can treat the patient in the community with appropriate oxygen therapy and antibiotics.(233) Secondly, most of these patients have multiple co-morbidities requiring X-rays and blood tests before treatment. The problem, however, is that the primary care does not have enough resources even if they attend these patients out of hours. A small research model can be conducted to assess if the direct correspondence between cardio-vascular patients and medical specialist team in the hospital is useful when these patients become unwell and the ambulance crew can directly transfer them. This way the investigations and treatment are carried out in a shorter time span.

5.5.6 Evaluation of active involvement of patients in their care

Patient's knowledge of being a high-impact user can encourage active participation in their care.(234) Once they understand the factors that can reduce their readmission rate, they can get involved in preventative measures.(235) In the analysis, compliance with medications and exercise recommendations were inversely related with high readmission rates. Thus, potential role of patient's awareness of his/her condition and educating the public about early signs of heart failure can be analysed.(236) Elderly patients noticing signs and symptoms of HF can promptly visit GP and initiate investigations to diagnose the condition. Diagnosis and treatment of HF in the community can avoid patients becoming high-impact as the results from the study have indicated that HF being diagnosed as an inpatient in the hospital is the most prominent risk factor for being a high-impact user.

HIGH-IMPACT USERS REQUIRE PROMPT INVOLVEMENT OF SOCIAL SUPPORT AND DIFFERENT SOCIAL CARE SET UP THAN GENERAL PATIENT POPULATION

5.5.7 Community programs to prevent cardio-pulmonary conditions

In all patient cohorts, cardio-pulmonary conditions were common in patients with multiple hospital admissions, even in surgical patients and those with non-traumatic intra-cranial haemorrhage. It could be a co-incidence that cardio-pulmonary conditions are picked up as common sequences of hospital readmissions. Nevertheless, a correlation can be asserted since they are common in the community. Even if this is the case, then Care Commissioning Groups can review local data and conduct further studies to assess if there are local trends of readmissions among high-impact users and if it is worth putting in measures to prevent them.

5.5.8 Review of clinical data of short-term high-impact users

This study suggests that different subgroups in the population may benefit from different social care pathway according to their trajectories.(237) People with chronic illnesses require an extensive network of social services set up, which places a huge economic burden on the health trust.(225) Different regions in the country have variable social care support, and the pathway for the referral to social care and their involvement is also not fully established in patients with chronic conditions.(237) For example, the results of this study show that short-term high-impact users have a significant association with worse prognosis. The review of the clinical data for these patients will be helpful to see what proportion of them were considered for palliation during their initial hospital visit. This way any unnecessary hospital admissions could be avoided and end of life care are made more comfortable. They can potentially benefit from palliative care pathway as soon as possible by the medical team after they have assessed them.

5.5.9 Potential role of prevention of HACs and thromboembolic events

High-impact users among cerebrovascular conditions were shown to have a significant association with HACs (hospital acquired complications) and thromboembolic events. Respiratory tract infections and urinary tract infections were most significant HACs. Thromboembolic events included myocardial infarction, acute coronary syndrome and pulmonary embolism. Further studies can be performed to evaluate why high-impact users are prone to increase numbers of HACs and thrombo-embolic events. If they are further shown to have a link with these conditions, then policymakers can focus on these factors which are potentially preventable and result from poor management of HACs during the hospital stay and inadequate secondary prevention of acute vascular events.(158)

5.6 Strengths of the analysis

5.6.1 Flexibility in the application of GBTM

GBTM has an advantage over other models used to study longitudinal data.(40) Repeated observations over time determine the shape of the trajectory of each subgroup. It assumes

TRAJECTORY AND SEQUENCE ANALYSIS HELPS IN VISUALISATION OF LARGE DATASETS, AND THEIR APPLICATION ON PRIMARY CARE LINKED TO HOSPITAL DATASET PROVIDES ADDITIONAL INFORMATION ON SUBGROUPS OF PATIENTS.

that the subgroups are part of the same population, but each follows different developmental pathways. GBTM can be used to study both continuous and binary outcomes by incorporation of various statistical methods, for example, zero-inflated Poisson model, censored normal and logistic analysis.(40) It also adjusts for participants lost to follow up by the application of full information maximum likelihood estimation to impute the missing information which is unbiased. It does not pre-empt the number of groups but uses a statistical approach for approximating the unknown distribution of trajectories across the population.(40) Although medical research has recently used GBTM, it has been an effective tool in the analysis of longitudinal data in psychology, criminology and social sciences over the last 25 years.(21)

5.6.2 Visualisation of subtle changes in patients' outcomes

Visualisation of data and disease course of patients assist in the understanding of complex information simply.(242) In big data analysis, the number of patients and their healthcare encounter is large. The data is collected routinely, and all the information is regularly processed. The outcome for each patient is measured at each interphase or period. The analysis and tables of results provide extensive information, but extra and non-significant information muddles prominent outcomes which have clinical impact. Visualisation of data helps clinicians and health policymakers in recognising trends in outcome and impact of the intervention on the patient's outcome.(243) As it is said, 'seeing is believing'. The trajectory of outcomes and Lasagne plots depicts the pattern of measurement over a long period which is understood and interpreted in a short while.

GBTM is a novel approach because, in earlier outcome prediction studies, analysis has mostly been cross-sectional. Other fields of epidemiology, such as life course epidemiology, have tried to categorise study populations and behaviour of its groups over a long period. The modelling of early growth data to study its effect on different medical outcomes later in life has been of particular interest in life course epidemiology, and different models have been applied to fully exploit datasets to understand the pattern of growth in subgroups.(244) The model that gave the provision to produce complex shapes of the trajectory of outcome using polynomial functions was better in studying changes in the salient behaviour of groups in the study population. This feature is present in group-based trajectory modelling, and it allows for the trajectory of each group to be different from each other; one group can have a simple-shaped linear pattern, and another group in the same population can have a curved trajectory.

5.6.3 Importance of assessment of sequence of clinical events

Over the past few years, the sequence of clinical events has shown to impact clinical outcomes.(19) For instance, a particular sequence of resolution of symptoms in pneumonia was associated with poor prognosis.(19) Similarly, the chronological order of atrial

fibrillation and heart failure determined the risk of mortality in the patients.(34) Previous studies evaluating causes of readmissions with the use of hospital administrative data has merely searched for the common causes of readmission.(43) We have not come across studies that analysed the temporal sequence of causes of readmissions in the high-impact users by using hospital administrative data.

The use of administrative data provides additional information with a pragmatic approach on the behaviour of patients in the community. Since inpatient emergency admissions with the standardised coding of the primary diagnosis are effectively and routinely recorded, the hospital administrative data provides a fruitful opportunity for sequence analysis.(70) Previous studies have mainly used clinical data to study chronological clinical events among patients.(70) The information on 'real life' events from the administrative data can complement the findings from clinical studies and formulate management pathways for the patients with practical applications and realistic goal settings.

Sequence analysis provides common linkages of causes of readmission and offers insight into the course of deteriorating events in the life of the patient and in establishing an understanding of natural history of adverse events.(245) An elderly patient with multiple co-morbidities has few body reserves to combat complications.(245) An acute medical condition leading to hospital admission deteriorates functional health of the patient.(245) Once the patient is discharged from the hospital, their health status does not fully recuperate and they become more prone to further hospitalisations with rapid deterioration, resulting in a 'snowball effect'.

5.6.4 Advantage of using primary care data linked to hospital data over hospital administrative data

The analysis of hospital data linked to primary care data delivered detailed information on predictors associated with different groups which enhanced the predictive power of the model. Hospital data alone missed information on socio-demographic, pharmacological, and lifestyle-related factors and this information can be obtained easily from primary care data. The linked data does not include all patients with a particular diagnosis as it is obtained from eligible primary care practices with standard research protocol and then matched with patient's hospital records.(142,246) However, the number of patients in the linked epidemiological data was large enough to run the analysis and identify important predictors. In an earlier study, the use of linked datasets has shown improved quality and sensitivity in estimating incidence of community-acquired pneumonia as compared with stand alone primary or secondary care data.(247) Furthermore, in other population-based longitudinal studies, the need for finer classification models based on long-term outcomes has been suggested. For instance, research on comparing classification of disability in a population-based study, binary *ad-hoc* classification of disability based on World Health Organisation definitions poorly categorised individuals with different levels of disability because another classification model showed that there were 4 classes of disability.(248)

5.7 Limitations of the studies

5.7.1 Channelling bias among surgical patients

Among the surgical patients, the analysis was prone to channelling bias because the patients who underwent EVAR (endovascular repair) for AAA were different from patients who underwent open repair.(249) During the early use of EVAR, the elderly patients with

increased co-morbidities who were not fit for open repair were selected for the procedure.(184)

5.7.2 Consideration of other healthcare resources

The analysis used in the research did not take into account use of other healthcare resources like outpatient visits, accident and emergency department visits. The categorisation of groups was based on emergency hospital readmission rate to understand long-term morbidity and real-life events that impact quality of life. A major contributor to health cost among high-impact users have been emergency hospital admissions - this was the primary outcome of the research. Recent advancement in trajectory analysis is the use of multi-trajectory modelling that can assess the pattern of more than 1 outcome and inter-link them. We applied this model to HF patients and found a correlation between hospital readmission rate and out-of-hours GP visits during the follow-up period. In addition, the data on other services in the national hospital database is also limited. The graph displays trajectories of discrete groups, but it cannot predict the trajectory of an individual in the study sample. The comparison of the study results with previous studies was limited because very few studies have conducted trajectory and sequence analysis to study long term hospital care use.(43)

5.7.3 Coding of diagnosis

The ICD and OPCS coding of the conditions used to select patient cohort have high specificity despite coding errors, and primary diagnoses and procedures are accurate.(193,250) We tried to use all possible codes that define the condition, to include most cases. It is important to consider the issues of large data quality when interpreting the results. The primary diagnosis associated with each hospital episode in HES is defined by the condition which has incurred the most cost in patient care - which may be different from the condition for which the patient was initially admitted to the hospital. The secondary diagnosis listed in each hospital spell provided information on the covariates. However, it does not distinguish if the condition occurred during the hospital stay or before admission to the hospital. Administrative data seldom record these distinctions.(250) However, it may not make a significant difference in the outcome as the risk factors found to be significant in this study were similar to the one found in earlier clinical studies. Administrative staff collects the data. They lack clinical knowledge and are not involved in patient management.

5.7.4 Lack of social and demographic factors in hospital data

Information on demographics, social and lifestyle factors lacked in hospital administrative that limited the predictive ability of the model as evident in the analysis conducted on patients with cerebrovascular conditions and repair of AAA. The analysis on the HF patients had information from CPRD data, which included valuable information on patient demographics, lifestyle and social factors, and pharmacological treatment. Some of these factors had an association with high-impact users which increased the predictive power of the model.

5.7.5 Limitation of generalisability of the results

5.7.5.1 AAA repair

Among the patient cohort of AAA repair, the number of patients undergoing endovascular aneurysmal repair (EVAR) was small compared with patients with open repair. The patient cohort was selected to achieve follow-up of 5 years which is a declared minimum standard

for long-term follow-up by the Society for Vascular Surgeons.(183) During this period, the use of EVAR in ruptured AAA was not widespread as its use has increased only in the last few years. The EVAR technique has significantly evolved with new catheters, graft stents, wires and balloons for implantation. The clinicians are also more experienced in patient selection and procedural techniques.(251) A separate analysis is required in the future studies on a significant number of patients undergoing EVAR to assess long-term morbidity associated with the procedures done with advanced instrumentation. Furthermore, the decision to perform EVAR is based on a complex interplay of availability of service, anatomical complexity and patient co-morbidity which leads to biases in the selection of patients.(185) Therefore the differences between the outcomes of EVAR and open rAAA repair may be accounted for by this bias. Another model on long-term mortality will be beneficial as factors associated with them differ from those of readmission rate. One may assume that high-impact users will also have high mortality due to multiple readmissions resulting in a decline in health status.(7) However, the mortality rate among them was significantly lower than low-impact users following rAAA repair.

5.7.5.2 Primary care data

The use of primary care data linked to hospital data in CPRD does not include all patients suffering from the condition in focus. 674 practices in the UK are registered with CPRD and provide information for primary care data.(142,246) Approximately half of these practices meet the quality criteria for data input.(160) Not all GP practices are linked with secondary data. However, it is the best available linked data in the country and indeed the largest such database in the world, which provides a great opportunity to assess various hospital- and primary care-based factors and to evaluate long-term outcomes. The incorporation of information from primary and secondary care made the model more reliable and predictable. But some social factors, e.g. patient was a carer or had a financial problem, were not commonly coded in the primary practice and were therefore not included in the statistical model.

5.7.6 Patients lost to follow-up

The patients who died during the follow-up period after being discharged from the hospital with the primary diagnosis were also included in the analysis. The reason to include them was to identify those patients who had a poor prognosis. I wanted to find out what were common sequences of causes of hospital admissions among them so that any potentially preventable cause can be recognised.

In the analysis, it was assumed that there were very few patients who were lost to follow-up for other reasons because the HES data captures all hospital admissions for a patient treated in every NHS hospitals.(71) For instance, if during the treatment the patient is moved to another hospital that is also recorded.(71) The primary outcome was a measurement of non-elective hospital admissions. Even if the patients were treated in private healthcare settings, the initial management of acute medical condition was started in NHS setting which is recorded.(71) The only time a patient could be lost to follow-up is when the patient has moved abroad. Excluding patients with Carstairs's score of 6, those with unknown postcode, helps with this problem. The incidence of this is very low especially when the patients are elderly and suffer complex medical conditions as was the case in the selected cohort of patients included in this research.(252) The patient population in the research consisted of a majority of elderly patients.(252,253) If in any case, patients lost to

follow-up were significant in number, that would have been treated as missing at random in statistical analysis.(21,254)

5.7.7 Use of sequence analysis limited to information provided by dataset

The sequence analysis of single outcome, hospital admissions, was conducted using hospital data, which did not have information on other healthcare resources and types. However, use of primary care data that was linked to hospital data provided more information on types of healthcare events which allowed sequence analysis to be performed on a different outcome. The potential use of sequence analysis depends on the information provided by the type of dataset.

5.7.8 Lack of standard categorisation of readmissions or healthcare type

Since this is the initial application of the analysis of the dataset, there is no standard categorisation of causes of readmissions or types of health care visits. Among cerebrovascular conditions, the causes of readmissions were categorised based on similar pathology and diagnosis-related group.(255,256) Among AAA and HF patients, certain conditions constituted the majority of hospital admissions. Therefore the causes were not categorised. The types of healthcare visits were categorised based on the potential impact on the outcome of patients. Emergency admissions were associated with poor morbidity as compared with elective admissions.(257,258) The analysis was conducted to assess when patients in different subgroups started using emergency services repeatedly demonstrating a decline in health status and eventually leading to death.

5.7.9 Lack of standard definition of potentially preventable readmissions

This study looked at all emergency readmissions and assessed if they can be potentially avoided, but there is a lack of consensus on the standard definition of potentially preventable readmissions (PPR). Jenck *et al.* class all unplanned readmissions within 30 days as PPR.(259) Gisenger *et al.* regards 90-day unplanned readmission related to initial hospital admission as PPR. However, it was not clear what conditions were related to initial hospital admission.(224) PPR are also defined as all those hospital admissions that can be avoided by the adequate quality of care and discharge program set by the hospital during the index admission and also if the cause of readmission can be diagnosed early and treated promptly within the primary care settings.(224) In this analysis, all non-elective hospital admissions were assessed because they put a huge burden on the healthcare system and compromise the patient's health status.(224)

5.7.10 Frailty as a confounding factor

Frailty is an important marker of morbidity and can partly confound the results of the study.(260-263) It is significantly associated with the patient's outcome and hospital admission.(264) It impacts the use of healthcare services and is affected by hospital admissions and prolonged length of stay in the hospital.(265) The definition of frailty is variable, and there are proxy measurements of frailty in administrative data. However, data does not direct code frailty, and its direct association with the outcome cannot be measured. The primary care data may suggest admission to a nursing home, but more detailed information is required to assess frailty such as the use of social services by the patient, one's mobility and ability to perform activities of daily living. In this study, increased co-morbidity status, prolonged length of stay and older age was associated with high-impact

FUTURE RESEARCH PROSPECTS INCLUDE UNDERSTANDING ROLE OF ARTIFICIAL INTELLIGENCE IN MODEL APPLICATIONS, CONSTRUCTION OF HEALTH ECONOMICS MODEL, FORMULATION ON BEDSIDE PREDICTION TOOL AND A MODEL TO ASSESS RE-STRUCTURING OF NHS SERVICES FOR ACCESS OF HEALTHCARE.

users that may indicate increased frailty among these patients. However, we are not sure about frailty status about patients in high-impact and other subgroups.

5.7.11 Limitations of information available in the data

The availability of specialist team with targeted management pathway has shown to affect the outcomes among HF patients.(249) Tertiary specialist centres have increased availability of specialist care and follow regional protocols for the care of HF patients.(249) Regional data in CPRD did not have information on the number of hospitals in each with medical and nursing staff that specialises in heart failure condition, have dedicated team with targeted management pathway to treat these patients.

Similarly, the administrative data did not include information on the pathological severity of stroke and HF, or anatomy of abdominal aortic aneurysm, which are important determinants of a patient's morbidity.(44)

5.7.12 Completeness of administrative data

Administrative data has been criticized in earlier studies for its accuracy and completeness.(250) In particular, the coding of secondary diagnoses and co-morbidities has been of variable standards.(250) Due to the inconsistency of data gathering, a direct link between a clinical variable and the outcome cannot be established affirmatively.(280) This will also impair the understanding of the sequence of clinical events and long-term outcomes based on coding. In hospitals, the discharge summaries are completed by junior doctors who focus on main conditions and may not provide thorough information on co-morbidities and other medical conditions and procedures that the patient suffered from.(250) In the current environment, the doctors work in a shift pattern due to European directives that results in lack of continuity and follow up of patient care.(281) This may contribute to junior doctors' incomplete assessment of the patients' complications that they have incurred during the hospital stay. Efforts have been made to improve the coding of secondary diagnosis for correct billing by involving the multi-disciplinary team, consisting of senior clinicians and management staff, to review clinical case notes of the discharged patients.(282)

Similarly, the coding of other conditions in primary care has been affected by various factors.(280,283,284) GPs have limited time for each patient's consultation. They have to assess the patient's primary medical complaint, examine them, and formulate a management plan during the consultation. The assessment of past medical conditions of the patients and their social circumstances does not take priority and they can be missed. Equally, GPs do not get any financial incentives to spend extra time for coding of patient's lifestyle and social factors.(280,284) Although, in the analysis of primary data for HF patients, this study tried to evaluate various social factors that can impact hospital readmission rate. However, in most cases, the coding of these factors was very limited.(284) It was not possible to deduce accurate association of these factors with the outcome of interest. If these factors are coded through a dedicated staff, it can provide useful information and may help in the formation of effective predictive models for healthcare.(282,203) The coding system used in CPRD primary data have the codes for important lifestyle factors like mobility of the patient, home care assistance; however, the coding of these factors was very scanty and I was unable to obtain data on it.(284)

The coding of co-morbidities, complications and patient's social history is variable in different hospitals and GP practices.(280) In some hospitals, there are discharge teams that analyse patient admissions and clinical records for coding. Likewise, in some regions, GPs get incentives to code and document for patient's cardiovascular risk factors. The comparison of outcomes among different regions should take into consideration the heterogeneity of coding among different health trusts.

The completeness of the data can be measured by conducting local studies where administrative data of the institute are compared to clinical records of the patients.(282,283) In earlier study, the coding of primary diagnosis in administrative data was compared to clinical data of the patient and the sensitivity of the administrative data was shown to be high.(250) Same approach can be used to assess how complete the information on secondary diagnosis and social factors is in the administrative data. This will provide initial evidence to promote accurate coding in the administrative data. The coding should not be solely left to the non-clinical staff. The health trust should give incentives to senior clinicians at local level to collaborate with management staff to review patient's records in the hospital before they are coded for billing.(282)

5.8 Future research prospects

5.8.1 Potential role of artificial intelligence

Artificial intelligence software can incorporate trajectory and sequence analysis that can generate trajectories and outcomes in subgroups among different patient populations. The best-fit model is chosen based on set criteria mentioned earlier in the study. For any given patient cohort, computer software using artificial intelligence can be configured in a manner which allows high-impact users to be automatically identified while simultaneously creating a predictor algorithm. In this study, risk factors associated with high-impact users among the patient population with a particular primary medical diagnosis were different from patients with other significant diagnoses; therefore, the best-fit model for every cohort had to make calculations individually. On the other hand, artificial intelligence can make this process more quick and convenient. For the same reason, previous predictive models that identify

high-impact users have not performed well because they were based on general patient population which included patients with different primary diagnosis.(1,66,266)

5.8.2 Research on health economics model based on use of other healthcare resources

As an initial attempt, the research has applied trajectory and sequence analysis to one aspect of healthcare use, i.e. hospital readmission rate. It has been shown that the population dataset can be converted to patient-level data and used to assess trends in healthcare change at a personal level. In clinical settings, the model can be extended to formulate an algorithm to identify high-risk patients at their bedside. Further aspects of healthcare use in other patient population can also be evaluated, such as, visits to emergency departments, outpatient visits, discharge to nursing home etc. The analysis of all healthcare usage can be used to construct an economic model which accurately assesses the cost incurred by every patient or group, during long-term follow-up. If more clinical data is available, as in the case of cancer registry linked to hospital administrative data, the sequence and timing of diagnostic procedures and treatments can be assessed in patients with poor morbidity, and better prognosis can be made using sequence analysis.

5.8.3 Bed-side risk prediction tool

Risk prediction tools are more effective once they are part of regular clinical practice, like POSSUM scoring for surgical mortality or CURB-65 scoring for morbidity after pneumonia.(267,268) These scoring systems provide additional information to the doctor, patient and the patient's family when considering a major or risky intervention, so they can collectively make more informed decisions. Research should be undertaken to develop a scoring system from a trajectory model, which can be used in the hospitals and outpatient clinics to guide management and update patients about further emergency readmissions they can encounter.

The inclusion of clinical data can improve the predictive ability of the model. The application of the model to primary care data linked to hospital data increased predictability of the model by providing additional information on social and lifestyle factors. In the case of heart failure patients, the information on ejection fraction, BNP measures, and findings from echocardiogram can considerably improve predictability of the model.(269,270) Similarly, the diameter of the abdominal aortic aneurysm can be a valuable piece of information for the analysis.(271) The use of clinical registries can provide this vital clinical information.

5.8.4 Pilot studies for early involvement of specialist care

Readmission rates may be curbed among certain specialist conditions by easy accessibility to specialist nurses.(225) High-impact users are noted to have multiple elective admissions and GP reviews. Some pilot studies have been conducted in the recent years where GPs get telephone advice from specialist nurses which have reduced readmission rates.(225) In countries like Germany and New Zealand, which allow easy access to secondary healthcare have been shown to have increased patient satisfaction, reduced waiting times and improved continuity of healthcare as compared to other European countries.(272,273) The analysis of HF patients shows that the majority of the patients who get reviewed by out-of-hours GPs get emergency hospital admission. Similar studies can be conducted among heart failure and stroke patients in the community where the effect of direct telephone or online

advice from specialist nurses to the patients on the rates of GP and hospital visits can be analysed.

5.9 Conclusion

The adaptation of trajectory and sequence analysis – from social, psychological and life epidemiology – to analyse administrative population data has produced important results. The models were successfully applied to all dataset and all cohorts of patients that were tried. In addition to this, all study populations consisted of discrete subgroups based on their long-term readmission rates. High-impact users constituted a large number in every population that had major risk factors associated with them. In most cases, they had a persistently high readmission rate throughout the follow-up period, hence they were termed as chronic high-impact users. In some study populations, another discrete subgroup of high-impact users was identified; these short-term high-impact users had an initial high readmission rate followed by a rapid decline. This group represented those patients who had very poor prognosis and died soon after their first hospital readmission. When the same model was applied to a different cohort of patients with the same diagnosis, it produced similar kinds of groups and the same proportion of high-impact users. The model has good predictive power when applied to the different dataset and can also be used to identify these patients earlier, at the time of diagnosis.

The main aim of this project was to apply trajectory and sequence analysis on epidemiological data stems from the desire to visualise events at patient-level through time and to identify common patterns of adverse events occurring among them using large population data and a pragmatic approach. Before the application of trajectory analysis, the pattern of healthcare use and sequence of adverse events were not investigated in detail among patients after they were labelled as high-impact users. Thus, to fill this information gap this project attempted to adopt trajectory and sequence modelling from other science fields, where it is conventionally used, along with life course trajectories to apply them to administrative data.

The categorisation, classification and grouping of entities and pathophysiological processes is the primary step towards understanding how nature works. It also requires a close observation of the characteristics of the subjects under scrutiny, the changes in their behaviour and their interaction with the environment. These concepts are important to understand to formulate a treatment or management pathway for any condition. Keeping this in mind, trajectory and sequence analysis were applied to administrative epidemiological data to improve classification of the patient population and to understand the behaviour of healthcare use among different subgroups. Like any statistical modelling, the methodology has certain limitations. However, it represents a new way to analyse administrative data.

The first phase of the study was to find out if discrete groups within selected patient populations existed and continued to be distinct based on their healthcare resource utilisation. The second step was to investigate if there were common sets of repeated events that occur in these groups that make them different. On the surface, a patient may have a random course of hospital admissions or other health care visits for a variety of medical conditions. But, based on the results of this study, there is some suggestion that

high-impact users follow a certain pattern of similar events causing a ‘snowball’ effect due to many factors related to their health, care in hospital or management in the community.

Trajectory analysis showed the ability to identify and predict high-impact users’ condition and allow appropriate disease management programs to target patients who need rnular and timely follow-up and aggressive update of medical management. The clinical data on disease management programs in various conditions has shown that some aspects of these pathways can help in the reduction of readmission rate.(15,203,274-277) The primary aim of using trajectory analysis was to assess and follow the pathway of high-impact users and other groups; however, the model has also demonstrated good predictive power. When applied to various cohorts of patients, it showed high sensitivity and specificity. The model was validated using another dataset, which also verified an ability to predict high-impact users’ condition. This model can, therefore, aid in the early and prompt implementation of disease management programs.

As Professor Stephen Hawking famously quoted, “The whole history of science has been the gradual realisation that events do not happen arbitrarily, but that they reflect a certain underlying order, which may or may not be divinely inspired.” The research in the second phase aimed to explore if there is an order with regards to certain adverse events in a patient’s history of health and healthcare, just as there is a sequence of events in other pathological processes. For example, the process of carcinogenesis starts with a change of normal cells to different cell types in metaplasia, turn into dysplasia, characterised by disordered growth and maturation, and ends in neoplasia, that is, the development of cancer. Similarly, the course of inflammation is a sequence of 5 stages: incubation, aggravation, destruction, abatement, and reconstruction. The results of the study showed that patients with multiple emergency hospital admissions undergo a repetitive sequence of cardio-pulmonary conditions along with urinary tract infections and iatrogenic injuries. Prevention of these few conditions may assist in breaking the cycle of morbidity among these patients.

High-impact users had distinct common sequences of causes of readmissions compared with other groups. Cardiopulmonary conditions and iatrogenic injuries were main contributors to the sequences of readmissions among high-impact users in all patient populations. The analysis of primary care data linked to hospital data showed that high-impact users have repetitive series of emergency hospital admissions and urgent GP visits following elective hospital admissions. The reason is that they are complex patients and therefore are difficult to manage in the community; hence the GP has to refer them to hospital care most of the times, once they have been assessed for the signs and symptoms they are exhibiting. Further research is required to improve care pathways for patients with complex or specialist medical conditions.(278,279)

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7.0 Appendices

7.1 Appendix 1. Medcodes of various conditions used in the heart failure study

Diagnosis of heart failure:

'G58.00' 'G580.00' 'G580000' 'G580100' 'G580.11' 'G580.12' 'G580.13' 'G580.14' 'G580200' 'G580300' 'G580400' 'G581.00' 'G581000' 'G58.11' 'G581.11' 'G581.12' 'G581.13' 'G582.00' 'G583.00' 'G583.11' 'G584.00' 'G58z.00' 'G58z.11' 'G58z.12' 'G5yy900' 'G5yyA00'

Smoking:

Current smoking status:
'12958','12941','12944','1878','3568','1822','54','12942','12967','31114','12964','30423','46654', '30762','41979','46321','62686','12947','12943','12945','101338','105501','93','1823','12952','12951', '10558','12966','12965','12963','12960','103507','98154','104230','104185','106391','106359', '98347','104310','102361','12953','2111','10211','38112','18926','74907','94958','91708','41042', '18573','98245','10742','90522','7622','96992','7130','32083','40417','42722','60720','66387','53101', '58597','19485','34126','101764','102951','98137','100099','11356','11527','40418','16717','9045'

Status of ex-smoking:
'12961','12957','12955','12956','12959','12946','97210','776','99838','60','100495','26470','19488',
'90','12878','98447','100963'

Heavy alcohol intake:
'322','749','956','12985','19495','26472','669','1618','7545','7746','8999','12974','12976','12977',
'12982','12983','12984','19401','19493','19494','28150','30695'

Renal function recorded at GP visit:
'32','1097','2072','13812','13813','13814','26832','26943','26944','26945','103493','2998','3980',
'4265','5458','10768','25763','26001','37236'));

Blood pressure monitoring at GP visit:
'1','101','57','100','5341','27274','859','3481','5020','14643','14452','23312','43547','22595','38278',
'27271','31305','14640','29261','14641','41052','14642','48008','27273','25553','19905','37242',
'37243','18418','42280','43282','65990','103','38277','41445','34618','27272','15126','29390',
'27534','102','676','6598','5760','351','8574','14448','20049','12519','104203','1956','31744'

Medications used to treat signs and symptoms of HF:

Diuretics:

'10066','10316','10392','10422','10781','11265','11268','11348','11351','1143','1144','11448','11469',
'11487','11526','11561','11567','11641','11864','11937','11965','11983','11987','12226','12294',
'12313','12318','12354','12367','12411','12412','12574','12815','12836','12858','12874','1293','1299',
'1301','13026','13123','13435','1369','13755','13821','14228','14283','14387','14477','14478','14587',
'147','14738','14761','14837','14870','14943','14960','14965','14983','15031','15085','15096','15108',
'15121','1520','15341','15605','15874','15958','16060','16161','16196','16197','16206','16212',
'16285','16371','16701','16708','16710','16924','17006','17120','17474','17545','17624','17633',
'17655','17686','17689','1776','1780','17960','1807','18096','18200','18202','18219','18223','18263',
'18269','18325','18332','18497','18650','18716','18903','18910','1904','19056','19192','19194',
'19198','19204','19208','19223','19258','193','19300','196','19690','20117','20188','20538','20579',
'20849','20975','21053','211','21162','21231','21423','21849','21938','21943','22439','22658','22708',
'23252','23456','23478','23642','24041','24268','24359','24482','24484','24632','24832','24835',
'2493','2495','25334','25382','25717','25965','25998','26292','26529','26995','27447','27520','27690',
'27696','277','2772','27871','2788','27926','28127','28129','28438','28486','28586','28724','28725',
'28820','28902','29130','29530','2961','29634','2971','29780','2982','30039','3050','30625','3069',
'30773','30875','30913','30921','31072','31307','31548','31587','31716','31773','31810','31932',
'32002','3203','32048','32091','32166','3222','32241','32277','3248','32514','32560','32597','32857',
'3287','32896','32918','32934','33057','33078','33095','3310','33336','33353','33527','33646','33658',
'33811','33894','33977','34006','34280','34374','34382','34390','34400','34412','34429','34431',
'34432','34453','34471','34490','34505','34528','34539','34540','34544','34557','34562','34567','3458
3','34589','34613','34622','34651','34652','34657','34696','34698','34710','34712','34719','34732',
'34768','34798','34799','34877','34893','34934','34936','34937','34943','34952','34953','35007',
'35096','35162','35173','35174','35189','35196','35302','35304','35317','35329','35343','35380',
'35481','35697','35794','36190','36742','36753','36767','36939','37080','37087','3720','37573','37650
','37655','37710','37747','37778','37908','3793','37930','37964','37965','37971','37978','38026',
'38034','38285','38308','38367','3839','38395','38459','38510','38854','38889','38899','38901',
'38995','39021','39137','39147','39199','39227','39242','3929','39355','39421','39512','39602',
'39786','39807','39944','39984','40190','40247','40316','40355','40384','40571','40639','40668',
'40711','40738','40898','4103','41203','41205','41232','41292','41405','41417','41522','41532',
'41533','41538','41573','41617','41633','41694','41719','41743','41746','4182','41828','42081','4211',
'4226','42285','42388','42488','4258','42723','42894','42901','42902','42908','43012','43322','43411',
'43412','43413','43416','43418','43432','43507','43508','43563','43566','43649','43813','43915',
'44527','44657','44778','448','45217','45228','45264','45300','45305','45319','45324','45337','45340',

'4540','45554','45600','4571','45816','45938','46116','46355','46365','4645','46525','4661','46687',
'46699','46715','46792','4685','46851','46890','46948','46951','46957','46974','46975','46979',
'47006','47021','4705','47159','4741','47467','47573','47616','47647','47727','47815','47998','48008',
'48039','48049','48053','48098','4818','48180','48214','48398','4873','49164','49268','49491','49492',
'49588','5013','50185','50334','50347','50402','5047','50509','50607','50780','50863','50971','51117',
'5117','51186','51368','51433','51519','5159','51601','51647','51701','51714','51807','5189','51897',
'51983','520','52010','52045','52088','5218','52189','52197','5220','52208','52293','52399','52407',
'52427','5249','52499','52559','52658','52659','5275','52858','52882','52886','52887','52972','53058',
'531','53220','53271','53551','53612','53621','53680','53719','53820','53833','53915','53967','54037',
'54049','54057','54201','54283','54288','54298','54326','54345','54404','54414','54512','54544',
'54620','54733','54735','54740','54825','54843','54899','54928','54941','54942','54986','55','55002',
'55017','55160','55187','55296','55299','55358','55399','55446','55456','55548','55588','55639',
'55718','55738','55798','55896','55903','56','56013','56038','56051','56079','56104','5612','56129',
'56148','56157','56162','56169','562','56204','56244','56279','56356','56375','56472','56473','56505',
'56506','56508','56509','56510','56516','56606','56704','56763','56850','56855','56970','56975',
'57026','57028','57048','57073','5723','57235','57266','57273','5728','57333','57346','5735','57378',
'575','57539','57588','57600','57610','57658','57701','57796','57801','57864','57882','57908','57944',
'57977','5800','58078','58108','58195','58201','58224','58258','58274','58294','58451','58461','5861',
'58646','58649','58669','5868','58682','58751','58843','58863','58871','58874','58910','58967',
'59029','59030','59086','59109','59111','59271','59290','593','59340','59351','59393','59412','59448',
'59557','59603','59690','59699','59750','59770','59788','59790','59802','5988','59884','59903',
'59911','59915','59939','59972','59996','6','60007','60010','60065','60067','60076','60097','60143',
'60232','60258','60291','60309','60349','60465','60506','60597','6078','6118','6160','6200','6217',
'624','6261','6285','6288','6314','633','6351','6359','6362','6364','6408','6437','6468','65','6518','654',
'6765','6786','6794','6806','6807','6877','69','6939','7043','709','7314','7338','7419','7441','756',
'7582','7606','761','764','7709','7734','7799','78','7806','80','8025','8026','8052','8102','8105','8106',
'814','82','8268','828','8800','8830','9196','9431','9456','9646','9680'

Angiotensin-Converting-Enzyme inhibitors (ACEi):
'1021','10882','10902','11133','11197','1121','11351','1143','1144','11561','11641','11937','11983',
'11987','12313','12411','12412','12574','12815','12858','13026','13589','13755','14228','14387',
'14477','14478','147','14960','15031','15085','15096','15108','15121','15135','1520','15605','15958',
'16196','16197','16212','16701','16708','16710','16924','17006','17120','17474','17624','17633',
'17655','1807','18219','18263','18269','18325','1904','19198','19204','19208','19223','196','19690',
'20188','20579','20849','20975','21053','21162','21231','21943','22439','22708','23252','23478',
'23642','24041','24482','25998','26995','277','27871','28127','28486','28586','28724','28725','28820',
'28902','29130','29530','29627','2982','30039','3069','30921','31307','31587','31716','31810','3203',
'32048','32166','32241','32514','32560','32597','32857','32934','33057','33078','33095','3310',
'33336','33353','33646','33811','33894','33977','34357','34382','34390','34400','34412','34429',
'34431','34432','34453','34471','34490','34505','34528','34539','34540','34544','34562','34567',
'34583','34589','34651','34652','34657','34696','34698','34710','34712','34719','34732','34768',
'34798','34799','34877','34893','34936','34937','34943','34952','34953','35007','35302','35731',
'35794','36742','36753','37080','37087','3720','37655','37710','37778','37908','37930','37964',
'37965','37971','37978','38026','38034','38285','38308','3839','38510','38854','38899','38995',
'39137','39147','39227','39242','3929','39355','39512','40355','40384','4103','41417','41522','41532',
'41538','41573','41617','41633','41694','41743','41746','42081','42285','42723','42894','42901',
'42902','42908','43012','43411','43412','43413','43416','43418','43432','43507','43563','43566',
'43649','43813','44527','44657','448','45217','45228','45264','45300','45319','45324','45337','45340',
'45554','4571','45816','45938','46365','46851','46890','46951','46957','46974','46975','46979',
'47021','47159','47998','48008','48049','48053','48098','48180','48214','49164','49491','50334',
'50347','50402','5047','50509','50607','50780','50863','51433','5159','51701','51714','51807','5189',
'52010','52088','52197','52293','52399','52407','52499','5275','52882','53058','53271','53551',

'53612','53621','53719','53820','53915','54037','54201','54283','54288','54298','54345','54512',
'54544','54733','54899','54928','54941','54942','55002','55299','55399','55456','55588','55639',
'55798','55896','55903','56013','5612','56129','56148','56162','56169','56244','56279','56356',
'56472','56473','56505','56506','56508','56509','56510','56516','56704','56763','56850','56855',
'57048','57235','57333','57346','5735','57378','57539','57588','57658','57701','57801','57864',
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'58874','59109','59111','593','59557','59603','59770','59788','59790','59915','59972','59996','60010',
'60065','60067','60097','60143','60232','60309','60349','6078','6261','6288','6314','633','6359',
'6362','6364','6408','6468','65','654','6765','6786','6794','6806','6807','69','709','7314','7419','756',
'761','78','80','8025','8026','8105','8106','82','8268','8800','8830','9646','9693','97','9731','9764',
'9915','9948'

Beta-blockers:
'1006','10191','10429','1048','1050','10627','10716','10777','10892','1124','11338','11380','11432',
'11454','11711','11793','12037','12054','12141','12191','12296','12456','12495','12517','12519',
'12651','12678','12749','1288','1290','1295','13051','1333','1334','13394','13487','13499','13526',
'13871','14030','14057','14058','14117','14126','14146','14211','14286','14319','14438','1448',
'14552','14673','14808','14877','14952','15042','15117','15176','15488','15619','1572','15730','1597',
'16032','16156','16645','16776','16786','1684','17082','17115','17149','17322','17462','17615','17759
','17783','1788','18114','18185','18287','18414','18743','18950','18956','19055','1910','19142',
'19149','19172','19178','19182','19191','19200','19202','19437','197','19853','19858','20012','20015',
'20082','20093','20363','20468','20502','20728','21025','21133','21182','21506','21508','21838',
'21839','21866','21873','21885','21905','21966','220','22208','22793','22912','23131','23134','23326',
'23587','2361','2378','2380','2381','24','24083','24094','2414','24191','24195','24218','24280','2432',
'24832','2499','2523','25359','25363','25367','25462','25644','25730','2587','2590','26','26211',
'26228','26229','26248','26255','2629','26529','26741','26895','27141','27357','27700','27719','2774',
'2775','2780','27946','27964','28048','28128','28177','28700','28788','28996','29180','29230','29368',
'29398','29427','29610','297','29762','29763','29827','29998','3005','30400','30519','30636','30770','
3084','3085','3087','3112','31214','313','31470','31536','3167','31708','31776','31833','31934',
'32094','32114','32162','32552','32630','32634','32787','32836','33079','33085','33092','33184',
'33374','33376','33403','3344','33569','33602','33644','33650','33657','33659','33836','33839','33850
','33909','34012','34034','34092','34094','34125','34153','34171','34177','34185','34188','34208',
'34214','34227','34265','34337','34365','34371','34378','34407','34430','34443','34449','34492',
'34501','34509','34520','34575','34584','34585','34600','34640','34690','34695','3474','34740',
'34741','34754','34783','34785','34804','34818','34821','34825','34854','34867','34868','34882',
'34884','34890','34899','34925','34945','34949','3495','34963','34976','35054','35062','3516','35256',
'3526','35695','35710','35778','3588','35933','35938','35940','36261','36576','36603','367','3691',
'37118','3748','3765','37725','37837','3827','38433','38991','39233','39423','39646','3971','39846',
'4004','40167','40240','40247','40242','4025','40289','4059','40761','41555','41572','41591','41740',
'41827','42152','4265','42795','42796','43251','43427','43453','43525','43549','43564','44000',
'44083','4410','4429','44808','44858','45250','45289','45297','45309','4532','45343','4542','45494',
'45765','45877','4588','46363','46614','4667','46740','46882','46908','46931','46935','46936','46952',
'46991','47041','47107','472','4725','47300','47536','47673','47674','4771','47870','47907','4796',
'4847','48682','48745','49142','4983','49863','49953','5','50224','50300','50403','50514','50702',
'51447','51492','51528','51643','51998','52136','52145','52310','52500','52609','52611','52635',
'52686','52728','52777','5284','5290','53177','5319','53204','53215','5330','53334','53414','53664',
'53802','53826','53885','54106','54297','54479','54487','54542','54623','54752','5478','55228',
'55298','55416','55778','55791','55849','55853','55929','55949','55979','5605','56173','56240',
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'5736','57567','57573','57578','57626','57817','57934','581','58109','5816','58297','58407','58455',
'58491','58498','58511','5858','58763','58973','58974','58982','59037','59148','594','59415','59495',
'59549','59597','5968','59695','599','59961','59969','59982','60502','60565','6066','6751','7049',

'7066','707','7091','7288','739','7429','7474','751','7528','753','7543','7553','7620','769','7712','7852',
'7853','786','789','7974','8023','8061','8068','8071','8113','8140','8142','8147','817','8172','8189',
'822','8262','8290','8331','8369','8555','8623','8642','8673','8707','8807','8978','8987','9016','9143',
'9162','9178','9185','9273','9292','940','9653','9783','9873','9993'

Angiotensin II receptor blockers (ARB):
'520','529','531','575','624','764','828','1293','1780','2971','3222','4155','4226','4540','4645','4685',
'4741','4818','5013','5117','5723','5988','6217','6285','6351','6437','6518','6877','6939','7043','7338',
'9196','9745','10316','10323','11251','11252','11348','11448','11469','11526','11864','12836','12874',
'13123','13821','14283','14738','14870','14943','14965','14983','16060','16161','16285','16371',
'17545','17686','17689','18200','18202','18903','18910','20117','21423','23456','24268','24359',
'24484','24632','25382','27520','29634','31072','35096','35173','35174','35189','35196','35304',
'35317','35329','35343','35380','35481','35697','36939','37573','37650','37747','38367','38395',
'38459','38889','39021','39199','39786','39944','39984','40316','40571','40639','40668','40711',
'41203','41205','41232','43322','43915','44778','45600','46355','46687','46715','46792','47006',
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'51368','51519','51601','51647','51897','52189','52208','52427','52559','52659','52858','52886',
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'54843','55017','55160','55187','55296','55358','55718','55821','56104','56204','56606','56970',
'56975','57026','57028','57266','57273','57796','57977','58108','58201','58274','58646','58649',
'58669','58910','58967','59029','59086','59271','59340','59351','59393','59448','59690','59750',
'59802','60076','60506','60597','61053','61177','61288','61442','61495','61754','61781','62035',
'62140','62337','62376','62388','62415','62911','63222','63337','63385','63411','63717','63890',
'63918','64359','64888','65065','65094','65228','65274'

Digoxin:

'16366','17169','20844','20944','2302','24719','25043','2511','25238','27523','27547','29282','3181',
'3286','3308','33080','33274','333','33612','33675','34017','34023','34024','34327','34328','34519',
'34948','36','3705','40245','42989','42990','43577','47813','48587','54117','792','94','9522'

Bumetanide:

'12226','12294','14587','15341','1776','19300','2493','2495','2788','30913','31932','32091','34613',
'34934','36767','39602','45305','5218','55548','6160','7806','814'

Marital/relationship problems:

Divorce*:*

'4204','27385','5055','4925','42428','1522','9910','838','2159','20217','20313'

Widow:

'4312'

Separation/break-up/cheating on partner:

'1349','29544','723','954','333','3551','1540','30950','15313','42321','54816','29543','22873','42454',
'3483','24055','15020','6104','4531','3111','4149','2830','4177','42383','21259','27432','1650','465',
'23514','464','7840','34771','23409','27434','56178','20536','23445','39651','15777','42400','21433',
'39879','21925','37551','21619','9112'

Exercise recommendation coded by GP:
'13083','13084','13085','29051','32840','53124','41879','57429','18483','36399','24871','18457',
'53166','18168','13087','36','26525','95900','19528','96647','42314','106298','26524','109818',
'35492','109915','26523','19529','26526','26528','26529','26521','48555','31588','35493','13086',
'26530','59258','45785','32844','96646','96374','96913','96213','97179','26527','3734','62183',
'52631','29056','67610','94051'

Bereavement episodes:
'400','11228','12303','207','87334','8218','9163','1516','1502','3749','3854','16844','29382','5622',
'31106','28440','11251','17802','25097','18119','10526'

History of flu vaccination:
'210','2694','23550','6','103324','94301','95092','107646','97941','105077','107413','107730',
'110219','110182','98217','108772','98306','98234','98302','98449','98303','98183','98184','98304',
'104688','105195','107297','107573','107352','107156','106994','106995'

Atypical signs and symptoms of heart failure:

Weight gain:

'19208','102856','6533'

Weight loss:

'4663','5812','102563','12398','37937','104002'

Cachexia:

'24068','36473','53801'

Cardiac murmur:

'291','3138','18916','21953','7661','12557','894','3910','157','19572','3982','30090','44516','23007',
'52770','4857','95082','59965','103653','103644','103619','22550'

Peripheral oedema:

'3158','6047','2140','102720','102627','30309','11396','1906','9392','22734','15047','5919','31377',
'9108','49411','6764','61224','19714','6651','18685','20553','1906','1284','7106','19358','6585','5155'

Lung crepitation:

‘9062','15866','25571','21587'

Pleural effusion:

'21819','9559','947','52850'

Tachycardia:

'26716','7128','4044','6503','4940','1297','23647','51845','29491','35124','3418','7794','25266',
'60047','70366','1381','2212','1664','1757','1268','35127','96277','96076','107472','23437','4374',
'4827','25583','5484','41916'

Cheyne-Stokes:

'21042','27400'

Hepatosplenomegaly:

'3034','5698','42038','9301'

Ascites:

'16113','54878','98986','73305','52838','58736','1508','29009','37930'

Cold peripheries:

'17210','15980','7213','16952','36430'

Oliguria:

'57132','16063','30686','67395'

Confusion:

'3991','66271','98746','100133','4033','22466','41537','17021','24077','22466','55784','7389','5188','53446','52394','53924'

Depression:

'6546','6950','595','34390','16506','15155','15219','32159','43324','57409','7011','15099','6932','35671','29342','14709','25697','24171','56273','55384','6482','25563','3702','17385','27491','9183','17770','1055','655','4639','9055','18510','7604','11717','9211','9667','41989','22806','59386','12099','24117','52678','24112','28863','10667','98346','98252','98414','98417','101054','101153','103677','6854','10720','56609','2970','543','3291','5987','3292','8851','19696','8902','23731','28677','32941','31757','16861','37764','22116','47731','44300','36616','42857','26374','35320','9796','100977'

Palpitations:

'2975','29469','16170','326','15616','4789','15998'

Dizziness:

'5800','5816','5820','6410','1512','7417','6262','23332','18564','15909','132','392','4291','1114','393','15493'

Syncope:

'7431','11859','6201','7279','6186','15317','16267','2307','2357','184','1405','1812','7431'

Raised Jugular venous pressure:

'15900','10212','103509'

Edit heart sound:

'57385','32363','26669'

Displaced apex pulse:

'64242','54541'

7.2 Appendix 2. An example of data management for AAA repair patients

```
libname aaa 'H:\aorta';

run;

data aaa05; set arao.qi_episodes_hes2005;

where rtm=1 and inpatient=1 and dx_epi=1 and spell=1;

run;

data aaa05; set aaa05;

if oper1 in: ('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205', 'L206',
'L208', 'L209',

'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255',

'L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279', 'L281', 'L282',
'L283', 'L284', 'L285', 'L286', 'L288', 'L289')

then aaa=1;
```

```
else aaa=0;
run;
data aaa05;
set aaa05;
if aaa=0 then delete;
run;

data test; set aaa05(keep=extract_hesid);
run;
proc sort data=test nodupkey; by extract_hesid;
data ptlookup; set test;
start=extract_hesid; label='KEEP'; fmtname='$ptlookup';
proc format cntlin=ptlookup;
run;

%macro temp(yr,dset,dod);
data aaa_pts_adms&yr;
set arao.&dset(keep=dx_epi chosen_op prov2 provspell ccs_group dxgrp diag:
        extract_hesid quintile qi_death readm28 los emerg disyear admidate disdate
        classpat rtm superspell spell episode admiage oper: total_los site specialty
        admisorc disdest ethnic ethnicgroup ssyear &dod);
where put(extract_hesid,$ptlookup.)='KEEP' and rtm=1;
drop rtm;
run;
%mend;
%temp(06,qi_episodes_hes2006,dod);
%temp(07,qi_episodes_hes2007,dod);
%temp(08,qi_episodes_hes2008,dod);
%temp(09,qi_episodes_hes2009,dod);
%temp(10,qi_episodes_hes2010,dod);
data aaa_all_adms06_10;
set aaa_pts_adms06
        aaa_pts_adms07
        aaa_pts_adms08
        aaa_pts_adms09
        aaa_pts_adms10;
```

```
run;
data aaa06; set arao.qi_episodes_hes2006;
where rtm=1 and inpatient=1 and dx_epi=1 and spell=1;
run;
data aaa06; set aaa06;
if oper1 in: ('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205', 'L206',
'L208', 'L209',
'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255',
'L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279', 'L281', 'L282',
'L283', 'L284', 'L285', 'L286', 'L288', 'L289')
then aaa=1;
else aaa=0;
run;
data aaa06;
set aaa06;
if aaa=0 then delete;
run;

data test; set aaa06(keep=extract_hesid);
run;
proc sort data=test nodupkey; by extract_hesid;
data ptlookup; set test;
start=extract_hesid; label='KEEP'; fmtname='$ptlookup';
proc format cntlin=ptlookup;
run;

%macro temp(yr,dset,dod);
data aaa_pts_adms&yr;
set arao.&dset(keep=dx_epi chosen_op prov2 provspell ccs_group dxgrp diag:
        extract_hesid quintile qi_death readm28 los emerg disyear admidate disdate
        classpat rtm superspell spell episode admiage oper: total_los site specialty
        admisorc disdest ethnic ethnicgroup ssyear &dod);
where put(extract_hesid,$ptlookup.)='KEEP' and rtm=1;
drop rtm;
run;
%mend;
```

```
%temp(07,qi_episodes_hes2007,dod);

%temp(08,qi_episodes_hes2008,dod);

%temp(09,qi_episodes_hes2009,dod);

%temp(10,qi_episodes_hes2010,dod);

%temp(11,qi_episodes_hes2011,dod);

data aaa_all_adms07_11;

set aaa_pts_adms07

        aaa_pts_adms08

        aaa_pts_adms09

        aaa_pts_adms10

        aaa_pts_adms11;

run;

data aaa07; set arao.qi_episodes_hes2007;

where rtm=1 and inpatient=1 and dx_epi=1 and spell=1;

run;

data aaa07; set aaa07;

if oper1 in: ('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205', 'L206',
'L208', 'L209',

'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255',

'L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279', 'L281', 'L282',
'L283', 'L284', 'L285', 'L286', 'L288', 'L289')

then aaa=1;

else aaa=0;

run;

data aaa07;

set aaa07;

if aaa=0 then delete;

run;


data test; set aaa07(keep=extract_hesid);

run;

proc sort data=test nodupkey; by extract_hesid;

data ptlookup; set test;

start=extract_hesid; label='KEEP'; fmtname='$ptlookup';

proc format cntlin=ptlookup;

run;
```

```
%macro temp(yr,dset,dod);
data aaa_pts_adms&yr;
set arao.&dset(keep=dx_epi chosen_op prov2 provspell ccs_group dxgrp diag:
        extract_hesid quintile qi_death readm28 los emerg disyear admidate disdate
        classpat rtm superspell spell episode admiage oper: total_los site specialty
        admisorc disdest ethnic ethnicgroup ssyear &dod);
where put(extract_hesid,$ptlookup.)='KEEP' and rtm=1;
drop rtm;
run;
%mend;
%temp(08,qi_episodes_hes2008,dod);
%temp(09,qi_episodes_hes2009,dod);
%temp(10,qi_episodes_hes2010,dod);
%temp(11,qi_episodes_hes2011,dod);
%temp(12,qi_episodes_hes2012);
data aaa_all_adms08_12;
set
        aaa_pts_adms08
        aaa_pts_adms09
        aaa_pts_adms10
        aaa_pts_adms11
        aaa_pts_adms12;
run;
data aaa08; set arao.qi_episodes_hes2008;
where rtm=1 and inpatient=1 and dx_epi=1 and spell=1;
run;
data aaa08; set aaa08;
if oper1 in: ('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205', 'L206',
'L208', 'L209',
'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255',
'L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279', 'L281', 'L282',
'L283', 'L284', 'L285', 'L286', 'L288', 'L289')
then aaa=1;
else aaa=0;
run;
```

```
data aaa08;
set aaa08;
if aaa=0 then delete;
run;

data test; set aaa08(keep=extract_hesid);
run;
proc sort data=test nodupkey; by extract_hesid;
data ptlookup; set test;
start=extract_hesid; label='KEEP'; fmtname='$ptlookup';
proc format cntlin=ptlookup;
run;

%macro temp(yr,dset,dod);
data aaa_pts_adms&yr;
set arao.&dset(keep=dx_epi chosen_op prov2 provspell ccs_group dxgrp diag:
        extract_hesid quintile qi_death readm28 los emerg disyear admidate disdate
        classpat rtm superspell spell episode admiage oper: total_los site specialty
        admisorc disdest ethnic ethnicgroup ssyear &dod);
where put(extract_hesid,$ptlookup.)='KEEP' and rtm=1;
drop rtm;
run;
%mend;
%temp(09,qi_episodes_hes2009,dod);
%temp(10,qi_episodes_hes2010,dod);
%temp(11,qi_episodes_hes2011,dod);
%temp(12,qi_episodes_hes2012);
%temp(13,qi_episodes_hes2013);
data aaa_all_adms09_13;
set
        aaa_pts_adms09
        aaa_pts_adms10
        aaa_pts_adms11
        aaa_pts_adms12
        aaa_pts_adms13;
run;
```

```
data aaa09; set arao.qi_episodes_hes2009;
where rtm=1 and inpatient=1 and dx_epi=1 and spell=1;
run;
data aaa09; set aaa09;
if oper1 in: ('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205', 'L206',
'L208', 'L209',
'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255',
'L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279', 'L281', 'L282',
'L283', 'L284', 'L285', 'L286', 'L288', 'L289')
then aaa=1;
else aaa=0;
run;
data aaa09;
set aaa09;
if aaa=0 then delete;
run;

data test; set aaa09(keep=extract_hesid);
run;
proc sort data=test nodupkey; by extract_hesid;
data ptlookup; set test;
start=extract_hesid; label='KEEP'; fmtname='$ptlookup';
proc format cntlin=ptlookup;
run;

%macro temp(yr,dset,dod);
data aaa_pts_adms&yr;
set arao.&dset(keep=dx_epi chosen_op prov2 provspell ccs_group dxgrp diag:
        extract_hesid quintile qi_death readm28 los emerg disyear admidate disdate
        classpat rtm superspell spell episode admiage oper: total_los site specialty
        admisorc disdest ethnic ethnicgroup ssyear &dod);
where put(extract_hesid,$ptlookup.)='KEEP' and rtm=1;
drop rtm;
run;
%mend;
%temp(10,qi_episodes_hes2010,dod);
```

```
%temp(11,qi_episodes_hes2011,dod);
%temp(12,qi_episodes_hes2012);
%temp(13,qi_episodes_hes2013);
%temp(14,qi_episodes_hes2013);
data aaa_all_adms10_14;
set
        aaa_pts_adms10
        aaa_pts_adms11
        aaa_pts_adms12
        aaa_pts_adms13
        aaa_pts_adms14;
run;
data aaa.aaa05;
set aaa05;
run;
data aaa.aaa06;
set aaa06;
run;
data aaa.aaa07;
set aaa07;
run;
data aaa.aaa08;
set aaa08;
run;
data aaa.aaa09;
set aaa09;
run;
data aaa.a09_fu;
set aaa_all_adms10_14;
run;

data aaa.a08_fu;
set aaa_all_adms09_13;
run;
data aaa.a07_fu;
set aaa_all_adms08_12;
```

```
run;
data aaa.a06_fu;
set aaa_all_adms07_11;
run;
data aaa.a05_fu;
set aaa_all_adms06_10;
run;
/*for past medical history we now aggregate previous years for each year's aaa patients*/
data test; set aaa05(keep=extract_hesid);
run;
proc sort data=test nodupkey; by extract_hesid;
data ptlookup; set test;
start=extract_hesid; label='KEEP'; fmtname='$ptlookup';
proc format cntlin=ptlookup;
run;

%macro temp(yr,dset,dod);
data aaa_pts_adms&yr;
set arao.&dset(keep=dx_epi chosen_op prov2 provspell ccs_group dxgrp diag:
        extract_hesid quintile qi_death readm28 los emerg disyear admidate disdate
        classpat rtm superspell spell episode admiage oper: total_los site specialty
        admisorc disdest ethnic ethnicgroup ssyear &dod);
where put(extract_hesid,$ptlookup.)='KEEP' and rtm=1;
drop rtm;
run;
%mend;
%temp(03,qi_episodes_hes2003,dod);
%temp(04,qi_episodes_hes2004,dod);

data aaa_all_adms03_04;
set aaa_pts_adms03
        aaa_pts_adms04;
run;
data test; set aaa06(keep=extract_hesid);
run;
proc sort data=test nodupkey; by extract_hesid;
```

```
data ptlookup; set test;
start=extract_hesid; label='KEEP'; fmtname='$ptlookup';
proc format cntlin=ptlookup;
run;

%macro temp(yr,dset,dod);
data aaa_pts_adms&yr;
set arao.&dset(keep=dx_epi chosen_op prov2 provspell ccs_group dxgrp diag:
        extract_hesid quintile qi_death readm28 los emerg disyear admidate disdate
        classpat rtm superspell spell episode admiage oper: total_los site specialty
        admisorc disdest ethnic ethnicgroup ssyear &dod);
where put(extract_hesid,$ptlookup.)='KEEP' and rtm=1;
drop rtm;
run;
%mend;
%temp(03,qi_episodes_hes2003,dod);
%temp(04,qi_episodes_hes2004,dod);
%temp(05,qi_episodes_hes2005,dod);

data aaa_all_adms03_05;
set aaa_pts_adms03
        aaa_pts_adms04
        aaa_pts_adms05;
run;
data test; set aaa07(keep=extract_hesid);
run;
proc sort data=test nodupkey; by extract_hesid;
data ptlookup; set test;
start=extract_hesid; label='KEEP'; fmtname='$ptlookup';
proc format cntlin=ptlookup;
run;

%macro temp(yr,dset,dod);
data aaa_pts_adms&yr;
set arao.&dset(keep=dx_epi chosen_op prov2 provspell ccs_group dxgrp diag:
        extract_hesid quintile qi_death readm28 los emerg disyear admidate disdate
```

```
        classpat rtm superspell spell episode admiage oper: total_los site specialty
        admisorc disdest ethnic ethnicgroup ssyear &dod);
where put(extract_hesid,$ptlookup.)='KEEP' and rtm=1;
drop rtm;
run;
%mend;
%temp(04,qi_episodes_hes2004,dod);
%temp(05,qi_episodes_hes2005,dod);
%temp(06,qi_episodes_hes2006,dod);

data aaa_all_adms04_06;
set
        aaa_pts_adms04
        aaa_pts_adms05
        aaa_pts_adms06;
run;
data test; set aaa08(keep=extract_hesid);
run;
proc sort data=test nodupkey; by extract_hesid;
data ptlookup; set test;
start=extract_hesid; label='KEEP'; fmtname='$ptlookup';
proc format cntlin=ptlookup;
run;

%macro temp(yr,dset,dod);
data aaa_pts_adms&yr;
set arao.&dset(keep=dx_epi chosen_op prov2 provspell ccs_group dxgrp diag:
        extract_hesid quintile qi_death readm28 los emerg disyear admidate disdate
        classpat rtm superspell spell episode admiage oper: total_los site specialty
        admisorc disdest ethnic ethnicgroup ssyear &dod);
where put(extract_hesid,$ptlookup.)='KEEP' and rtm=1;
drop rtm;
run;
%mend;
%temp(05,qi_episodes_hes2005,dod);
%temp(06,qi_episodes_hes2006,dod);
```

```
%temp(07,qi_episodes_hes2007,dod);

data aaa_all_adms05_07;
set
        aaa_pts_adms05
        aaa_pts_adms06
        aaa_pts_adms07;
run;
data test; set aaa09(keep=extract_hesid);
run;
proc sort data=test nodupkey; by extract_hesid;
data ptlookup; set test;
start=extract_hesid; label='KEEP'; fmtname='$ptlookup';
proc format cntlin=ptlookup;
run;

%macro temp(yr,dset,dod);
data aaa_pts_adms&yr;
set arao.&dset(keep=dx_epi chosen_op prov2 provspell ccs_group dxgrp diag:
        extract_hesid quintile qi_death readm28 los emerg disyear admidate disdate
        classpat rtm superspell spell episode admiage oper: total_los site specialty
        admisorc disdest ethnic ethnicgroup ssyear &dod);
where put(extract_hesid,$ptlookup.)='KEEP' and rtm=1;
drop rtm;
run;
%mend;
%temp(06,qi_episodes_hes2006,dod);
%temp(07,qi_episodes_hes2007,dod);
%temp(08,qi_episodes_hes2008,dod);

data aaa_all_adms06_08;
set
        aaa_pts_adms06
        aaa_pts_adms07
        aaa_pts_adms08;
run;
```

```
data aaa.a06_pmh;
set aaa_all_adms03_05;
run;
data aaa.a07_pmh;
set aaa_all_adms04_06;
run;
data aaa.a08_pmh;
set aaa_all_adms05_07;
run;
data aaa.a09_pmh;
set aaa_all_adms06_08;
run;
data aaa06;
set aaa.aaa06;
if los>0 then aneu=1;
else aneu=1;
run;

data aaa.allpts;
set aaa.aaa06
        aaa.aaa07
        aaa.aaa08
        aaa.aaa09;
run;
data aaa.allpmh;
set aaa.a06_pmh
        aaa.a07_pmh
        aaa.a08_pmh
        aaa.a09_pmh;
run;
data aaa.allfu;
set aaa.a06_fu
        aaa.a07_fu
        aaa.a08_fu
        aaa.a09_fu;
run;
```

```
proc freq data=aaa.allpts;
table diag1 oper1;
run;
data aaa.allpts;
set aaa.allpts;
if diag1 in:('I700','I701','I702','I708','I709','I710','I711','I712','I713','I714','I715','I716','I718','I719')
then aaadx=1;
else aaadx=0;
run;
proc freq data=aaa.allpts;
table aaadx;
run;

data aaa.allpts;
set aaa.allpts;
if aaadx=0 then delete;
run;
data aaa.allpmh;
set aaa.allpmh;
living_alone=(diag1=:'Z602' or diag2=:'Z602' or diag3=:'Z602' or diag4=:'Z602' or
        diag5=:'Z602' or diag6=:'Z602' or diag7=:'Z602' or diag8=:'Z602' or diag9=:'Z602' or
        diag10=:'Z602' or diag11=:'Z602' or diag12=:'Z602' or diag13=:'Z602' or diag14=:'Z602' or
        diag15=:'Z602' or diag16=:'Z602' or diag17=:'Z602' or diag18=:'Z602' or diag19=:'Z602' or
        diag20=:'Z602');
run;
data aaa.allpmh;
set aaa.allpmh;
hx_prod=(diag1 in:('L181','L182','L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L191', 'L192',
'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L254','L271','L272' ,'L273','L274','L275','L276',
'L278','L279','L281','L282','L283','L284') or diag2 in:('L181','L182','L183', 'L184', 'L185', 'L186', 'L188', 'L189',
'L191', 'L192',
'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L254','L271','L272' ,'L273','L274','L275','L276',
'L278','L279','L281','L282','L283','L284') or diag3 in:('L181','L182','L183', 'L184', 'L185', 'L186', 'L188', 'L189',
'L191', 'L192',
'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L254','L271','L272' ,'L273','L274','L275','L276',
'L278','L279','L281','L282','L283','L284') or diag4 in:('L181','L182','L183', 'L184', 'L185', 'L186', 'L188', 'L189',
'L191', 'L192',
```

'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L254','L271','L272' ,'L273','L274','L275','L276',

'L278','L279','L281','L282','L283','L284') or diag5 in:('L181','L182','L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L191', 'L192',

'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L254','L271','L272' ,'L273','L274','L275','L276',

'L278','L279','L281','L282','L283','L284') or diag6 in:('L181','L182','L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L191', 'L192',

'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L254','L271','L272' ,'L273','L274','L275','L276',

'L278','L279','L281','L282','L283','L284') or diag7 in:('L181','L182','L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L191', 'L192',

'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L254','L271','L272' ,'L273','L274','L275','L276',

'L278','L279','L281','L282','L283','L284') or diag8 in:('L181','L182','L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L191', 'L192',

'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L254','L271','L272' ,'L273','L274','L275','L276',

'L278','L279','L281','L282','L283','L284') or diag9 in:('L181','L182','L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L191', 'L192',

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'L278','L279','L281','L282','L283','L284') or diag14 in:('L181','L182','L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L191', 'L192',

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'L278','L279','L281','L282','L283','L284') or diag16 in:('L181','L182','L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L191', 'L192',

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'L278','L279','L281','L282','L283','L284') or diag19 in:('L181','L182','L183', 'L184', 'L185', 'L186', 'L188', 'L189',
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'L278','L279','L281','L282','L283','L284'));

run;

proc freq data=aaa.allpts;

table living_alone;

run;

data aaa.allpts;

set aaa.allpts;

living_alone=(diag1=:'Z602' or diag2=:'Z602' or diag3=:'Z602' or diag4=:'Z602' or

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        diag10=:'Z602' or diag11=:'Z602' or diag12=:'Z602' or diag13=:'Z602' or diag14=:'Z602' or

        diag15=:'Z602' or diag16=:'Z602' or diag17=:'Z602' or diag18=:'Z602' or diag19=:'Z602' or

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run;


data aaa.allpts;

set aaa.allpts;

other_vas=(oper2 in:('L161', 'L162', 'L168', 'L169', 'L411', 'L412', 'L413', 'L414', 'L415', 'L416', 'L418', 'L419',

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'L701', 'L702', 'L703', 'L704', 'L705', 'L708', 'L709', 'L711', 'L712', 'L713', 'L714', 'L715', 'L716', 'L717', 'L718', 'L719') or

oper10 in:('L161', 'L162', 'L168', 'L169', 'L411', 'L412', 'L413', 'L414', 'L415', 'L416', 'L418', 'L419',

'L421', 'L422', 'L423', 'L424', 'L428', 'L429', 'L431', 'L432', 'L433', 'L434', 'L435', 'L438', 'L439', 'L451', 'L452', 'L453',

'L454', 'L458', 'L459', 'L461', 'L462', 'L463', 'L464', 'L468', 'L469', 'L471', 'L472', 'L473', 'L474', 'L478', 'L479',

'L761', 'L762', 'L763', 'L764', 'L765', 'L766', 'L767', 'L768', 'L769', 'L891', 'L892', 'L893', 'L894', 'L895', 'L896', 'L898', 'L899',

'L481', 'L482', 'L484', 'L485', 'L486', 'L488', 'L489', 'L491', 'L492', 'L493', 'L494', 'L495', 'L496', 'L498', 'L499',

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'L581', 'L582', 'L583', 'L584', 'L585', 'L586', 'L587', 'L588', 'L589', 'L591', 'L592', 'L593', 'L594', 'L595', 'L596', 'L597', 'L598', 'L599',

'L601', 'L602', 'L603', 'L604', 'L608', 'L609', 'L621', 'L622', 'L623', 'L624', 'L628', 'L629', 'L631', 'L632', 'L633', 'L634', 'L635', 'L638', 'L639',

'L653', 'L661', 'L662', 'L663', 'L664', 'L665', 'L667', 'L668', 'L669', 'L681', 'L682', 'L683', 'L684', 'L688', 'L689',

'L701', 'L702', 'L703', 'L704', 'L705', 'L708', 'L709', 'L711', 'L712', 'L713', 'L714', 'L715', 'L716', 'L717', 'L718', 'L719') or

oper11 in:('L161', 'L162', 'L168', 'L169', 'L411', 'L412', 'L413', 'L414', 'L415', 'L416', 'L418', 'L419',

'L421', 'L422', 'L423', 'L424', 'L428', 'L429', 'L431', 'L432', 'L433', 'L434', 'L435', 'L438', 'L439', 'L451', 'L452', 'L453',

'L454', 'L458', 'L459', 'L461', 'L462', 'L463', 'L464', 'L468', 'L469', 'L471', 'L472', 'L473', 'L474', 'L478', 'L479',

'L761', 'L762', 'L763', 'L764', 'L765', 'L766', 'L767', 'L768', 'L769', 'L891', 'L892', 'L893', 'L894', 'L895', 'L896', 'L898', 'L899',

'L481', 'L482', 'L484', 'L485', 'L486', 'L488', 'L489', 'L491', 'L492', 'L493', 'L494', 'L495', 'L496', 'L498', 'L499',

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'L581', 'L582', 'L583', 'L584', 'L585', 'L586', 'L587', 'L588', 'L589', 'L591', 'L592', 'L593', 'L594', 'L595', 'L596', 'L597', 'L598', 'L599',

'L601', 'L602', 'L603', 'L604', 'L608', 'L609', 'L621', 'L622', 'L623', 'L624', 'L628', 'L629', 'L631', 'L632', 'L633', 'L634', 'L635', 'L638', 'L639',

'L653', 'L661', 'L662', 'L663', 'L664', 'L665', 'L667', 'L668', 'L669', 'L681', 'L682', 'L683', 'L684', 'L688', 'L689',

'L701', 'L702', 'L703', 'L704', 'L705', 'L708', 'L709', 'L711', 'L712', 'L713', 'L714', 'L715', 'L716', 'L717', 'L718', 'L719') or

oper12 in:('L161', 'L162', 'L168', 'L169', 'L411', 'L412', 'L413', 'L414', 'L415', 'L416', 'L418', 'L419',

'L421', 'L422', 'L423', 'L424', 'L428', 'L429', 'L431', 'L432', 'L433', 'L434', 'L435', 'L438', 'L439', 'L451', 'L452', 'L453',

'L454', 'L458', 'L459', 'L461', 'L462', 'L463', 'L464', 'L468', 'L469', 'L471', 'L472', 'L473', 'L474', 'L478', 'L479',

'L761', 'L762', 'L763', 'L764', 'L765', 'L766', 'L767', 'L768', 'L769', 'L891', 'L892', 'L893', 'L894', 'L895', 'L896', 'L898', 'L899',

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'L581', 'L582', 'L583', 'L584', 'L585', 'L586', 'L587', 'L588', 'L589', 'L591', 'L592', 'L593', 'L594', 'L595', 'L596', 'L597', 'L598', 'L599',

'L601', 'L602', 'L603', 'L604', 'L608', 'L609', 'L621', 'L622', 'L623', 'L624', 'L628', 'L629', 'L631', 'L632', 'L633', 'L634', 'L635', 'L638', 'L639',

'L653', 'L661', 'L662', 'L663', 'L664', 'L665', 'L667', 'L668', 'L669', 'L681', 'L682', 'L683', 'L684', 'L688', 'L689',

'L701', 'L702', 'L703', 'L704', 'L705', 'L708', 'L709', 'L711', 'L712', 'L713', 'L714', 'L715', 'L716', 'L717', 'L718', 'L719') or

oper13 in:('L161', 'L162', 'L168', 'L169', 'L411', 'L412', 'L413', 'L414', 'L415', 'L416', 'L418', 'L419',

'L421', 'L422', 'L423', 'L424', 'L428', 'L429', 'L431', 'L432', 'L433', 'L434', 'L435', 'L438', 'L439', 'L451', 'L452', 'L453',

'L454', 'L458', 'L459', 'L461', 'L462', 'L463', 'L464', 'L468', 'L469', 'L471', 'L472', 'L473', 'L474', 'L478', 'L479',

'L761', 'L762', 'L763', 'L764', 'L765', 'L766', 'L767', 'L768', 'L769', 'L891', 'L892', 'L893', 'L894', 'L895', 'L896', 'L898', 'L899',

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'L581', 'L582', 'L583', 'L584', 'L585', 'L586', 'L587', 'L588', 'L589', 'L591', 'L592', 'L593', 'L594', 'L595', 'L596', 'L597', 'L598', 'L599',

'L601', 'L602', 'L603', 'L604', 'L608', 'L609', 'L621', 'L622', 'L623', 'L624', 'L628', 'L629', 'L631', 'L632', 'L633', 'L634', 'L635', 'L638', 'L639',

'L653', 'L661', 'L662', 'L663', 'L664', 'L665', 'L667', 'L668', 'L669', 'L681', 'L682', 'L683', 'L684', 'L688', 'L689',

'L701', 'L702', 'L703', 'L704', 'L705', 'L708', 'L709', 'L711', 'L712', 'L713', 'L714', 'L715', 'L716', 'L717', 'L718', 'L719') or

oper14 in:('L161', 'L162', 'L168', 'L169', 'L411', 'L412', 'L413', 'L414', 'L415', 'L416', 'L418', 'L419',

'L421', 'L422', 'L423', 'L424', 'L428', 'L429', 'L431', 'L432', 'L433', 'L434', 'L435', 'L438', 'L439', 'L451', 'L452', 'L453',

'L454', 'L458', 'L459', 'L461', 'L462', 'L463', 'L464', 'L468', 'L469', 'L471', 'L472', 'L473', 'L474', 'L478', 'L479',

'L761', 'L762', 'L763', 'L764', 'L765', 'L766', 'L767', 'L768', 'L769', 'L891', 'L892', 'L893', 'L894', 'L895', 'L896', 'L898', 'L899',

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'L601', 'L602', 'L603', 'L604', 'L608', 'L609', 'L621', 'L622', 'L623', 'L624', 'L628', 'L629', 'L631', 'L632', 'L633', 'L634', 'L635', 'L638', 'L639',

'L653', 'L661', 'L662', 'L663', 'L664', 'L665', 'L667', 'L668', 'L669', 'L681', 'L682', 'L683', 'L684', 'L688', 'L689',

'L701', 'L702', 'L703', 'L704', 'L705', 'L708', 'L709', 'L711', 'L712', 'L713', 'L714', 'L715', 'L716', 'L717', 'L718', 'L719') or

oper15 in:('L161', 'L162', 'L168', 'L169', 'L411', 'L412', 'L413', 'L414', 'L415', 'L416', 'L418', 'L419',

'L421', 'L422', 'L423', 'L424', 'L428', 'L429', 'L431', 'L432', 'L433', 'L434', 'L435', 'L438', 'L439', 'L451', 'L452', 'L453',

'L454', 'L458', 'L459', 'L461', 'L462', 'L463', 'L464', 'L468', 'L469', 'L471', 'L472', 'L473', 'L474', 'L478', 'L479',

'L761', 'L762', 'L763', 'L764', 'L765', 'L766', 'L767', 'L768', 'L769', 'L891', 'L892', 'L893', 'L894', 'L895', 'L896', 'L898', 'L899',

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'L581', 'L582', 'L583', 'L584', 'L585', 'L586', 'L587', 'L588', 'L589', 'L591', 'L592', 'L593', 'L594', 'L595', 'L596', 'L597', 'L598', 'L599',

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'L653', 'L661', 'L662', 'L663', 'L664', 'L665', 'L667', 'L668', 'L669', 'L681', 'L682', 'L683', 'L684', 'L688', 'L689',

'L701', 'L702', 'L703', 'L704', 'L705', 'L708', 'L709', 'L711', 'L712', 'L713', 'L714', 'L715', 'L716', 'L717', 'L718', 'L719') or

oper16 in:('L161', 'L162', 'L168', 'L169', 'L411', 'L412', 'L413', 'L414', 'L415', 'L416', 'L418', 'L419',

'L421', 'L422', 'L423', 'L424', 'L428', 'L429', 'L431', 'L432', 'L433', 'L434', 'L435', 'L438', 'L439', 'L451', 'L452', 'L453',

'L454', 'L458', 'L459', 'L461', 'L462', 'L463', 'L464', 'L468', 'L469', 'L471', 'L472', 'L473', 'L474', 'L478', 'L479',

'L761', 'L762', 'L763', 'L764', 'L765', 'L766', 'L767', 'L768', 'L769', 'L891', 'L892', 'L893', 'L894', 'L895', 'L896', 'L898', 'L899',

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'L601', 'L602', 'L603', 'L604', 'L608', 'L609', 'L621', 'L622', 'L623', 'L624', 'L628', 'L629', 'L631', 'L632', 'L633', 'L634', 'L635', 'L638', 'L639',

'L653', 'L661', 'L662', 'L663', 'L664', 'L665', 'L667', 'L668', 'L669', 'L681', 'L682', 'L683', 'L684', 'L688', 'L689',

'L701', 'L702', 'L703', 'L704', 'L705', 'L708', 'L709', 'L711', 'L712', 'L713', 'L714', 'L715', 'L716', 'L717', 'L718', 'L719') or

oper17 in:('L161', 'L162', 'L168', 'L169', 'L411', 'L412', 'L413', 'L414', 'L415', 'L416', 'L418', 'L419',

'L421', 'L422', 'L423', 'L424', 'L428', 'L429', 'L431', 'L432', 'L433', 'L434', 'L435', 'L438', 'L439', 'L451', 'L452', 'L453',

'L454', 'L458', 'L459', 'L461', 'L462', 'L463', 'L464', 'L468', 'L469', 'L471', 'L472', 'L473', 'L474', 'L478', 'L479',

'L761', 'L762', 'L763', 'L764', 'L765', 'L766', 'L767', 'L768', 'L769', 'L891', 'L892', 'L893', 'L894', 'L895', 'L896', 'L898', 'L899',

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'L601', 'L602', 'L603', 'L604', 'L608', 'L609', 'L621', 'L622', 'L623', 'L624', 'L628', 'L629', 'L631', 'L632', 'L633', 'L634', 'L635', 'L638', 'L639',

'L653', 'L661', 'L662', 'L663', 'L664', 'L665', 'L667', 'L668', 'L669', 'L681', 'L682', 'L683', 'L684', 'L688', 'L689',

'L701', 'L702', 'L703', 'L704', 'L705', 'L708', 'L709', 'L711', 'L712', 'L713', 'L714', 'L715', 'L716', 'L717', 'L718', 'L719') or

oper18 in:('L161', 'L162', 'L168', 'L169', 'L411', 'L412', 'L413', 'L414', 'L415', 'L416', 'L418', 'L419',

'L421', 'L422', 'L423', 'L424', 'L428', 'L429', 'L431', 'L432', 'L433', 'L434', 'L435', 'L438', 'L439', 'L451', 'L452', 'L453',

'L454', 'L458', 'L459', 'L461', 'L462', 'L463', 'L464', 'L468', 'L469', 'L471', 'L472', 'L473', 'L474', 'L478', 'L479',

'L761', 'L762', 'L763', 'L764', 'L765', 'L766', 'L767', 'L768', 'L769', 'L891', 'L892', 'L893', 'L894', 'L895', 'L896', 'L898', 'L899',

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'L701', 'L702', 'L703', 'L704', 'L705', 'L708', 'L709', 'L711', 'L712', 'L713', 'L714', 'L715', 'L716', 'L717', 'L718', 'L719') or

oper19 in:('L161', 'L162', 'L168', 'L169', 'L411', 'L412', 'L413', 'L414', 'L415', 'L416', 'L418', 'L419',

'L421', 'L422', 'L423', 'L424', 'L428', 'L429', 'L431', 'L432', 'L433', 'L434', 'L435', 'L438', 'L439', 'L451', 'L452', 'L453',

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'L761', 'L762', 'L763', 'L764', 'L765', 'L766', 'L767', 'L768', 'L769', 'L891', 'L892', 'L893', 'L894', 'L895', 'L896', 'L898', 'L899',

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data aaa.allpts;

set aaa.allpts;

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oper3 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

oper4 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

oper5 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

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oper6 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

oper7 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

oper8 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

oper9 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

oper10 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

oper11 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

oper12 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

oper14 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

oper15 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

oper16 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

oper17 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

oper18 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659') or

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run;

data aaa.allpts;

set aaa.allpts;

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'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

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'T208' 'T209') or

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'T208' 'T209') or

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'X344', 'X348', 'X349', 'T251', 'T252', 'T253', 'T258', 'T259', 'T261', 'T262', 'T263', 'T264', 'T268', 'T269', 'T271',

'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

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'T429', 'T431', 'T432', 'T433', 'T434', 'T438', 'T439', 'T451', 'T452', 'T453', 'T458', 'T459', 'T454', 'G761', 'G762',

'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209') or

oper8 in:('G581', 'G582', 'G583', 'G584', 'G585', 'G588', 'G589', 'G611', 'G612', 'G613', 'G618', 'G619',

'G691', 'G692', 'G693', 'G694', 'G698', 'G699', 'G711', 'G712', 'G713', 'G714', 'G715', 'G716', 'G718', 'G719', 'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

'H041', 'H042', 'H043', 'H048', 'H049', 'H051', 'H052', 'H053', 'H058', 'H059', 'H061', 'H062', 'H063', 'H064', 'H068', 'H069', 'H071', 'H072', 'H073',

'H074', 'H078', 'H079', 'H081', 'H082', 'H083', 'H084', 'H085', 'H088', 'H089', 'H091', 'H092', 'H093', 'H094', 'H095', 'H098', 'H099', 'H101', 'H102', 'H103', 'H104',

'H105', 'H108', 'H109', 'H111', 'H112', 'H113', 'H114', 'H115', 'H118', 'H119', 'H131', 'H132', 'H133', 'H134', 'H135', 'H138', 'H139', 'H291', 'H292', 'H293', 'H294',

'H295', 'H298', 'H299', 'H331', 'H332', 'H333', 'H334', 'H335', 'H338', 'H339', 'X071', 'X072', 'X073', 'X074', 'X075', 'X078', 'X079', 'X081', 'X082', 'X083', 'X084', 'X088', 'X089',

'X091', 'X092', 'X093', 'X094', 'X098', 'X099', 'X101', 'X102', 'X103', 'X104', 'X108', 'X109', 'X111', 'X112', 'X118', 'X119', 'X121', 'X122', 'X123', 'X124',

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'X421', 'X428', 'X429', 'X322', 'X323', 'X324', 'X325', 'X326', 'X327', 'X328', 'X329', 'X331', 'X332', 'X333', 'X334', 'X335', 'X336', 'X338', 'X339', 'X341', 'X342', 'X343',

'X344', 'X348', 'X349', 'T251', 'T252', 'T253', 'T258', 'T259', 'T261', 'T262', 'T263', 'T264', 'T268', 'T269', 'T271',

'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

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'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209') or

oper9 in:('G581', 'G582', 'G583', 'G584', 'G585', 'G588', 'G589', 'G611', 'G612', 'G613', 'G618', 'G619',

'G691', 'G692', 'G693', 'G694', 'G698', 'G699', 'G711', 'G712', 'G713', 'G714', 'G715', 'G716', 'G718', 'G719', 'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

'H041', 'H042', 'H043', 'H048', 'H049', 'H051', 'H052', 'H053', 'H058', 'H059', 'H061', 'H062', 'H063', 'H064', 'H068', 'H069', 'H071', 'H072', 'H073',

'H074', 'H078', 'H079', 'H081', 'H082', 'H083', 'H084', 'H085', 'H088', 'H089', 'H091', 'H092', 'H093', 'H094', 'H095', 'H098', 'H099', 'H101', 'H102', 'H103', 'H104',

'H105', 'H108', 'H109', 'H111', 'H112', 'H113', 'H114', 'H115', 'H118', 'H119', 'H131', 'H132', 'H133', 'H134', 'H135', 'H138', 'H139', 'H291', 'H292', 'H293', 'H294',

'H295', 'H298', 'H299', 'H331', 'H332', 'H333', 'H334', 'H335', 'H338', 'H339', 'X071', 'X072', 'X073', 'X074', 'X075', 'X078', 'X079', 'X081', 'X082', 'X083', 'X084', 'X088', 'X089',

'X091', 'X092', 'X093', 'X094', 'X098', 'X099', 'X101', 'X102', 'X103', 'X104', 'X108', 'X109', 'X111', 'X112', 'X118', 'X119', 'X121', 'X122', 'X123', 'X124',

'X125', 'X128', 'X129', 'T553', 'T554', 'T555', 'T556', 'T558', 'T559', 'X401', 'X402', 'X403', 'X404', 'X405', 'X406', 'X407', 'X408', 'X409', 'X411', 'X412', 'X418', 'X419',

'X421', 'X428', 'X429', 'X322', 'X323', 'X324', 'X325', 'X326', 'X327', 'X328', 'X329', 'X331', 'X332', 'X333', 'X334', 'X335', 'X336', 'X338', 'X339', 'X341', 'X342', 'X343',

'X344', 'X348', 'X349', 'T251', 'T252', 'T253', 'T258', 'T259', 'T261', 'T262', 'T263', 'T264', 'T268', 'T269', 'T271',

'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

'T319', 'T341', 'T342', 'T343', 'T348', 'T349', 'T412', 'T413', 'T414', 'T415', 'T418', 'T419', 'T423', 'T424', 'T428',

'T429', 'T431', 'T432', 'T433', 'T434', 'T438', 'T439', 'T451', 'T452', 'T453', 'T458', 'T459', 'T454', 'G761', 'G762',

'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209') or

oper10 in:('G581', 'G582', 'G583', 'G584', 'G585', 'G588', 'G589', 'G611', 'G612', 'G613', 'G618', 'G619',

'G691', 'G692', 'G693', 'G694', 'G698', 'G699', 'G711', 'G712', 'G713', 'G714', 'G715', 'G716', 'G718', 'G719', 'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

'H041', 'H042', 'H043', 'H048', 'H049', 'H051', 'H052', 'H053', 'H058', 'H059', 'H061', 'H062', 'H063', 'H064', 'H068', 'H069', 'H071', 'H072', 'H073',

'H074', 'H078', 'H079', 'H081', 'H082', 'H083', 'H084', 'H085', 'H088', 'H089', 'H091', 'H092', 'H093', 'H094', 'H095', 'H098', 'H099', 'H101', 'H102', 'H103', 'H104',

'H105', 'H108', 'H109', 'H111', 'H112', 'H113', 'H114', 'H115', 'H118', 'H119', 'H131', 'H132', 'H133', 'H134', 'H135', 'H138', 'H139', 'H291', 'H292', 'H293', 'H294',

'H295', 'H298', 'H299', 'H331', 'H332', 'H333', 'H334', 'H335', 'H338', 'H339', 'X071', 'X072', 'X073', 'X074', 'X075', 'X078', 'X079', 'X081', 'X082', 'X083', 'X084', 'X088', 'X089',

'X091', 'X092', 'X093', 'X094', 'X098', 'X099', 'X101', 'X102', 'X103', 'X104', 'X108', 'X109', 'X111', 'X112', 'X118', 'X119', 'X121', 'X122', 'X123', 'X124',

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'X344', 'X348', 'X349', 'T251', 'T252', 'T253', 'T258', 'T259', 'T261', 'T262', 'T263', 'T264', 'T268', 'T269', 'T271',

'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

'T319', 'T341', 'T342', 'T343', 'T348', 'T349', 'T412', 'T413', 'T414', 'T415', 'T418', 'T419', 'T423', 'T424', 'T428',

'T429', 'T431', 'T432', 'T433', 'T434', 'T438', 'T439', 'T451', 'T452', 'T453', 'T458', 'T459', 'T454', 'G761', 'G762',

'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209') or

oper11 in:('G581', 'G582', 'G583', 'G584', 'G585', 'G588', 'G589', 'G611', 'G612', 'G613', 'G618', 'G619',

'G691', 'G692', 'G693', 'G694', 'G698', 'G699', 'G711', 'G712', 'G713', 'G714', 'G715', 'G716', 'G718', 'G719', 'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

'H041', 'H042', 'H043', 'H048', 'H049', 'H051', 'H052', 'H053', 'H058', 'H059', 'H061', 'H062', 'H063', 'H064', 'H068', 'H069', 'H071', 'H072', 'H073',

'H074', 'H078', 'H079', 'H081', 'H082', 'H083', 'H084', 'H085', 'H088', 'H089', 'H091', 'H092', 'H093', 'H094', 'H095', 'H098', 'H099', 'H101', 'H102', 'H103', 'H104',

'H105', 'H108', 'H109', 'H111', 'H112', 'H113', 'H114', 'H115', 'H118', 'H119', 'H131', 'H132', 'H133', 'H134', 'H135', 'H138', 'H139', 'H291', 'H292', 'H293', 'H294',

'H295', 'H298', 'H299', 'H331', 'H332', 'H333', 'H334', 'H335', 'H338', 'H339', 'X071', 'X072', 'X073', 'X074', 'X075', 'X078', 'X079', 'X081', 'X082', 'X083', 'X084', 'X088', 'X089',

'X091', 'X092', 'X093', 'X094', 'X098', 'X099', 'X101', 'X102', 'X103', 'X104', 'X108', 'X109', 'X111', 'X112', 'X118', 'X119', 'X121', 'X122', 'X123', 'X124',

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'X344', 'X348', 'X349', 'T251', 'T252', 'T253', 'T258', 'T259', 'T261', 'T262', 'T263', 'T264', 'T268', 'T269', 'T271',

'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

'T319', 'T341', 'T342', 'T343', 'T348', 'T349', 'T412', 'T413', 'T414', 'T415', 'T418', 'T419', 'T423', 'T424', 'T428',

'T429', 'T431', 'T432', 'T433', 'T434', 'T438', 'T439', 'T451', 'T452', 'T453', 'T458', 'T459', 'T454', 'G761', 'G762',

'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209') or

oper12 in:('G581', 'G582', 'G583', 'G584', 'G585', 'G588', 'G589', 'G611', 'G612', 'G613', 'G618', 'G619',

'G691', 'G692', 'G693', 'G694', 'G698', 'G699', 'G711', 'G712', 'G713', 'G714', 'G715', 'G716', 'G718', 'G719', 'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

'H041', 'H042', 'H043', 'H048', 'H049', 'H051', 'H052', 'H053', 'H058', 'H059', 'H061', 'H062', 'H063', 'H064', 'H068', 'H069', 'H071', 'H072', 'H073',

'H074', 'H078', 'H079', 'H081', 'H082', 'H083', 'H084', 'H085', 'H088', 'H089', 'H091', 'H092', 'H093', 'H094', 'H095', 'H098', 'H099', 'H101', 'H102', 'H103', 'H104',

'H105', 'H108', 'H109', 'H111', 'H112', 'H113', 'H114', 'H115', 'H118', 'H119', 'H131', 'H132', 'H133', 'H134', 'H135', 'H138', 'H139', 'H291', 'H292', 'H293', 'H294',

'H295', 'H298', 'H299', 'H331', 'H332', 'H333', 'H334', 'H335', 'H338', 'H339', 'X071', 'X072', 'X073', 'X074', 'X075', 'X078', 'X079', 'X081', 'X082', 'X083', 'X084', 'X088', 'X089',

'X091', 'X092', 'X093', 'X094', 'X098', 'X099', 'X101', 'X102', 'X103', 'X104', 'X108', 'X109', 'X111', 'X112', 'X118', 'X119', 'X121', 'X122', 'X123', 'X124',

'X125', 'X128', 'X129', 'T553', 'T554', 'T555', 'T556', 'T558', 'T559', 'X401', 'X402', 'X403', 'X404', 'X405', 'X406', 'X407', 'X408', 'X409', 'X411', 'X412', 'X418', 'X419',

'X421', 'X428', 'X429', 'X322', 'X323', 'X324', 'X325', 'X326', 'X327', 'X328', 'X329', 'X331', 'X332', 'X333', 'X334', 'X335', 'X336', 'X338', 'X339', 'X341', 'X342', 'X343',

'X344', 'X348', 'X349', 'T251', 'T252', 'T253', 'T258', 'T259', 'T261', 'T262', 'T263', 'T264', 'T268', 'T269', 'T271',

'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

'T319', 'T341', 'T342', 'T343', 'T348', 'T349', 'T412', 'T413', 'T414', 'T415', 'T418', 'T419', 'T423', 'T424', 'T428',

'T429', 'T431', 'T432', 'T433', 'T434', 'T438', 'T439', 'T451', 'T452', 'T453', 'T458', 'T459', 'T454', 'G761', 'G762',

'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209') or

oper13 in:('G581', 'G582', 'G583', 'G584', 'G585', 'G588', 'G589', 'G611', 'G612', 'G613', 'G618', 'G619',

'G691', 'G692', 'G693', 'G694', 'G698', 'G699', 'G711', 'G712', 'G713', 'G714', 'G715', 'G716', 'G718', 'G719', 'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

'H041', 'H042', 'H043', 'H048', 'H049', 'H051', 'H052', 'H053', 'H058', 'H059', 'H061', 'H062', 'H063', 'H064', 'H068', 'H069', 'H071', 'H072', 'H073',

'H074', 'H078', 'H079', 'H081', 'H082', 'H083', 'H084', 'H085', 'H088', 'H089', 'H091', 'H092', 'H093', 'H094', 'H095', 'H098', 'H099', 'H101', 'H102', 'H103', 'H104',

'H105', 'H108', 'H109', 'H111', 'H112', 'H113', 'H114', 'H115', 'H118', 'H119', 'H131', 'H132', 'H133', 'H134', 'H135', 'H138', 'H139', 'H291', 'H292', 'H293', 'H294',

'H295', 'H298', 'H299', 'H331', 'H332', 'H333', 'H334', 'H335', 'H338', 'H339', 'X071', 'X072', 'X073', 'X074', 'X075', 'X078', 'X079', 'X081', 'X082', 'X083', 'X084', 'X088', 'X089',

'X091', 'X092', 'X093', 'X094', 'X098', 'X099', 'X101', 'X102', 'X103', 'X104', 'X108', 'X109', 'X111', 'X112', 'X118', 'X119', 'X121', 'X122', 'X123', 'X124',

'X125', 'X128', 'X129', 'T553', 'T554', 'T555', 'T556', 'T558', 'T559', 'X401', 'X402', 'X403', 'X404', 'X405', 'X406', 'X407', 'X408', 'X409', 'X411', 'X412', 'X418', 'X419',

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'X344', 'X348', 'X349', 'T251', 'T252', 'T253', 'T258', 'T259', 'T261', 'T262', 'T263', 'T264', 'T268', 'T269', 'T271',

'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

'T319', 'T341', 'T342', 'T343', 'T348', 'T349', 'T412', 'T413', 'T414', 'T415', 'T418', 'T419', 'T423', 'T424', 'T428',

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'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209') or

oper14 in:('G581', 'G582', 'G583', 'G584', 'G585', 'G588', 'G589', 'G611', 'G612', 'G613', 'G618', 'G619',

'G691', 'G692', 'G693', 'G694', 'G698', 'G699', 'G711', 'G712', 'G713', 'G714', 'G715', 'G716', 'G718', 'G719', 'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

'H041', 'H042', 'H043', 'H048', 'H049', 'H051', 'H052', 'H053', 'H058', 'H059', 'H061', 'H062', 'H063', 'H064', 'H068', 'H069', 'H071', 'H072', 'H073',

'H074', 'H078', 'H079', 'H081', 'H082', 'H083', 'H084', 'H085', 'H088', 'H089', 'H091', 'H092', 'H093', 'H094', 'H095', 'H098', 'H099', 'H101', 'H102', 'H103', 'H104',

'H105', 'H108', 'H109', 'H111', 'H112', 'H113', 'H114', 'H115', 'H118', 'H119', 'H131', 'H132', 'H133', 'H134', 'H135', 'H138', 'H139', 'H291', 'H292', 'H293', 'H294',

'H295', 'H298', 'H299', 'H331', 'H332', 'H333', 'H334', 'H335', 'H338', 'H339', 'X071', 'X072', 'X073', 'X074', 'X075', 'X078', 'X079', 'X081', 'X082', 'X083', 'X084', 'X088', 'X089',

'X091', 'X092', 'X093', 'X094', 'X098', 'X099', 'X101', 'X102', 'X103', 'X104', 'X108', 'X109', 'X111', 'X112', 'X118', 'X119', 'X121', 'X122', 'X123', 'X124',

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'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

'T319', 'T341', 'T342', 'T343', 'T348', 'T349', 'T412', 'T413', 'T414', 'T415', 'T418', 'T419', 'T423', 'T424', 'T428',

'T429', 'T431', 'T432', 'T433', 'T434', 'T438', 'T439', 'T451', 'T452', 'T453', 'T458', 'T459', 'T454', 'G761', 'G762',

'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209') or

oper15 in:('G581', 'G582', 'G583', 'G584', 'G585', 'G588', 'G589', 'G611', 'G612', 'G613', 'G618', 'G619',

'G691', 'G692', 'G693', 'G694', 'G698', 'G699', 'G711', 'G712', 'G713', 'G714', 'G715', 'G716', 'G718', 'G719', 'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

'H041', 'H042', 'H043', 'H048', 'H049', 'H051', 'H052', 'H053', 'H058', 'H059', 'H061', 'H062', 'H063', 'H064', 'H068', 'H069', 'H071', 'H072', 'H073',

'H074', 'H078', 'H079', 'H081', 'H082', 'H083', 'H084', 'H085', 'H088', 'H089', 'H091', 'H092', 'H093', 'H094', 'H095', 'H098', 'H099', 'H101', 'H102', 'H103', 'H104',

'H105', 'H108', 'H109', 'H111', 'H112', 'H113', 'H114', 'H115', 'H118', 'H119', 'H131', 'H132', 'H133', 'H134', 'H135', 'H138', 'H139', 'H291', 'H292', 'H293', 'H294',

'H295', 'H298', 'H299', 'H331', 'H332', 'H333', 'H334', 'H335', 'H338', 'H339', 'X071', 'X072', 'X073', 'X074', 'X075', 'X078', 'X079', 'X081', 'X082', 'X083', 'X084', 'X088', 'X089',

'X091', 'X092', 'X093', 'X094', 'X098', 'X099', 'X101', 'X102', 'X103', 'X104', 'X108', 'X109', 'X111', 'X112', 'X118', 'X119', 'X121', 'X122', 'X123', 'X124',

'X125', 'X128', 'X129', 'T553', 'T554', 'T555', 'T556', 'T558', 'T559', 'X401', 'X402', 'X403', 'X404', 'X405', 'X406', 'X407', 'X408', 'X409', 'X411', 'X412', 'X418', 'X419',

'X421', 'X428', 'X429', 'X322', 'X323', 'X324', 'X325', 'X326', 'X327', 'X328', 'X329', 'X331', 'X332', 'X333', 'X334', 'X335', 'X336', 'X338', 'X339', 'X341', 'X342', 'X343',

'X344', 'X348', 'X349', 'T251', 'T252', 'T253', 'T258', 'T259', 'T261', 'T262', 'T263', 'T264', 'T268', 'T269', 'T271',

'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

'T319', 'T341', 'T342', 'T343', 'T348', 'T349', 'T412', 'T413', 'T414', 'T415', 'T418', 'T419', 'T423', 'T424', 'T428',

'T429', 'T431', 'T432', 'T433', 'T434', 'T438', 'T439', 'T451', 'T452', 'T453', 'T458', 'T459', 'T454', 'G761', 'G762',

'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209') or

oper16 in:('G581', 'G582', 'G583', 'G584', 'G585', 'G588', 'G589', 'G611', 'G612', 'G613', 'G618', 'G619',

'G691', 'G692', 'G693', 'G694', 'G698', 'G699', 'G711', 'G712', 'G713', 'G714', 'G715', 'G716', 'G718', 'G719', 'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

'H041', 'H042', 'H043', 'H048', 'H049', 'H051', 'H052', 'H053', 'H058', 'H059', 'H061', 'H062', 'H063', 'H064', 'H068', 'H069', 'H071', 'H072', 'H073',

'H074', 'H078', 'H079', 'H081', 'H082', 'H083', 'H084', 'H085', 'H088', 'H089', 'H091', 'H092', 'H093', 'H094', 'H095', 'H098', 'H099', 'H101', 'H102', 'H103', 'H104',

'H105', 'H108', 'H109', 'H111', 'H112', 'H113', 'H114', 'H115', 'H118', 'H119', 'H131', 'H132', 'H133', 'H134', 'H135', 'H138', 'H139', 'H291', 'H292', 'H293', 'H294',

'H295', 'H298', 'H299', 'H331', 'H332', 'H333', 'H334', 'H335', 'H338', 'H339', 'X071', 'X072', 'X073', 'X074', 'X075', 'X078', 'X079', 'X081', 'X082', 'X083', 'X084', 'X088', 'X089',

'X091', 'X092', 'X093', 'X094', 'X098', 'X099', 'X101', 'X102', 'X103', 'X104', 'X108', 'X109', 'X111', 'X112', 'X118', 'X119', 'X121', 'X122', 'X123', 'X124',

'X125', 'X128', 'X129', 'T553', 'T554', 'T555', 'T556', 'T558', 'T559', 'X401', 'X402', 'X403', 'X404', 'X405', 'X406', 'X407', 'X408', 'X409', 'X411', 'X412', 'X418', 'X419',

'X421', 'X428', 'X429', 'X322', 'X323', 'X324', 'X325', 'X326', 'X327', 'X328', 'X329', 'X331', 'X332', 'X333', 'X334', 'X335', 'X336', 'X338', 'X339', 'X341', 'X342', 'X343',

'X344', 'X348', 'X349', 'T251', 'T252', 'T253', 'T258', 'T259', 'T261', 'T262', 'T263', 'T264', 'T268', 'T269', 'T271',

'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

'T319', 'T341', 'T342', 'T343', 'T348', 'T349', 'T412', 'T413', 'T414', 'T415', 'T418', 'T419', 'T423', 'T424', 'T428',

'T429', 'T431', 'T432', 'T433', 'T434', 'T438', 'T439', 'T451', 'T452', 'T453', 'T458', 'T459', 'T454', 'G761', 'G762',

'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209') or

oper17 in:('G581', 'G582', 'G583', 'G584', 'G585', 'G588', 'G589', 'G611', 'G612', 'G613', 'G618', 'G619',

'G691', 'G692', 'G693', 'G694', 'G698', 'G699', 'G711', 'G712', 'G713', 'G714', 'G715', 'G716', 'G718', 'G719',
'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

'H041', 'H042', 'H043', 'H048', 'H049', 'H051', 'H052', 'H053', 'H058', 'H059', 'H061', 'H062', 'H063', 'H064',
'H068', 'H069', 'H071', 'H072', 'H073',

'H074', 'H078', 'H079', 'H081', 'H082', 'H083', 'H084', 'H085', 'H088', 'H089', 'H091', 'H092', 'H093', 'H094',
'H095', 'H098', 'H099', 'H101', 'H102', 'H103', 'H104',

'H105', 'H108', 'H109', 'H111', 'H112', 'H113', 'H114', 'H115', 'H118', 'H119', 'H131', 'H132', 'H133', 'H134',
'H135', 'H138', 'H139', 'H291', 'H292', 'H293', 'H294',

'H295', 'H298', 'H299', 'H331', 'H332', 'H333', 'H334', 'H335', 'H338', 'H339', 'X071', 'X072', 'X073', 'X074',
'X075', 'X078', 'X079', 'X081', 'X082', 'X083', 'X084', 'X088', 'X089',

'X091', 'X092', 'X093', 'X094', 'X098', 'X099', 'X101', 'X102', 'X103', 'X104', 'X108', 'X109', 'X111', 'X112', 'X118',
'X119', 'X121', 'X122', 'X123', 'X124',

'X125', 'X128', 'X129', 'T553', 'T554', 'T555', 'T556', 'T558', 'T559', 'X401', 'X402', 'X403', 'X404', 'X405', 'X406',
'X407', 'X408', 'X409', 'X411', 'X412', 'X418', 'X419',

'X421', 'X428', 'X429', 'X322', 'X323', 'X324', 'X325', 'X326', 'X327', 'X328', 'X329', 'X331', 'X332', 'X333', 'X334',
'X335', 'X336', 'X338', 'X339', 'X341', 'X342', 'X343',

'X344', 'X348', 'X349', 'T251', 'T252', 'T253', 'T258', 'T259', 'T261', 'T262', 'T263', 'T264', 'T268', 'T269', 'T271',

'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

'T319', 'T341', 'T342', 'T343', 'T348', 'T349', 'T412', 'T413', 'T414', 'T415', 'T418', 'T419', 'T423', 'T424', 'T428',

'T429', 'T431', 'T432', 'T433', 'T434', 'T438', 'T439', 'T451', 'T452', 'T453', 'T458', 'T459', 'T454', 'G761', 'G762',

'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209') or

oper18 in:('G581', 'G582', 'G583', 'G584', 'G585', 'G588', 'G589', 'G611', 'G612', 'G613', 'G618', 'G619',

'G691', 'G692', 'G693', 'G694', 'G698', 'G699', 'G711', 'G712', 'G713', 'G714', 'G715', 'G716', 'G718', 'G719',
'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

'H041', 'H042', 'H043', 'H048', 'H049', 'H051', 'H052', 'H053', 'H058', 'H059', 'H061', 'H062', 'H063', 'H064',
'H068', 'H069', 'H071', 'H072', 'H073',

'H074', 'H078', 'H079', 'H081', 'H082', 'H083', 'H084', 'H085', 'H088', 'H089', 'H091', 'H092', 'H093', 'H094',
'H095', 'H098', 'H099', 'H101', 'H102', 'H103', 'H104',

'H105', 'H108', 'H109', 'H111', 'H112', 'H113', 'H114', 'H115', 'H118', 'H119', 'H131', 'H132', 'H133', 'H134',
'H135', 'H138', 'H139', 'H291', 'H292', 'H293', 'H294',

'H295', 'H298', 'H299', 'H331', 'H332', 'H333', 'H334', 'H335', 'H338', 'H339', 'X071', 'X072', 'X073', 'X074',
'X075', 'X078', 'X079', 'X081', 'X082', 'X083', 'X084', 'X088', 'X089',

'X091', 'X092', 'X093', 'X094', 'X098', 'X099', 'X101', 'X102', 'X103', 'X104', 'X108', 'X109', 'X111', 'X112', 'X118',
'X119', 'X121', 'X122', 'X123', 'X124',

'X125', 'X128', 'X129', 'T553', 'T554', 'T555', 'T556', 'T558', 'T559', 'X401', 'X402', 'X403', 'X404', 'X405', 'X406', 'X407', 'X408', 'X409', 'X411', 'X412', 'X418', 'X419',

'X421', 'X428', 'X429', 'X322', 'X323', 'X324', 'X325', 'X326', 'X327', 'X328', 'X329', 'X331', 'X332', 'X333', 'X334', 'X335', 'X336', 'X338', 'X339', 'X341', 'X342', 'X343',

'X344', 'X348', 'X349', 'T251', 'T252', 'T253', 'T258', 'T259', 'T261', 'T262', 'T263', 'T264', 'T268', 'T269', 'T271',

'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

'T319', 'T341', 'T342', 'T343', 'T348', 'T349', 'T412', 'T413', 'T414', 'T415', 'T418', 'T419', 'T423', 'T424', 'T428',

'T429', 'T431', 'T432', 'T433', 'T434', 'T438', 'T439', 'T451', 'T452', 'T453', 'T458', 'T459', 'T454', 'G761', 'G762',

'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209') or

oper19 in:('G581', 'G582', 'G583', 'G584', 'G585', 'G588', 'G589', 'G611', 'G612', 'G613', 'G618', 'G619',

'G691', 'G692', 'G693', 'G694', 'G698', 'G699', 'G711', 'G712', 'G713', 'G714', 'G715', 'G716', 'G718', 'G719', 'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

'H041', 'H042', 'H043', 'H048', 'H049', 'H051', 'H052', 'H053', 'H058', 'H059', 'H061', 'H062', 'H063', 'H064', 'H068', 'H069', 'H071', 'H072', 'H073',

'H074', 'H078', 'H079', 'H081', 'H082', 'H083', 'H084', 'H085', 'H088', 'H089', 'H091', 'H092', 'H093', 'H094', 'H095', 'H098', 'H099', 'H101', 'H102', 'H103', 'H104',

'H105', 'H108', 'H109', 'H111', 'H112', 'H113', 'H114', 'H115', 'H118', 'H119', 'H131', 'H132', 'H133', 'H134', 'H135', 'H138', 'H139', 'H291', 'H292', 'H293', 'H294',

'H295', 'H298', 'H299', 'H331', 'H332', 'H333', 'H334', 'H335', 'H338', 'H339', 'X071', 'X072', 'X073', 'X074', 'X075', 'X078', 'X079', 'X081', 'X082', 'X083', 'X084', 'X088', 'X089',

'X091', 'X092', 'X093', 'X094', 'X098', 'X099', 'X101', 'X102', 'X103', 'X104', 'X108', 'X109', 'X111', 'X112', 'X118', 'X119', 'X121', 'X122', 'X123', 'X124',

'X125', 'X128', 'X129', 'T553', 'T554', 'T555', 'T556', 'T558', 'T559', 'X401', 'X402', 'X403', 'X404', 'X405', 'X406', 'X407', 'X408', 'X409', 'X411', 'X412', 'X418', 'X419',

'X421', 'X428', 'X429', 'X322', 'X323', 'X324', 'X325', 'X326', 'X327', 'X328', 'X329', 'X331', 'X332', 'X333', 'X334', 'X335', 'X336', 'X338', 'X339', 'X341', 'X342', 'X343',

'X344', 'X348', 'X349', 'T251', 'T252', 'T253', 'T258', 'T259', 'T261', 'T262', 'T263', 'T264', 'T268', 'T269', 'T271',

'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

'T319', 'T341', 'T342', 'T343', 'T348', 'T349', 'T412', 'T413', 'T414', 'T415', 'T418', 'T419', 'T423', 'T424', 'T428',

'T429', 'T431', 'T432', 'T433', 'T434', 'T438', 'T439', 'T451', 'T452', 'T453', 'T458', 'T459', 'T454', 'G761', 'G762',

'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209') or

oper20 in:('G581', 'G582', 'G583', 'G584', 'G585', 'G588', 'G589', 'G611', 'G612', 'G613', 'G618', 'G619',

'G691', 'G692', 'G693', 'G694', 'G698', 'G699', 'G711', 'G712', 'G713', 'G714', 'G715', 'G716', 'G718', 'G719', 'G721', 'G722', 'G723', 'G724', 'G725', 'G728', 'G729',

'H041', 'H042', 'H043', 'H048', 'H049', 'H051', 'H052', 'H053', 'H058', 'H059', 'H061', 'H062', 'H063', 'H064', 'H068', 'H069', 'H071', 'H072', 'H073',

'H074', 'H078', 'H079', 'H081', 'H082', 'H083', 'H084', 'H085', 'H088', 'H089', 'H091', 'H092', 'H093', 'H094', 'H095', 'H098', 'H099', 'H101', 'H102', 'H103', 'H104',

'H105', 'H108', 'H109', 'H111', 'H112', 'H113', 'H114', 'H115', 'H118', 'H119', 'H131', 'H132', 'H133', 'H134', 'H135', 'H138', 'H139', 'H291', 'H292', 'H293', 'H294',

'H295', 'H298', 'H299', 'H331', 'H332', 'H333', 'H334', 'H335', 'H338', 'H339', 'X071', 'X072', 'X073', 'X074', 'X075', 'X078', 'X079', 'X081', 'X082', 'X083', 'X084', 'X088', 'X089',

'X091', 'X092', 'X093', 'X094', 'X098', 'X099', 'X101', 'X102', 'X103', 'X104', 'X108', 'X109', 'X111', 'X112', 'X118', 'X119', 'X121', 'X122', 'X123', 'X124',

'X125', 'X128', 'X129', 'T553', 'T554', 'T555', 'T556', 'T558', 'T559', 'X401', 'X402', 'X403', 'X404', 'X405', 'X406', 'X407', 'X408', 'X409', 'X411', 'X412', 'X418', 'X419',

'X421', 'X428', 'X429', 'X322', 'X323', 'X324', 'X325', 'X326', 'X327', 'X328', 'X329', 'X331', 'X332', 'X333', 'X334', 'X335', 'X336', 'X338', 'X339', 'X341', 'X342', 'X343',

'X344', 'X348', 'X349', 'T251', 'T252', 'T253', 'T258', 'T259', 'T261', 'T262', 'T263', 'T264', 'T268', 'T269', 'T271',

'T272', 'T273', 'T274', 'T278', 'T279', 'T301', 'T302', 'T303', 'T304', 'T308', 'T309', 'T315', 'T316', 'T317', 'T318',

'T319', 'T341', 'T342', 'T343', 'T348', 'T349', 'T412', 'T413', 'T414', 'T415', 'T418', 'T419', 'T423', 'T424', 'T428',

'T429', 'T431', 'T432', 'T433', 'T434', 'T438', 'T439', 'T451', 'T452', 'T453', 'T458', 'T459', 'T454', 'G761', 'G762',

'G763', 'G768', 'G769', 'H175', 'H176', 'H178', 'H179', 'T191', 'T192', 'T198', 'T199', 'T201', 'T202', 'T203', 'T204',

'T208' 'T209'));

run;

data aaa.allpts;

set aaa.allpts;

rf=(diag2 in:('N170','N171','N172','N178','N179','N19','N280') or

diag3 in:('N170','N171','N172','N178','N179','N19','N280') or

diag4 in:('N170','N171','N172','N178','N179','N19','N280') or

diag5 in:('N170','N171','N172','N178','N179','N19','N280') or

diag6 in:('N170','N171','N172','N178','N179','N19','N280') or

diag7 in:('N170','N171','N172','N178','N179','N19','N280') or

diag8 in:('N170','N171','N172','N178','N179','N19','N280') or

diag9 in:('N170','N171','N172','N178','N179','N19','N280') or

diag10 in:('N170','N171','N172','N178','N179','N19','N280') or

diag11 in:('N170','N171','N172','N178','N179','N19','N280') or

diag12 in:('N170','N171','N172','N178','N179','N19','N280') or

diag13 in:('N170','N171','N172','N178','N179','N19','N280') or

diag14 in:('N170','N171','N172','N178','N179','N19','N280') or

diag15 in:('N170','N171','N172','N178','N179','N19','N280') or

diag16 in:('N170','N171','N172','N178','N179','N19','N280') or

diag17 in:('N170','N171','N172','N178','N179','N19','N280') or

diag18 in:('N170','N171','N172','N178','N179','N19','N280') or

diag19 in:('N170','N171','N172','N178','N179','N19','N280') or

```
diag20 in:('N170','N171','N172','N178','N179','N19','N280'));

run;

data aaa.allpts;

set aaa.allpts;

uti=(diag2
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N39
0','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag3
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N39
0','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag4
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N39
0','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag5
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N39
0','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag6
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N39
0','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag7
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N39
0','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag8
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N39
0','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag9
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N39
0','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag10
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N39
0','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag11
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N39
0','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag12
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N39
0','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag13
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N39
0','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag14
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N39
0','N410','N450','N459','N47','N511','A540','A560','A562','B374') or
```

diag15
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N390','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag16
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N390','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag17
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N390','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag18
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N390','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag19
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N390','N410','N450','N459','N47','N511','A540','A560','A562','B374') or

diag20
in:('N10','N12','N151','N159','N158','N160','N288','N300','N303','N308','N309','N340','N341','N342','N370','N390','N410','N450','N459','N47','N511','A540','A560','A562','B374'));

bleed=(diag2 in:('R040','R041','R042','R048','R049','R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag3
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049', 'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag4
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049', 'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag5
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049', 'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag6
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049', 'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag7
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049', 'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag8
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049', 'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag9
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049', 'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag10
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049', 'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag11
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049',
'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag12
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049',
'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag13
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049',
'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag14
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049',
'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag15
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049',
'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag16
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049',
'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag17
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049',
'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag18
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049',
'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag19
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049',
'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252') or

diag20
in:('D693','D694','D695','D696','D699','D735','R161','R162','I971','I978','I979','R040','R041','R042','R048','R049',
'R58', 'K920' 'K921' 'K922' 'Y221' 'Y222' 'Y252'));

gi_comp=(diag2 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551',

'K552', 'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85',

'K869', 'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag3 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551',

'K552', 'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631',

'K85', 'K869', 'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag4 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550',

'K551', 'K552', 'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594',

'K630', 'K631', 'K85', 'K869', 'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag5 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551',

'K552', 'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630',

'K631', 'K85', 'K869', 'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag6 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551',

'K552', 'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631',

'K85', 'K869', 'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag7 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551', 'K552',

'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85',

'K869', 'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag8 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551',

'K552', 'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631',

'K85', 'K869', 'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag9 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551', 'K552',

'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85', 'K869',

'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag10 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551', 'K552',

'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85',

'K869', 'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag11 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551', 'K552',

'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85', 'K869',

'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag12 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551', 'K552',

'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85', 'K869',

'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag13 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551', 'K552',

'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85', 'K869',

'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag14 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551', 'K552',

'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85', 'K869',

'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag15 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551', 'K552',

'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85', 'K869',

'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag16 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551', 'K552',

'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85', 'K869',

'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or

diag17 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551', 'K552',

'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85', 'K869',

'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or
diag18 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551', 'K552',
'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85', 'K869',
'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or
diag19 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551', 'K552',
'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85', 'K869',
'K912', 'K913', 'K918', 'K919', 'K920', 'K921') or
diag20 in:('K25','K26','K27','K28','K290','K296','K297','K298','K299','R630','R633','R634', 'K550', 'K551', 'K552',
'K558', 'K559', 'K560', 'K562', 'K564', 'K565', 'K566', 'K567', 'K590', 'K593', 'K594', 'K630', 'K631', 'K85', 'K869',
'K912', 'K913', 'K918', 'K919', 'K920', 'K921'));

rti=(diag2 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag3 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag4 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag5 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',

'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag6 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag7 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag8 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag9 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag10 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',

'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag11 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag12 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag13 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag14 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag15 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',

'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag16 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag17 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag18 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag19 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59') or
diag20 in:('J100','J101','J108','J110','J111','J118','J120','J121','J122','J128','J129','J13','J14',
'J150','J151','J152','J153','J154','J155','J156','J157','J158','J159','J160','J168','J170','J171','J172',
'J173','J178','J180','J181','J182','J188','J189','J200','J201','J202','J203','J204','J205','J206','J207',
'J208','J209','J210','J218','J219','J22','J440','J441','J690','J691','J698','J702','J704','J708','J709',
'J851','J852','J960','J969','J981','J982','J985','J986','R092','J00','J028','J029','J040','J041','J042',
'J050','J051','J060','J068','J069','J170','B380','B450','B460','B440','B441','B420','J998','B390','B392',
'B400','B441','B420','J998','B390','B392','B400','B402','B59'));

```
hypobp=(diag2 in:('I950','I951','I952','I958','I959') or
diag3 in:('I950','I951','I952','I958','I959') or
diag4 in:('I950','I951','I952','I958','I959') or
diag5 in:('I950','I951','I952','I958','I959') or
diag6 in:('I950','I951','I952','I958','I959') or
diag7 in:('I950','I951','I952','I958','I959') or
diag8 in:('I950','I951','I952','I958','I959') or
diag9 in:('I950','I951','I952','I958','I959') or
diag10 in:('I950','I951','I952','I958','I959') or
diag11 in:('I950','I951','I952','I958','I959') or
diag12 in:('I950','I951','I952','I958','I959') or
diag13 in:('I950','I951','I952','I958','I959') or
diag14 in:('I950','I951','I952','I958','I959') or
diag15 in:('I950','I951','I952','I958','I959') or
diag16 in:('I950','I951','I952','I958','I959') or
diag17 in:('I950','I951','I952','I958','I959') or
diag18 in:('I950','I951','I952','I958','I959') or
diag19 in:('I950','I951','I952','I958','I959') or
diag20 in:('I950','I951','I952','I958','I959'));

ihd=(diag2
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I23
3','I234','I235','I236','I238','I240','I241','I248','I249') or
diag3
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I23
3','I234','I235','I236','I238','I240','I241','I248','I249') or
diag4
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I23
3','I234','I235','I236','I238','I240','I241','I248','I249') or
diag5
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I23
3','I234','I235','I236','I238','I240','I241','I248','I249') or
diag6
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I23
3','I234','I235','I236','I238','I240','I241','I248','I249') or
diag7
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I23
3','I234','I235','I236','I238','I240','I241','I248','I249') or
```

diag8
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I233','I234','I235','I236','I238','I240','I241','I248','I249') or

diag9
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I233','I234','I235','I236','I238','I240','I241','I248','I249') or

diag10
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I233','I234','I235','I236','I238','I240','I241','I248','I249') or

diag11
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I233','I234','I235','I236','I238','I240','I241','I248','I249') or

diag12
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I233','I234','I235','I236','I238','I240','I241','I248','I249') or

diag13
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I233','I234','I235','I236','I238','I240','I241','I248','I249') or

diag14
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I233','I234','I235','I236','I238','I240','I241','I248','I249') or

diag15
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I233','I234','I235','I236','I238','I240','I241','I248','I249') or

diag16
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I233','I234','I235','I236','I238','I240','I241','I248','I249') or

diag17
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I233','I234','I235','I236','I238','I240','I241','I248','I249') or

diag18
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I233','I234','I235','I236','I238','I240','I241','I248','I249') or

diag19
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I233','I234','I235','I236','I238','I240','I241','I248','I249') or

diag20
in:('I200','I201','I208','I209','I210','I211','I212','I213','I214','I219','I220','I221','I228','I229','I230','I231','I232','I233','I234','I235','I236','I238','I240','I241','I248','I249'));

hf=(diag2 in:('I500','I501','I509') or

diag3 in:('I500','I501','I509') or

diag4 in:('I500','I501','I509') or

diag5 in:('I500','I501','I509') or

```
diag6 in:('I500','I501','I509') or
diag7 in:('I500','I501','I509') or
diag8 in:('I500','I501','I509') or
diag9 in:('I500','I501','I509') or
diag10 in:('I500','I501','I509') or
diag11 in:('I500','I501','I509') or
diag12 in:('I500','I501','I509') or
diag13 in:('I500','I501','I509') or
diag14 in:('I500','I501','I509') or
diag15 in:('I500','I501','I509') or
diag16 in:('I500','I501','I509') or
diag17 in:('I500','I501','I509') or
diag18 in:('I500','I501','I509') or
diag19 in:('I500','I501','I509') or
diag20 in:('I500','I501','I509'));

af=(diag2=:'I48' or diag3=:'I48' or diag4=:'I48' or diag5=:'I48' or diag6=:'I48' or diag7=:'I48' or diag8=:'I48' or
diag9=:'I48' or diag10=:'I48' or diag11=:'I48' or diag12=:'I48' or diag13=:'I48' or diag14=:'I48' or diag15=:'I48' or
diag16=:'I48' or diag17=:'I48' or diag18=:'I48' or diag19=:'I48' or diag20=:'I48');

sepsis=(diag2 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag3 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag4 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag5 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag6 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag7 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag8 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag9 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
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diag10 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag11 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag12 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag13 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag14 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag15 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag16 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag17 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag18 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag19 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65') or
diag20 in:('A021','A394','A400','A401','A402','A403','A408','A409','A410','A411','A412','A413','A414',
'A415','A418','A419','A483','B377','B49','D65'));

anemia=(diag2 in:('D500','D501','D508','D509','D649') or
diag3 in:('D500','D501','D508','D509','D649') or
diag4 in:('D500','D501','D508','D509','D649') or
diag5 in:('D500','D501','D508','D509','D649') or
diag6 in:('D500','D501','D508','D509','D649') or
diag7 in:('D500','D501','D508','D509','D649') or
diag8 in:('D500','D501','D508','D509','D649') or
diag9 in:('D500','D501','D508','D509','D649') or
diag10 in:('D500','D501','D508','D509','D649') or
diag11 in:('D500','D501','D508','D509','D649') or
diag12 in:('D500','D501','D508','D509','D649') or
diag13 in:('D500','D501','D508','D509','D649') or
diag14 in:('D500','D501','D508','D509','D649') or
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diag15 in:('D500','D501','D508','D509','D649') or
diag16 in:('D500','D501','D508','D509','D649') or
diag17 in:('D500','D501','D508','D509','D649') or
diag18 in:('D500','D501','D508','D509','D649') or
diag19 in:('D500','D501','D508','D509','D649') or
diag20 in:('D500','D501','D508','D509','D649'));

dementia=(diag2
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G
309') or
diag3
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G
309') or
diag4
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G
309') or
diag5
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G
309') or
diag6
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G
309') or
diag7
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G
309') or
diag8
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G
309') or
diag9
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G
309') or
diag10
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G
309') or
diag11
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G
309') or
diag12
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G
309') or
diag13
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G
309') or
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diag14
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G309') or

diag15
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G309') or

diag16
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G309') or

diag17
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G309') or

diag18
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G309') or

diag19
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G309') or

diag20
in:('F010','F011','F012','F013','F018','F019','F020','F021','F022','F023','F024','F028','F03','G300','G301','G308','G309'));

delirium=(diag2 in:('F050','F051','F058','F059') or

diag3 in:('F050','F051','F058','F059') or

diag4 in:('F050','F051','F058','F059') or

diag5 in:('F050','F051','F058','F059') or

diag6 in:('F050','F051','F058','F059') or

diag7 in:('F050','F051','F058','F059') or

diag8 in:('F050','F051','F058','F059') or

diag9 in:('F050','F051','F058','F059') or

diag10 in:('F050','F051','F058','F059') or

diag11 in:('F050','F051','F058','F059') or

diag12 in:('F050','F051','F058','F059') or

diag13 in:('F050','F051','F058','F059') or

diag14 in:('F050','F051','F058','F059') or

diag15 in:('F050','F051','F058','F059') or

diag16 in:('F050','F051','F058','F059') or

diag17 in:('F050','F051','F058','F059') or

diag18 in:('F050','F051','F058','F059') or

diag19 in:('F050','F051','F058','F059') or

```
diag20 in:('F050','F051','F058','F059'));

mood=(diag2 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag3 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag4 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag5 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag6 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag7 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag8 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag9 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag10 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag11 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag12 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag13 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
```

'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag14 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag15 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag16 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag17 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag18 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag19 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466') or
diag20 in:('F063','F064','F251','F252','F258','F259','F320','F321','F322','F323','F328','F329','F330','F331',
'F332','F333','F334','F338','F339','F348','F349','F380','F388','F39','F410','F411','F412','F413','F418','F419',
'F430','F431','F432','F438','F439','R457','F454','F453','F452','F451','F450','F464','F466'));

c_arrest=(diag2 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or
diag3 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or
diag4 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or
diag5 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or
diag6 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or
diag7 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or
diag8 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or
diag9 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or
diag10 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or
diag11 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or
diag12 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or
diag13 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or

diag14 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or

diag15 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or

diag16 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or

diag17 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or

diag18 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or

diag19 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503') or

diag20 in:('I460','I461','I469','R570','R571','R578','R579','R960','R961','R68','X503'));

cabg_pci=(oper2
in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper3 in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper4 in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper5 in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper6 in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper7 in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper8 in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper9 in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper10
in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper11
in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper12
in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper13
in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper14
in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper15
in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper17
in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper18
in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

oper19
in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759') or

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oper20
in:('K411','K412','K413','K414','K418','K419','K421','K422','K423','K424','K428','K429','K431','K432','K433',

'K434','K438','K439','K441','K442','K448','K449','K461','K462','K463','K464','K465','K468','K469','K471','K472','K473',

'K475','K478','K479','K491','K492','K493','K494','K498','K499','K501','K502','K503','K504','K508','K509','K751','K752',

'K753','K758','K759'));


rrt=(diag2
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') or

diag3 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag4 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag5 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag6 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag7 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag8 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag9 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag10 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag11 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag12 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag13 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag14 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag15 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag16 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag17 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag18 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or
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diag19 in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429')
or

diag20
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429'));


wound_inf=(diag2 in:('T802', 'T814',
'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669',
'K720', 'K763') or

 diag3 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669',
'K720', 'K763') or

 diag4 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669',
'K720', 'K763') or

 diag5 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669',
'K720', 'K763') or

 diag6 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669',
'K720', 'K763') or

 diag7 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669',
'K720', 'K763') or

 diag8 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669',
'K720', 'K763') or

 diag9 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669',
'K720', 'K763') or

 diag10 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669',
'K720', 'K763') or

 diag11 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669',
'K720', 'K763') or

 diag12 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669',
'K720', 'K763') or

 diag13 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',
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'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669', 'K720', 'K763') or

diag14 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669', 'K720', 'K763') or

diag15 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669', 'K720', 'K763') or

diag16 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669', 'K720', 'K763') or

diag17 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669', 'K720', 'K763') or

diag18 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669', 'K720', 'K763') or

diag19 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669', 'K720', 'K763') or

diag20 in:('T802', 'T814', 'L022','L033','L024','L031','L041','L042','L043','L230','L231','L233','L234','L244',

'L248','L251','L252','L270','L271','L278','L279','L500','L506','L530', 'K650', 'K659', 'K661', 'K660', 'K668', 'K669', 'K720', 'K763'));

wound_dis=(diag2 in:('T810', 'T811', 'T812', 'T813') or

diag3 in:('T810', 'T811', 'T812', 'T813') or

diag4 in:('T810', 'T811', 'T812', 'T813') or

diag5 in:('T810', 'T811', 'T812', 'T813') or

diag6 in:('T810', 'T811', 'T812', 'T813') or

diag7 in:('T810', 'T811', 'T812', 'T813') or

diag8 in:('T810', 'T811', 'T812', 'T813') or

diag9 in:('T810', 'T811', 'T812', 'T813') or

diag10 in:('T810', 'T811', 'T812', 'T813') or

diag11 in:('T810', 'T811', 'T812', 'T813') or

diag12 in:('T810', 'T811', 'T812', 'T813') or

diag13 in:('T810', 'T811', 'T812', 'T813') or

diag14 in:('T810', 'T811', 'T812', 'T813') or

diag15 in:('T810', 'T811', 'T812', 'T813') or

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diag16 in:('T810', 'T811', 'T812', 'T813') or
diag17 in:('T810', 'T811', 'T812', 'T813') or
diag18 in:('T810', 'T811', 'T812', 'T813') or
diag19 in:('T810', 'T811', 'T812', 'T813') or
diag20 in:('T810', 'T811', 'T812', 'T813'));

graft_comp=(diag2 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag3 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag4 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag5 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag6 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag7 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag8 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag9 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag10 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag11 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag12 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag13 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag14 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag15 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag16 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag17 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag18 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag19 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859') or
diag20 in:('T823', 'T825', 'T828', 'T829', 'T856', 'T858', 'T859'));

graft_inf=(diag2 in:('T827', 'T857') or
diag3 in:('T827', 'T857') or
diag4 in:('T827', 'T857') or
diag5 in:('T827', 'T857') or
diag6 in:('T827', 'T857') or
diag7 in:('T827', 'T857') or
diag8 in:('T827', 'T857') or
diag9 in:('T827', 'T857') or
diag10 in:('T827', 'T857') or
diag11 in:('T827', 'T857') or
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diag12 in:('T827', 'T857') or

diag13 in:('T827', 'T857') or

diag14 in:('T827', 'T857') or

diag15 in:('T827', 'T857') or

diag16 in:('T827', 'T857') or

diag17 in:('T827', 'T857') or

diag18 in:('T827', 'T857') or

diag19 in:('T827', 'T857') or

diag20 in:('T827', 'T857'));


prod_comp=(diag2 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y63
1',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y65
4','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808',
'I809') or

diag3 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y63
1',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y65
4','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808',
'I809') or

diag4 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y63
1',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y65
4','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808',
'I809') or

diag5 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y63
1',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y65
4','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808',
'I809') or

diag6 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',
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'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag7 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag8 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag9 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag10 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag11 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag12 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag13 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag14 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag15 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag16 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag17 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag18 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag19 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809') or

diag20 in:('T815', 'T817', 'T818', 'T819', 'T888', 'T889', 'Y610','Y611','Y612','Y613','Y614','R58',

'Y615','Y616','Y617','Y618','Y619','Y620','Y621','Y622','Y623','Y624','Y625','Y626','Y627','Y628','Y629','Y630','Y631',

'Y632','Y633','Y634','Y635','Y636','Y637','Y638','Y639','Y640','Y641','Y648','Y649','Y650','Y651','Y652','Y653','Y654','Y655',

'Y656','Y658','Y66','Y69','Y70','Y71','Y74','Y75','Y880','Y881','Y882','Y883', 'I800', 'I801', 'I802', 'I803', 'I808', 'I809'));

dm=(diag2 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag3 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag4 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag5 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag6 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag7 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag8 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag9 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag10 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag11 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag12 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag13 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag14 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag15 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag16 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag17 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag18 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag19 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149') or

diag20 in:('E100', 'E101', 'E102', 'E103', 'E104', 'E105', 'E106', 'E107', 'E108', 'E109', 'E110',

'E112', 'E113', 'E114', 'E115', 'E116', 'E117', 'E118', 'E119', 'E121', 'E122', 'E123', 'E124', 'E125', 'E126', 'E127',

'E128', 'E129', 'E131', 'E132', 'E133', 'E134', 'E135', 'E136', 'E137', 'E138', 'E139', 'E141', 'E142', 'E143', 'E145',

'E144', 'E146', 'E147', 'E148', 'E149'));

stroke=(diag2
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag3
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag4
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag5
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag6
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag7
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag8
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag9
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag10
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag11
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag12
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag13
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag14
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag15
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag16
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag17
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag18
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag19
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698') or

diag20
in:('G450','G451','G452','G453','G454','G458','G459','G460','G461','G462','G463','G464','G465','G466','G467',

'G468','H930','H340','H341','H342','H348','H349',

'I630','I631','I632','I633','I634','I635','I636','I638','I639','I64','I64X','I650','I651','I652','I653','I658',

'I659','I660','I661','I662','I663','I664','I668','I669','I670','I671','I672','I677','I679','I681','I682','I693',

'I694','I698'));

ht=(diag2 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or

diag3 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or

diag4 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or

diag5 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or

diag6 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or

diag7 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or

diag8 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or

diag9 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or

diag10 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or

```
diag11 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or
diag12 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or
diag13 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or
diag14 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or
diag15 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or
diag16 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or
diag17 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or
diag18 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or
diag19 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159') or
diag20 in:('I10', 'I110', 'I119', 'I120', 'I129', 'I130', 'I131', 'I132', 'I139', 'I150', 'I151', 'I152', 'I518', 'I159'));

pvd=(diag2 in:('I730', 'I738', 'I739') or
diag3 in:('I730', 'I738', 'I739') or
diag4 in:('I730', 'I738', 'I739') or
diag5 in:('I730', 'I738', 'I739') or
diag6 in:('I730', 'I738', 'I739') or
diag7 in:('I730', 'I738', 'I739') or
diag8 in:('I730', 'I738', 'I739') or
diag9 in:('I730', 'I738', 'I739') or
diag10 in:('I730', 'I738', 'I739') or
diag11 in:('I730', 'I738', 'I739') or
diag12 in:('I730', 'I738', 'I739') or
diag13 in:('I730', 'I738', 'I739') or
diag14 in:('I730', 'I738', 'I739') or
diag15 in:('I730', 'I738', 'I739') or
diag16 in:('I730', 'I738', 'I739') or
diag17 in:('I730', 'I738', 'I739') or
diag18 in:('I730', 'I738', 'I739') or
diag19 in:('I730', 'I738', 'I739') or
diag20 in:('I730', 'I738', 'I739'));

acute_pvd=(diag2 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag3 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag4 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag5 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag6 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
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diag7 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag8 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag9 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag10 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag11 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag12 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag13 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag14 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag15 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag16 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag17 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag18 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag19 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749') or
diag20 in:('I742', 'I743', 'I744', 'I745', 'I748', 'I749'));

marfan=(diag2=:'Q874' or diag3=:'Q874' or diag4=:'Q874' or diag5=:'Q874' or diag6=:'Q874' or diag7=:'Q874'
or
diag8=:'Q874' or diag9=:'Q874' or diag10=:'Q874' or diag11=:'Q874' or diag12=:'Q874' or diag13=:'Q874' or
diag14=:'Q874' or
diag15=:'Q874' or diag16=:'Q874' or diag17=:'Q874' or diag18=:'Q874' or diag19=:'Q874' or diag20=:'Q874');

run;
data aaa.allpts;
set aaa.allpts;
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diag13 in:('T360','T361','T362','T363','T364','T365','T366','T367','T368','T369','T370','T371','T372','T373','T374',

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diag14 in:('T360','T361','T362','T363','T364','T365','T366','T367','T368','T369','T370','T371','T372','T373','T374',

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diag15 in:('T360','T361','T362','T363','T364','T365','T366','T367','T368','T369','T370','T371','T372','T373','T374',

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diag16 in:('T360','T361','T362','T363','T364','T365','T366','T367','T368','T369','T370','T371','T372','T373','T374',

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diag17 in:('T360','T361','T362','T363','T364','T365','T366','T367','T368','T369','T370','T371','T372','T373','T374',

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diag18 in:('T360','T361','T362','T363','T364','T365','T366','T367','T368','T369','T370','T371','T372','T373','T374',

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'Y556','Y557','Y558','Y559','Y560','Y561','Y562','Y563','Y564','Y565','Y566','Y567','Y568','Y569','Y570','Y571','Y572',

'Y573','Y574','Y575','Y576','Y577','Y578','Y579','D590','D592','D593','D611','D612','D690') or

diag19 in:('T360','T361','T362','T363','T364','T365','T366','T367','T368','T369','T370','T371','T372','T373','T374',

'T375','T376','T377','T378','T379','T380','T381','T382','T383','T384','T385','T386','T387','T388','T389','T390','T391',

'T392','T393','T394','T398','T399','T400','T401','T402','T403','T404','T405','T406','T407','T409','T410','T411','T412',

'T413','T414','T415','T420','T421','T422','T423','T424','T425','T426','T427','T428','T430','T431','T432','T433','T434',

'T435','T436','T438','T439','T440','T441','T442','T443','T444','T445','T446','T447','T448','T449','T450','T451','T452',

'T453','T454','T455','T456','T457','T458','T459','T460','T461','T462','T463','T464','T465','T466','T467','T468','T469',

'T470','T471','T472','T473','T474','T475','T476','T477','T478','T479','T480','T481','T482','T483','T484','T485','T486',

'T487','T490','T491','T492','T493','T494','T495','T496','T497','T498','T499','T500','T501','T502','T503','T504','T505',

'T506','T507','T508','T509','T510','T511','T512','T513','T518','T519','T520','T521','T522','T523','T524','T528','T530',

'T531','T532','T533','T534','T535','T536','T537','T539','T540','T541','T542','T543','T549','T560','T561','T562','T563',

'T564','T565','T566','T567','T568','T569','T570','T571','T572','T579','X60','X61','X62','X63','X64','X65','X66','X67',

'X68','X69','X70','X74','X76','X77','X78','X79','X83','X84','Y10','Y11','Y12','Y13','Y14','Y15','Y16','Y17','Y400','Y401',

'Y401','Y402','Y403','Y404','Y405','Y406','Y407','Y408','Y409','Y410','Y411','Y412','Y413','Y414','Y415','Y416','Y417',

'Y418','Y419','Y420','Y421','Y422','Y423','Y430','Y431','Y432','Y433','Y434','Y435','Y436','Y438','Y439','Y440','Y441','Y442',

'Y442','Y443','Y444','Y445','Y446','Y447','Y449','Y450','Y451','Y452','Y453','Y454','Y455','Y458','Y459','Y460','Y461',

'Y462','Y463','Y464','Y465','Y466','Y467','Y468','Y470','Y471','Y472','Y473','Y474','Y475','Y476','Y477','Y478','Y479',

'Y480','Y481','Y482','Y483','Y484','Y485','Y490','Y491','Y492','Y493','Y494','Y495','Y496','Y497','Y498','Y499','Y500',

'Y501','Y502','Y502','Y508','Y509','Y510','Y511','Y512','Y513','Y514','Y515','Y516','Y517','Y518','Y519','Y520','Y521',

'Y522','Y523','Y524','Y525','Y526','Y527','Y528','Y529','Y530','Y531','Y532','Y533','Y534','Y535','Y536','Y537','Y538',

'Y539','Y540','Y541','Y542','Y543','Y544','Y545','Y546','Y547','Y548','Y549','Y550','Y551','Y552','Y553','Y554','Y555',

'Y556','Y557','Y558','Y559','Y560','Y561','Y562','Y563','Y564','Y565','Y566','Y567','Y568','Y569','Y570','Y571','Y572',

'Y573','Y574','Y575','Y576','Y577','Y578','Y579','D590','D592','D593','D611','D612','D690'));

hfall=(diag2
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag3
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag4
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag5
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag6
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag7
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag8
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag9
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag10
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag11
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag12
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag13
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag14
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag15
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag16
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag17
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag18
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729') or

diag19
in:('M800','M801','M802','M803','M804','M805','M806','M807','M808','M809','R55','W00','W01','W02','W03','W04','W05','W06'

'W06','W07','W08','W09','W10','W17','W18','W19','S720','S721','S722','S723','S724','S727','S728','S729'));

hpres_ulcer=(diag2 in:('L890','L891','L892','L893','L899') or
diag3 in:('L890','L891','L892','L893','L899') or
diag4 in:('L890','L891','L892','L893','L899') or
diag5 in:('L890','L891','L892','L893','L899') or
diag6 in:('L890','L891','L892','L893','L899') or
diag7 in:('L890','L891','L892','L893','L899') or
diag8 in:('L890','L891','L892','L893','L899') or
diag9 in:('L890','L891','L892','L893','L899') or
diag10 in:('L890','L891','L892','L893','L899') or
diag11 in:('L890','L891','L892','L893','L899') or
diag12 in:('L890','L891','L892','L893','L899') or
diag13 in:('L890','L891','L892','L893','L899') or
diag14 in:('L890','L891','L892','L893','L899') or
diag15 in:('L890','L891','L892','L893','L899') or
diag16 in:('L890','L891','L892','L893','L899'));

hpe=(diag2 in:('I260','I269') or diag3 in:('I260','I269') or diag4 in:('I260','I269') or diag5 in:('I260','I269') or
diag6 in:('I260','I269') or diag7 in:('I260','I269') or diag8 in:('I260','I269') or diag9 in:('I260','I269') or diag10 in:('I260','I269') or
diag11 in:('I260','I269') or diag12 in:('I260','I269') or diag13 in:('I260','I269') or diag14 in:('I260','I269') or
diag15 in:('I260','I269') or diag16 in:('I260','I269'));

hpneumo=(diag2 in:('J930','J931','J938','J939','J942') or
diag3 in:('J930','J931','J938','J939','J942') or
diag4 in:('J930','J931','J938','J939','J942') or
diag5 in:('J930','J931','J938','J939','J942') or
diag6 in:('J930','J931','J938','J939','J942') or
diag7 in:('J930','J931','J938','J939','J942') or
diag8 in:('J930','J931','J938','J939','J942') or
diag9 in:('J930','J931','J938','J939','J942') or
diag10 in:('J930','J931','J938','J939','J942') or
diag11 in:('J930','J931','J938','J939','J942') or
diag12 in:('J930','J931','J938','J939','J942') or

diag13 in:('J930','J931','J938','J939','J942') or

diag14 in:('J930','J931','J938','J939','J942') or

diag15 in:('J930','J931','J938','J939','J942') or

diag16 in:('J930','J931','J938','J939','J942') or

diag17 in:('J930','J931','J938','J939','J942'));

hmeta_dis=(diag2
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739') or

diag3
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739') or

diag4
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739') or

diag5
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739') or

diag6
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739') or

diag7
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739') or

diag8
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739') or

diag9
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739') or

diag10
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739')or

diag11
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739') or

diag12
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739') or

diag13
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739') or

diag14
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739') or

diag15
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739') or

diag16
in:('E100','E101','E109','E110','E111','E119','E120','E121','E129','E130','E131','E139','E140','E141','E149','E15','E160','E870','E871','E872','E873','E874','E875','E876','E877','E878','R730','R739'));

hdvt=(diag2 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag3 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag4 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag5 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag6 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag7 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag8 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag9 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag10 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag11 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag12 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag13 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag14 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag15 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag16 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829') or

diag17 in:('I800','I801','I802','I803','I808','I809','I81','I822','I823','I828','I829'));

hbldtrans=(diag2 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or

diag3 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or

diag4 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or

diag5 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or

diag6 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or

diag7 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or

diag8 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or

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diag9 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or
diag10 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or
diag11 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or
diag12 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or
diag13 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or
diag14 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or
diag15 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or
diag16 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857') or
diag17 in:('T80','T800','T801','T802','T803','T804','T805','T808','T809','Y650','T814','T857'));

run;

data aaa.allpts;
set aaa.allpts;
if diag2 in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839')
then para_lysis=1;
else if diag3
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;
else if diag4
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;
else if diag5
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;
else if diag6
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;
else if diag7
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;
else if diag8
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;
else if diag9
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;
else if diag10
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;
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else if diag11
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;

else if diag12
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;

else if diag13
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;

else if diag14
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;

else if diag15
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;

else if diag16
in:('G810','G811','G819','G820','G821','G822','G823','G824','G825','G830','G831','G832','G833','G839') then
para_lysis=1;

else para_lysis=0;

run;

data aaa.allpts;

set aaa.allpts;

if oper1
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper2
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper3
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper4
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper5
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper6
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper7
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;
```

```
else if oper8
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper9
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper10
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper11
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper12
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper13
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper14
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper15
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else if oper16
in:('X401','X402','403','X404','X405','X406','X407','X408','X409','X411','X418','X419','X421','X428','X429') then
rrt_dial=1;

else rrt_dial=0;

run;

data aaa.allpts;

set aaa.allpts;

hac_total=sum(of uti rti hbldtans hdvt hpe hmeta_dis hpneumo hpres_ulcer hfall hdrug htrauma sepsis);

run;

data aaa.allpts;

set aaa.allpts;

if disdest=88 then dd=1;

else if disdest=54 then dd=1;

else if disdest=85 then dd=1;

else if disdest=86 then dd=1;

else if disdest=65 then dd=1;

else if disdest=66 then dd=1;
```

```
else dd=0;
run;
proc univariate data=aaa.allpts;
var admiage los;
run;
data aaa.allpts;
set aaa.allpts;
label sex="sex 1=male 2=female";
run;
data aaa.allpts;
set aaa.allpts;
if (admiage<50) then age=1;
if (50<=admiage<60) then age=2;
if (60<=admiage<70) then age=3;
if (70<=admiage<80) then age=4;
if (80<=admiage<90) then age=5;
if (admiage>=90) then age=6;
run;
data aaa.allpts;
set aaa.allpts;
if (los<5) then los_cat=1;
if (5<=admiage<14) then los_cat=2;
if (14<=admiage<25) then los_cat=3;
if (admiage>=25) then los_cat=4;
run;
data aaa.hes06;
set arao.qi_episodes_hes2006;
run;
data aaa.hes07;
set arao.qi_episodes_hes2007;
run;
data aaa.hes08;
set arao.qi_episodes_hes2008;
run;
data aaa.hes09;
set arao.qi_episodes_hes2009;
```

```
run;
data aaa.aaa09;
set aaa.aaa09;
thorax=(oper1 in:('L181', 'L182','L201', 'L202','L191', 'L192','L211' ,'L212','L273','L283'));
RUN;
proc freq data=aaa.aaa09;
table thorax;
run;
data aaa.aaa09;
set aaa.aaa09;
if thorax=1 then delete;
run;
/*these steps are used to get readmissions after aaa repair from the same year when they had operation*/
data aaa06;
set aaa.aaa06;
run;

data aaa06;
set aaa06;
rename admidate=indexadm;
run;
data a06;
set aaa06;
keep extract_hesid indexadm;
run;
proc sort data=a06;
by extract_hesid;
run;
proc sort data=aaa.hes06;
by extract_hesid;
run;
data NEW;
merge aaa.hes06 (in=a) a06 (in=b);
by extract_hesid;
if b;
run;
```

```
proc contents data=new;
run;
data new;
set new;
time=indexadm - admidate;
run;
proc freq data=new;
table time;
run;
data aaa.new06;
set new;
if time<=0 then delete;
run;
data aaa.ptid06_indexadm;
set a06;
run;

data aaa07;
set aaa.aaa07;
run;

data aaa07;
set aaa07;
rename admidate=indexadm;
run;
data a07;
set aaa07;
keep extract_hesid indexadm;
run;
proc sort data=a07;
by extract_hesid;
run;
proc sort data=aaa.hes07;
by extract_hesid;
run;
data NEW;
```

```
merge aaa.hes07 (in=a) a07 (in=b);
by extract_hesid;
if b;
run;
proc contents data=new;
run;
data new;
set new;
time=indexadm - admidate;
run;
proc freq data=new;
table time;
run;
data aaa.new07;
set new;
if time<=0 then delete;
run;
data aaa.ptid07_indexadm;
set a07;
run;

data aaa08;
set aaa.aaa08;
run;

data aaa08;
set aaa08;
rename admidate=indexadm;
run;
data a08;
set aaa08;
keep extract_hesid indexadm;
run;
proc sort data=a08;
by extract_hesid;
run;
```

```
proc sort data=aaa.hes08;
by extract_hesid;
run;
data NEW;
merge aaa.hes08 (in=a) a08 (in=b);
by extract_hesid;
if b;
run;

data new;
set new;
time=indexadm - admidate;
run;
proc freq data=new;
table time;
run;
data aaa.new08;
set new;
if time<=0 then delete;
run;
data aaa.ptid08_indexadm;
set a08;
run;

data aaa09;
set aaa.aaa09;
run;

data aaa09;
set aaa09;
rename admidate=indexadm;
run;
data a09;
set aaa09;
keep extract_hesid indexadm;
run;
```

```
proc sort data=a09;
by extract_hesid;
run;
proc sort data=aaa.hes09;
by extract_hesid;
run;
data NEW;
merge aaa.hes09 (in=a) a09 (in=b);
by extract_hesid;
if b;
run;
proc contents data=new;
run;
data new;
set new;
time=indexadm - admidate;
run;
proc freq data=new;
table time;
run;
data aaa.new09;
set new;
if time<=0 then delete;
run;
data aaa.ptid09_indexadm;
set a09;
run;
data aaa.new06;
set aaa.new06;
keep dx_epi chosen_op prov2 provspell ccs_group dxgrp diag:
        extract_hesid quintile qi_death readm28 los emerg disyear admidate disdate
        classpat rtm superspell spell episode admiage oper: total_los site specialty
        admisorc disdest ethnic ethnicgroup ssyear dod time indexadm;
        run;

data aaa.new09;
```

```
set aaa.new09;
keep dx_epi chosen_op prov2 provspell ccs_group dxgrp diag:
        extract_hesid quintile qi_death readm28 los emerg disyear admidate disdate
        classpat rtm superspell spell episode admiage oper: total_los site specialty
        admisorc disdest ethnic ethnicgroup ssyear dod time indexadm;
run;
data allfu;
set
        aaa.allfu
        aaa.new06
        aaa.new07
        aaa.new08
        aaa.new09;
run;
data aaa.allpts;
set aaa.allpts;
thorax=(oper1 in:('L181', 'L182','L201', 'L202','L191', 'L192','L211' ,'L212','L273','L283'));
RUN;
proc freq data=aaa.allpts;
table thorax;
run;
data aaa.allpts;
set aaa.allpts;
if thorax=1 then delete;
run;
proc freq data=aaa.allpts;
table raaa e_aaa;
run;
data aaa.allpts;
set aaa.allpts;
raaa=(diag1 in:('I718', 'I713'));
RUN;
data aaa.allpts;
set aaa.allpts;
e_aaa=(diag1 in:('I719', 'I714'));
RUN;
```

```
data r_aaa;
set aaa.allpts;
if raaa=1;
run;
data e_aaa;
set aaa.allpts;
if e_aaa=1;
run;
proc freq data=e_aaa;
table open evar;
run;
data e_aaa;
set e_aaa;
open=(oper1 in:('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205',
'L206', 'L208', 'L209',
'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255'));
run;
data e_aaa;
set e_aaa;
evar=(oper1 in:('L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279',
'L281', 'L282', 'L283', 'L284', 'L285', 'L286', 'L288', 'L289'));
run;
data e_open;
set e_aaa;
if open=1;
run;
data e_evar;
set e_aaa;
if evar=1;
run;
data aaa.e_open;
set e_open;
run;
data aaa.e_evar;
set e_evar;
```

```
run;
data r_aaa;
set r_aaa;
open=(oper1 in:('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205',
'L206', 'L208', 'L209',
'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255'));
run;
data r_aaa;
set r_aaa;
evar=(oper1 in:('L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279',
'L281', 'L282', 'L283', 'L284', 'L285', 'L286', 'L288', 'L289'));
run;
data r_open;
set r_aaa;
if open=1;
run;
data r_evar;
set r_aaa;
if evar=1;
run;
data aaa.e_open;
set e_open;
run;
data aaa.e_evar;
set e_evar;
run;
data aaa.allfu;
set allfu;
run;
data e_evar;
set aaa.e_evar;
keep extract_hesid;
run;
data e_open;
set aaa.e_open;
```

```
keep extract_hesid;
run;
data aaa.r_aaa;
set r_aaa;
run;
data r_aaa;
set r_aaa;
keep extract_hesid;
run;
data r_evar;
set aaa.r_evar;
keep extract_hesid;
run;
data r_open;
set aaa.r_open;
keep extract_hesid;
run;
proc sort data=r_evar;
by extract_hesid;
run;
proc sort data=aaa.allfu;
by extract_hesid;
run;
data e_open_fu;
merge e_open (in=a) aaa.allfu (in=b);
by extract_hesid;
if a;
run;
data e_evar_fu;
merge e_evar (in=a) aaa.allfu (in=b);
by extract_hesid;
if a;
run;
data r_evar_fu;
merge r_evar (in=a) aaa.allfu (in=b);
by extract_hesid;
```

```
if a;
run;
data r_aaa_fu;
merge r_aaa (in=a) aaa.allfu (in=b);
by extract_hesid;
if a;
run;
data aaa.e_open_fu;
set e_open_fu;
run;
data aaa.e_evar_fu;
set e_evar_fu;
run;
data aaa.r_open_fu;
set r_open_fu;
run;
data aaa.r_evar_fu;
set r_evar_fu;
run;
data aaa.r_aaa_fu;
set r_aaa_fu;
run;

data aaa.a06_fu;
set aaa.a06_fu
        aaa.new06;
run;

data aaa.a07_fu;
set aaa.a07_fu
        aaa.new07;
run;

data aaa.a08_fu;
set aaa.a08_fu
        aaa.new08;
```

```
run;

data aaa.a09_fu;
set aaa.a09_fu
        aaa.new09;
run;
data aaa.emerg09;
set aaa.a09_fu;
if emerg=1;
run;

data one;
set aaa.emerg06;
if ADMIDATE =>"01jan2006"d and ADMIDATE <="31dec2007"d;
run;
proc sort data=one nodupkey out=one;
by extract_hesid admidate;
run;
data one;
set one;
los=(total_los+1);
run;

proc transpose data=one out=one prefix=los;
by extract_hesid;
var los;
run;

data one;
set one;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
```

```
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
run;
data one;
set one;
hyr01=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11);
run;

data one;
set one;
tlos01=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11);
run;
data one;
set one;
if tlos01=>365 then tlos01=365;
else tlos01=tlos01;
run;
proc univariate data=one;
var tlos01;
run;
data two;
set aaa.emerg06;
if ADMIDATE =>"01jan2008"d and ADMIDATE <="31dec2008"d;
run;
proc sort data=two nodupkey out=two;
by extract_hesid admidate;
run;
data two;
set two;
los=(total_los+1);
run;
proc transpose data=two out=two prefix=los;
by extract_hesid;
```

```
var los;
run;

data two;
set two;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
if los12=>1 then L12=1;
if los13=>1 then L13=1;
if los14=>1 then L14=1;
if los15=>1 then L15=1;
if los16=>1 then L16=1;
if los17=>1 then L17=1;
if los18=>1 then L18=1;
if los19=>1 then L19=1;
if los20=>1 then L20=1;
run;
data two;
set two;
hyr02=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12,L13,L14,L15,L16,L17,L18,L19,L20);
run;
proc freq data=two;
table hyr02;
run;

data two;
set two;
```

```
tlos02=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11,los12,los13,los14,los15,los16,los17,los18,los
19,los20);
run;
proc freq data=two;
table tlos02;
run;
data two;
set two;
if tlos02=>365 then tlos02=365;
else tlos02=tlos02;
run;

proc univariate data=two;
var tlos02;
run;
data three;
set aaa.emerg06;
if ADMIDATE =>"01jan2009"d and ADMIDATE <="31dec2009"d;
run;
proc sort data=three nodupkey out=three;
by extract_hesid admidate;
run;
data three;
set three;
los=(total_los+1);
run;
proc transpose data=three out=three prefix=los;
by extract_hesid;
var los;
run;

data three;
set three;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
```

```
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
run;

data three;
set three;
hyr03=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10);
run;
proc freq data=three;
table hyr03;
run;
data three;
set three;
tlos03=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10);
run;
proc freq data=three;
table tlos03;
run;
data three;
set three;
if tlos03=>365 then tlos03=365;
else tlos03=tlos03;
run;
proc univariate data=three;
var tlos03;
run;
data four;
set aaa.emerg06;
if ADMIDATE =>"01jan2010"d and ADMIDATE <="31dec2010"d;
run;
proc sort data=four nodupkey out=four;
```

```
by extract_hesid admidate;
run;
data four;
set four;
los=(total_los+1);
run;
proc transpose data=four out=four prefix=los;
by extract_hesid;
var los;
run;

data four;
set four;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
if los12=>1 then L12=1;
if los13=>1 then L13=1;
if los14=>1 then L14=1;
if los15=>1 then L15=1;
if los16=>1 then L16=1;
if los17=>1 then L17=1;
if los18=>1 then L18=1;
if los19=>1 then L19=1;

run;
data four;
set four;
```

```
hyr04=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12,L13,L14,L15,L16,L17,L18,L19);
run;
proc freq data=four;
table hyr04;
run;
data four;
set four;
tlos04=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11,los12,los13,los14,los15,los16,los17,los18,los
19);
run;
proc freq data=four;
table tlos04;
run;
data four;
set four;
if tlos04=>365 then tlos04=365;
else tlos04=tlos04;
run;
proc univariate data=four;
var tlos04;
run;
data five;
set aaa.emerg06;
if ADMIDATE =>"01jan2011"d and ADMIDATE <="31dec2011"d;
run;
proc sort data=five nodupkey out=five;
by extract_hesid admidate;
run;
data five;
set five;
los=(total_los+1);
run;
proc transpose data=five out=five prefix=los;
by extract_hesid;
var los;
run;
```

```
data five;
set five;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
if los12=>1 then L12=1;
if los13=>1 then L13=1;
if los14=>1 then L14=1;
if los15=>1 then L15=1;
if los16=>1 then L16=1;
if los17=>1 then L17=1;
if los18=>1 then L18=1;
if los19=>1 then L19=1;
if los20=>1 then L20=1;
if los21=>1 then L21=1;
if los22=>1 then L22=1;
if los23=>1 then L23=1;
if los24=>1 then L24=1;
if los25=>1 then L25=1;
if los26=>1 then L26=1;
if los27=>1 then L27=1;
run;
data five;
set five;
hyr05=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12,L13,L14,L15,L16,L17,L18,L19,L20,L21,L22,L23,L24,L25,L26,L27);
run;
```

```
proc freq data=five;
table hyr05;
run;
data five;
set five;
tlos05=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11,los12,los13,los14,los15,los16,los17,los18,los
19,los20,los21,
los22,los23,los24,los25,los26,los27);
run;
proc freq data=five;
table tlos05;
run;
data five;
set five;
if tlos05=>365 then tlos05=365;
else tlos05=tlos05;
run;
proc univariate data=five;
var tlos05;
run;
data one;
set one;
keep extract_hesid hyr01 tlos01;
run;
data two;
set two;
keep extract_hesid hyr02 tlos02;
run;
data three;
set three;
keep extract_hesid hyr03 tlos03;
run;
data four;
set four;
keep extract_hesid hyr04 tlos04;
run;
```

```
data five;
set five;
keep extract_hesid hyr05 tlos05;
run;
proc sort data=one out=one;
by extract_hesid;
run;

proc sort data=two out=two;
by extract_hesid;
run;
data one1;
merge one two;
by extract_hesid;
run;

proc sort data=one1;
by extract_hesid;
run;

proc sort data=one1 nodupkey out=one1;
by extract_hesid;
run;

proc sort data=three out=three;
by extract_hesid;
run;

proc sort data=four out=four;
by extract_hesid;
run;
data three1;
merge three four;
by extract_hesid;
run;
proc sort data=three1 nodupkey out=three1;
```

```
by extract_hesid;
run;
data oneto4;
merge one1 three1;
by extract_hesid;
run;
proc sort data=oneto4 nodupkey out=oneto4;
by extract_hesid;
run;

proc sort data=five;
by extract_hesid;
run;
data a06traj;
merge oneto4 five;
by extract_hesid;
run;
proc sort data=a06traj nodupkey out=a06traj;
by extract_hesid;
run;
data aaa.a06traj;
set a06traj;
run;



data one;
set aaa.emerg07;
if ADMIDATE =>"01jan2007"d and ADMIDATE <="31dec2008"d;
run;
proc sort data=one nodupkey out=one;
by extract_hesid admidate;
run;
data one;
set one;
los=(total_los+1);
run;
```

```
proc transpose data=one out=one prefix=los;
by extract_hesid;
var los;
run;

data one;
set one;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
if los12=>1 then L12=1;
run;
data one;
set one;
hyr01=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12);
run;
proc freq data=one;
table hyr01;
run;

data one;
set one;
tlos01=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11,los12);
run;
data one;
set one;
if tlos01=>365 then tlos01=365;
```

```
else tlos01=tlos01;
run;
proc univariate data=one;
var tlos01;
run;
data two;
set aaa.emerg07;
if ADMIDATE =>"01jan2009"d and ADMIDATE <="31dec2009"d;
run;
proc sort data=two nodupkey out=two;
by extract_hesid admidate;
run;
data two;
set two;
los=(total_los+1);
run;
proc transpose data=two out=two prefix=los;
by extract_hesid;
var los;
run;

data two;
set two;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
run;
data two;
set two;
```

```
hyr02=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10);
run;
proc freq data=two;
table hyr02;
run;

data two;
set two;
tlos02=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10);
run;
proc freq data=two;
table tlos02;
run;
data two;
set two;
if tlos02=>365 then tlos02=365;
else tlos02=tlos02;
run;

proc univariate data=two;
var tlos02;
run;
data three;
set aaa.emerg07;
if ADMIDATE =>"01jan2010"d and ADMIDATE <="31dec2010"d;
run;
proc sort data=three nodupkey out=three;
by extract_hesid admidate;
run;
data three;
set three;
los=(total_los+1);
run;
proc transpose data=three out=three prefix=los;
by extract_hesid;
var los;
```

```
run;

data three;
set three;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
if los12=>1 then L12=1;
run;

data three;
set three;
hyr03=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12);
run;
proc freq data=three;
table hyr03;
run;
data three;
set three;
tlos03=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11,los12);
run;
proc freq data=three;
table tlos03;
run;
data three;
set three;
if tlos03=>365 then tlos03=365;
else tlos03=tlos03;
```

```
run;
proc univariate data=three;
var tlos03;
run;
data four;
set aaa.emerg07;
if ADMIDATE =>"01jan2011"d and ADMIDATE <="31dec2011"d;
run;
proc sort data=four nodupkey out=four;
by extract_hesid admidate;
run;
data four;
set four;
los=(total_los+1);
run;
proc transpose data=four out=four prefix=los;
by extract_hesid;
var los;
run;

data four;
set four;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
if los12=>1 then L12=1;
```

```
run;
data four;
set four;
hyr04=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12);
run;
proc freq data=four;
table hyr04;
run;
data four;
set four;
tlos04=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11,los12);
run;
proc freq data=four;
table tlos04;
run;
data four;
set four;
if tlos04=>365 then tlos04=365;
else tlos04=tlos04;
run;
proc univariate data=four;
var tlos04;
run;
data five;
set aaa.emerg07;
if ADMIDATE =>"01jan2012"d and ADMIDATE <="31dec2012"d;
run;
proc sort data=five nodupkey out=five;
by extract_hesid admidate;
run;
data five;
set five;
los=(total_los+1);
run;
proc transpose data=five out=five prefix=los;
by extract_hesid;
```

```
var los;
run;

data five;
set five;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
if los12=>1 then L12=1;
if los13=>1 then L13=1;
if los14=>1 then L14=1;
if los15=>1 then L15=1;
if los16=>1 then L16=1;
if los17=>1 then L17=1;

run;
data five;
set five;
hyr05=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12,L13,L14,L15,L16,L17);
run;
proc freq data=five;
table hyr05;
run;
data five;
set five;
tlos05=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11,los12,los13,los14,los15,los16,los17);
run;
proc freq data=five;
```

```
table tlos05;
run;
data five;
set five;
if tlos05=>365 then tlos05=365;
else tlos05=tlos05;
run;
proc univariate data=five;
var tlos05;
run;
data one;
set one;
keep extract_hesid hyr01 tlos01;
run;
data two;
set two;
keep extract_hesid hyr02 tlos02;
run;
data three;
set three;
keep extract_hesid hyr03 tlos03;
run;
data four;
set four;
keep extract_hesid hyr04 tlos04;
run;
data five;
set five;
keep extract_hesid hyr05 tlos05;
run;
proc sort data=one out=one;
by extract_hesid;
run;

proc sort data=two out=two;
by extract_hesid;
```

```
run;
data one1;
merge one two;
by extract_hesid;
run;

proc sort data=one1;
by extract_hesid;
run;

proc sort data=one1 nodupkey out=one1;
by extract_hesid;
run;

proc sort data=three out=three;
by extract_hesid;
run;

proc sort data=four out=four;
by extract_hesid;
run;
data three1;
merge three four;
by extract_hesid;
run;
proc sort data=three1 nodupkey out=three1;
by extract_hesid;
run;
data oneto4;
merge one1 three1;
by extract_hesid;
run;
proc sort data=oneto4 nodupkey out=oneto4;
by extract_hesid;
run;
```

```
proc sort data=five;
by extract_hesid;
run;
data a07traj;
merge oneto4 five;
by extract_hesid;
run;
proc sort data=a07traj nodupkey out=a07traj;
by extract_hesid;
run;
data aaa.a07traj;
set a07traj;
run;



data one;
set aaa.emerg08;
if ADMIDATE =>"01jan2008"d and ADMIDATE <="31dec2009"d;
run;
proc sort data=one nodupkey out=one;
by extract_hesid admidate;
run;
data one;
set one;
los=(total_los+1);
run;

proc transpose data=one out=one prefix=los;
by extract_hesid;
var los;
run;

data one;
set one;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
```

```
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
run;
data one;
set one;
hyr01=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11);
run;

data one;
set one;
tlos01=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11);
run;
data one;
set one;
if tlos01=>365 then tlos01=365;
else tlos01=tlos01;
run;
proc univariate data=one;
var tlos01;
run;
data two;
set aaa.emerg08;
if ADMIDATE =>"01jan2010"d and ADMIDATE <="31dec2010"d;
run;
proc sort data=two nodupkey out=two;
by extract_hesid admidate;
run;
data two;
set two;
```

```
los=(total_los+1);
run;
proc transpose data=two out=two prefix=los;
by extract_hesid;
var los;
run;

data two;
set two;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;

run;
data two;
set two;
hyr02=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11);
run;
proc freq data=two;
table hyr02;
run;

data two;
set two;
tlos02=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11);
run;
proc freq data=two;
table tlos02;
```

```
run;
data two;
set two;
if tlos02=>365 then tlos02=365;
else tlos02=tlos02;
run;

proc univariate data=two;
var tlos02;
run;
data three;
set aaa.emerg08;
if ADMIDATE =>"01jan2011"d and ADMIDATE <="31dec2011"d;
run;
proc sort data=three nodupkey out=three;
by extract_hesid admidate;
run;
data three;
set three;
los=(total_los+1);
run;
proc transpose data=three out=three prefix=los;
by extract_hesid;
var los;
run;

data three;
set three;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
```

```
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
if los12=>1 then L12=1;
if los13=>1 then L13=1;
run;

data three;
set three;
hyr03=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12,L13);
run;
proc freq data=three;
table hyr03;
run;
data three;
set three;
tlos03=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11,los12,los13);
run;
proc freq data=three;
table tlos03;
run;
data three;
set three;
if tlos03=>365 then tlos03=365;
else tlos03=tlos03;
run;
proc univariate data=three;
var tlos03;
run;
data four;
set aaa.emerg08;
if ADMIDATE =>"01jan2012"d and ADMIDATE <="31dec2012"d;
run;
proc sort data=four nodupkey out=four;
by extract_hesid admidate;
run;
```

```
data four;
set four;
los=(total_los+1);
run;
proc transpose data=four out=four prefix=los;
by extract_hesid;
var los;
run;

data four;
set four;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
if los12=>1 then L12=1;
if los13=>1 then L13=1;
if los14=>1 then L14=1;
if los15=>1 then L15=1;
if los16=>1 then L16=1;
if los17=>1 then L17=1;
if los18=>1 then L18=1;
if los19=>1 then L19=1;
if los20=>1 then L20=1;
if los21=>1 then L21=1;
if los22=>1 then L22=1;
if los23=>1 then L23=1;
if los24=>1 then L24=1;
if los25=>1 then L25=1;
```

```
if los26=>1 then L26=1;

if los27=>1 then L27=1;

if los28=>1 then L28=1;

if los29=>1 then L29=1;

if los30=>1 then L30=1;

run;

data four;

set four;

hyr04=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12,L13,L14,L15,L16,L17,L18,L19,L20,L21,L22,L23,L24,L25,L26,L2
7,L28,L29,L30);

run;

proc freq data=four;

table hyr04;

run;

data four;

set four;

tlos04=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11,los12,los13,los14,los15,los16,los17,los18,los
19,

los20,los21,los22,los23,los24,los25,los26,los27,los28,los29,los30);

run;

proc freq data=four;

table tlos04;

run;

data four;

set four;

if tlos04=>365 then tlos04=365;

else tlos04=tlos04;

run;

proc univariate data=four;

var tlos04;

run;

data five;

set aaa.emerg08;

if ADMIDATE =>"01jan2013"d and ADMIDATE <="31dec2013"d;

run;

proc sort data=five nodupkey out=five;
```

```
by extract_hesid admidate;
run;
data five;
set five;
los=(total_los+1);
run;
proc transpose data=five out=five prefix=los;
by extract_hesid;
var los;
run;

data five;
set five;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
if los12=>1 then L12=1;
if los13=>1 then L13=1;
if los14=>1 then L14=1;
if los15=>1 then L15=1;
if los16=>1 then L16=1;
if los17=>1 then L17=1;
if los18=>1 then L18=1;
if los19=>1 then L19=1;
if los20=>1 then L20=1;
if los21=>1 then L21=1;
if los22=>1 then L22=1;
if los23=>1 then L23=1;
```

```
if los24=>1 then L24=1;
if los25=>1 then L25=1;
if los26=>1 then L26=1;
if los27=>1 then L27=1;
run;
data five;
set five;
hyr05=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12,L13,L14,L15,L16,L17,L18,L19,L20,L21,L22,L23,L24,L25,L26,L27);
run;
proc freq data=five;
table hyr05;
run;
data five;
set five;
tlos05=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11,los12,los13,los14,los15,los16,los17,los18,los19,los20,los21,
los22,los23,los24,los25,los26,los27);
run;
proc freq data=five;
table tlos05;
run;
data five;
set five;
if tlos05=>365 then tlos05=365;
else tlos05=tlos05;
run;
proc univariate data=five;
var tlos05;
run;
data one;
set one;
keep extract_hesid hyr01 tlos01;
run;
data two;
set two;
```

```
keep extract_hesid hyr02 tlos02;
run;
data three;
set three;
keep extract_hesid hyr03 tlos03;
run;
data four;
set four;
keep extract_hesid hyr04 tlos04;
run;
data five;
set five;
keep extract_hesid hyr05 tlos05;
run;
proc sort data=one out=one;
by extract_hesid;
run;

proc sort data=two out=two;
by extract_hesid;
run;
data one1;
merge one two;
by extract_hesid;
run;

proc sort data=one1;
by extract_hesid;
run;

proc sort data=one1 nodupkey out=one1;
by extract_hesid;
run;

proc sort data=three out=three;
by extract_hesid;
```

```
run;

proc sort data=four out=four;
by extract_hesid;
run;
data three1;
merge three four;
by extract_hesid;
run;
proc sort data=three1 nodupkey out=three1;
by extract_hesid;
run;
data oneto4;
merge one1 three1;
by extract_hesid;
run;
proc sort data=oneto4 nodupkey out=oneto4;
by extract_hesid;
run;

proc sort data=five;
by extract_hesid;
run;
data a08traj;
merge oneto4 five;
by extract_hesid;
run;
proc sort data=a08traj nodupkey out=a08traj;
by extract_hesid;
run;
data aaa.a08traj;
set a08traj;
run;
```

```
data one;
set aaa.emerg09;
if ADMIDATE =>"01jan2009"d and ADMIDATE <="31dec2010"d;
run;
proc sort data=one nodupkey out=one;
by extract_hesid admidate;
run;
data one;
set one;
los=(total_los+1);
run;

proc transpose data=one out=one prefix=los;
by extract_hesid;
var los;
run;

data one;
set one;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
run;
data one;
set one;
hyr01=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11);
run;
```

```
data one;
set one;
tlos01=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11);
run;
data one;
set one;
if tlos01=>365 then tlos01=365;
else tlos01=tlos01;
run;
proc univariate data=one;
var tlos01;
run;
data two;
set aaa.emerg09;
if ADMIDATE =>"01jan2011"d and ADMIDATE <="31dec2011"d;
run;
proc sort data=two nodupkey out=two;
by extract_hesid admidate;
run;
data two;
set two;
los=(total_los+1);
run;
proc transpose data=two out=two prefix=los;
by extract_hesid;
var los;
run;

data two;
set two;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
```

```
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
if los12=>1 then L12=1;
if los13=>1 then L13=1;
if los14=>1 then L14=1;
if los15=>1 then L15=1;
if los16=>1 then L16=1;
if los17=>1 then L17=1;
if los18=>1 then L18=1;
if los19=>1 then L19=1;
if los20=>1 then L20=1;
if los21=>1 then L21=1;
if los22=>1 then L22=1;
if los23=>1 then L23=1;
if los24=>1 then L24=1;
if los25=>1 then L25=1;

run;
data two;
set two;
hyr02=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12,L13,L14,L15,L16,L17,L18,L19,L20,L21,L22,L23,L24,L25);
run;
proc freq data=two;
table hyr02;
run;

data two;
set two;
tlos02=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11,los12,los13,los14,los15,los16,los17,los18,los
19,los20,
los21,los22,los23,los24,los25);
run;
proc freq data=two;
```

```
table tlos02;
run;
data two;
set two;
if tlos02=>365 then tlos02=365;
else tlos02=tlos02;
run;

proc univariate data=two;
var tlos02;
run;
data three;
set aaa.emerg09;
if ADMIDATE =>"01jan2012"d and ADMIDATE <="31dec2012"d;
run;
proc sort data=three nodupkey out=three;
by extract_hesid admidate;
run;
data three;
set three;
los=(total_los+1);
run;
proc transpose data=three out=three prefix=los;
by extract_hesid;
var los;
run;

data three;
set three;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
```

```
if los8=>1 then L8=1;

run;

data three;
set three;
hyr03=sum(L1,L2,L3,L4,L5,L6,L7,L8);
run;
proc freq data=three;
table hyr03;
run;
data three;
set three;
tlos03=sum(los1,los2,los3,los4,los5,los6,los7,los8);
run;
proc freq data=three;
table tlos03;
run;
data three;
set three;
if tlos03=>365 then tlos03=365;
else tlos03=tlos03;
run;
proc univariate data=three;
var tlos03;
run;
data four;
set aaa.emerg09;
if ADMIDATE =>"01jan2013"d and ADMIDATE <="31dec2013"d;
run;
proc sort data=four nodupkey out=four;
by extract_hesid admidate;
run;
data four;
set four;
los=(total_los+1);
```

```
run;
proc transpose data=four out=four prefix=los;
by extract_hesid;
var los;
run;

data four;
set four;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
if los12=>1 then L12=1;
if los13=>1 then L13=1;
if los14=>1 then L14=1;

run;
data four;
set four;
hyr04=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12,L13,L14);
run;
proc freq data=four;
table hyr04;
run;
data four;
set four;
tlos04=sum(los1,los2,los3,los4,los5,los6,los7,los8,los9,los10,los11,los12,los13,los14);
run;
proc freq data=four;
```

```
table tlos04;
run;
data four;
set four;
if tlos04=>365 then tlos04=365;
else tlos04=tlos04;
run;
proc univariate data=four;
var tlos04;
run;
data five;
set aaa.emerg09;
if ADMIDATE =>"01jan2014"d and ADMIDATE <="31dec2014"d;
run;
proc sort data=five nodupkey out=five;
by extract_hesid admidate;
run;
data five;
set five;
los=(total_los+1);
run;
proc transpose data=five out=five prefix=los;
by extract_hesid;
var los;
run;

data five;
set five;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;

run;
data five;
set five;
```

```
hyr05=sum(L1,L2,L3,L4);
run;
proc freq data=five;
table hyr05;
run;
data five;
set five;
tlos05=sum(los1,los2,los3,los4);
run;
proc freq data=five;
table tlos05;
run;
data five;
set five;
if tlos05=>365 then tlos05=365;
else tlos05=tlos05;
run;
proc univariate data=five;
var tlos05;
run;
data one;
set one;
keep extract_hesid hyr01 tlos01;
run;
data two;
set two;
keep extract_hesid hyr02 tlos02;
run;
data three;
set three;
keep extract_hesid hyr03 tlos03;
run;
data four;
set four;
keep extract_hesid hyr04 tlos04;
run;
```

```
data five;
set five;
keep extract_hesid hyr05 tlos05;
run;
proc sort data=one out=one;
by extract_hesid;
run;

proc sort data=two out=two;
by extract_hesid;
run;
data one1;
merge one two;
by extract_hesid;
run;

proc sort data=one1;
by extract_hesid;
run;

proc sort data=one1 nodupkey out=one1;
by extract_hesid;
run;

proc sort data=three out=three;
by extract_hesid;
run;

proc sort data=four out=four;
by extract_hesid;
run;
data three1;
merge three four;
by extract_hesid;
run;
proc sort data=three1 nodupkey out=three1;
```

```
by extract_hesid;
run;
data oneto4;
merge one1 three1;
by extract_hesid;
run;
proc sort data=oneto4 nodupkey out=oneto4;
by extract_hesid;
run;

proc sort data=five;
by extract_hesid;
run;
data a09traj;
merge oneto4 five;
by extract_hesid;
run;
proc sort data=a09traj nodupkey out=a09traj;
by extract_hesid;
run;
data aaa.a09traj;
set a09traj;
run;
proc contents data=a06;
run;
proc sort data=aaa.allpts;
by extract_hesid;
run;
proc sort data=a06;
by extract_hesid;
run;
data aaa.a06;
merge aaa.allpts(in=a) a06(in=b);
by extract_hesid;
if b;
run;
```

```
proc sort data=a09 nodupkey out=a09;
by extract_hesid;
run;
proc sort data=aaa.allpts nodupkey out=aaa.allpts;
by extract_hesid;
run;
data aaa.a07;
merge aaa.allpts(in=a) a07(in=b);
by extract_hesid;
if b;
run;
data aaa.a08;
merge aaa.allpts(in=a) a08(in=b);
by extract_hesid;
if b;
run;
data aaa.a09;
merge aaa.allpts(in=a) a09(in=b);
by extract_hesid;
if b;
run;
data aaa.a09;
set aaa.a09;
keep extract_hesid ACS admiage charlson QI_DEATHALL1826 diag: elec emerg ethnicgroup ITU LOS oper:
quintile sex dod ONS_DEATHALL1826
living_alone redo_prod other_vas rf uti bleed gi_comp rti hypobp ihd hf af sepsis anemia dementia delirium
mood c_arrest
cabg_pci rrt wound_inf wound_dis graft_inf prod_comp dm stroke ht pvd acute_pvd marfan htrauma hdrug
hfall hpres_ulcer hpe
hpneumo hmeta_dis hdvt hbldtrans para_lysis rrt_dial hac_total dd age los_cat thorax raaa e_aaa indexadm;
run;
proc sort data=aaa.a06 nodupkey out=aaa.a06;
by extract_hesid;
run;
proc sort data=aaa.a07;
by extract_hesid;
run;
```

```
proc sort data=aaa.a08;
by extract_hesid;
run;
proc sort data=aaa.a09;
by extract_hesid;
run;
proc sort data=aaa.a06traj;
by extract_hesid;
run;
proc sort data=aaa.a07traj;
by extract_hesid;
run;
proc sort data=aaa.a08traj;
by extract_hesid;
run;
proc sort data=aaa.a09traj;
by extract_hesid;
run;
data a06full;
merge aaa.a06 (in=a) aaa.a06traj (in=b);
by extract_hesid;
if a;
run;
data a07full;
merge aaa.a07 (in=a) aaa.a07traj (in=b);
by extract_hesid;
if a;
run;
data a08full;
merge aaa.a08 (in=a) aaa.a08traj (in=b);
by extract_hesid;
if a;
run;
data a09full;
merge aaa.a09 (in=a) aaa.a09traj (in=b);
by extract_hesid;
```

```
if a;
run;
proc sort data=aaa.emerg09 nodupkey out=kia;
by extract_hesid admidate;
run;
proc transpose data=kia out=time9 prefix=admidate;
by extract_hesid;
var admidate;
run;
data time9;
set time9;
keep extract_hesid admidate:;
run;
data a9;
set a09;
keep extract_hesid indexadm;
run;
proc sort data=a9;
by extract_hesid;
run;
data aaja9;
merge a9 (in=a) time9 (in=b);
by extract_hesid;
if a and b;
run;
data aaja9;
set aaja9;
t32=admidate32-admidate31;
run;
data aaja9;
set aaja9;
keep extract_hesid t:;
run;
data aaja9;
set aaja9;
if t1<=0 then delete;
```

```
run;
proc sort data=a09full nodupkey out=a09full;
by extract_hesid;
run;
data fulla09;
merge a09full (in=a) aaja9 (in=b);
by extract_hesid;
if a;
run;
data aaa.a06full;
set fulla06;
run;
data aaa.a06full;
set aaa.a06full;
raaa=(diag1 in:('I718','I713'));
e_aaa=(diag1 in:('I719','I714'));
run;
data ra6;
set aaa.a06full;
if raaa=1;
run;
data ea6;
set aaa.a06full;
if e_aaa=1;
run;
proc freq data=ea6;
table open evar;
run;

data ra6;
set ra6;
open=(oper1 in:('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205',
'L206', 'L208', 'L209',
'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255'));
run;
```

```
data ra6;
set ra6;
evar=(oper1 in:('L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279',
'L281', 'L282', 'L283', 'L284', 'L285', 'L286', 'L288', 'L289'));
run;
data ra6open;
set ra6;
if open=1;
run;
data ra6evar;
set ra6;
if evar=1;
run;
data ea6;
set ea6;
open=(oper1 in:('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205',
'L206', 'L208', 'L209',
'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255'));
run;
data ea6;
set ea6;
evar=(oper1 in:('L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279',
'L281', 'L282', 'L283', 'L284', 'L285', 'L286', 'L288', 'L289'));
run;
data ea6open;
set ea6;
if open=1;
run;
data ea6evar;
set ea6;
if evar=1;
run;
data aaa.a07full;
set aaa.a07full;
raaa=(diag1 in:('I718','I713'));
```

```
e_aaa=(diag1 in:('I719','I714'));
run;
data ra7;
set aaa.a07full;
if raaa=1;
run;
data ea7;
set aaa.a07full;
if e_aaa=1;
run;



data ra7;
set ra7;
open=(oper1 in:('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205',
'L206', 'L208', 'L209',
'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255'));
run;
data ra7;
set ra7;
evar=(oper1 in:('L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279',
'L281', 'L282', 'L283', 'L284', 'L285', 'L286', 'L288', 'L289'));
run;
data ra7open;
set ra7;
if open=1;
run;
data ra7evar;
set ra7;
if evar=1;
run;
data ea7;
set ea7;
open=(oper1 in:('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205',
'L206', 'L208', 'L209',
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```
'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255'));
run;
data ea7;
set ea7;
evar=(oper1 in:('L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279',
'L281', 'L282', 'L283', 'L284', 'L285', 'L286', 'L288', 'L289'));
run;
data ea7open;
set ea7;
if open=1;
run;
data ea7evar;
set ea7;
if evar=1;
run;

data aaa.a08full;
set aaa.a08full;
raaa=(diag1 in:('I718','I713'));
e_aaa=(diag1 in:('I719','I714'));
run;
data ra8;
set aaa.a08full;
if raaa=1;
run;
data ea8;
set aaa.a08full;
if e_aaa=1;
run;



data ra8;
set ra8;
open=(oper1 in:('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205',
'L206', 'L208', 'L209',
```

```
'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255'));

run;

data ra8;

set ra8;

evar=(oper1 in:('L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279',

'L281', 'L282', 'L283', 'L284', 'L285', 'L286', 'L288', 'L289'));

run;

data ra8open;

set ra8;

if open=1;

run;

data ra8evar;

set ra8;

if evar=1;

run;

data ea8;

set ea8;

open=(oper1 in:('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205',
'L206', 'L208', 'L209',

'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255'));

run;

data ea8;

set ea8;

evar=(oper1 in:('L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279',

'L281', 'L282', 'L283', 'L284', 'L285', 'L286', 'L288', 'L289'));

run;

data ea8open;

set ea8;

if open=1;

run;

data ea8evar;

set ea8;

if evar=1;

run;
```

```
data aaa.a09full;
set aaa.a09full;
raaa=(diag1 in:('I718','I713'));
e_aaa=(diag1 in:('I719','I714'));
run;
data ra9;
set aaa.a09full;
if raaa=1;
run;
data ea9;
set aaa.a09full;
if e_aaa=1;
run;



data ra9;
set ra9;
open=(oper1 in:('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205',
'L206', 'L208', 'L209',
'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255'));
run;
data ra9;
set ra9;
evar=(oper1 in:('L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279',
'L281', 'L282', 'L283', 'L284', 'L285', 'L286', 'L288', 'L289'));
run;
data ra9open;
set ra9;
if open=1;
run;
data ra9evar;
set ra9;
if evar=1;
run;
data ea9;
```

```
set ea9;
open=(oper1 in:('L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205',
'L206', 'L208', 'L209',
'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255'));
run;
data ea9;
set ea9;
evar=(oper1 in:('L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279',
'L281', 'L282', 'L283', 'L284', 'L285', 'L286', 'L288', 'L289'));
run;
data ea9open;
set ea9;
if open=1;
run;
data ea9evar;
set ea9;
if evar=1;
run;

data raopen;
set ra6open
ra7open
ra8open
ra9open;
run;
proc sort data=raopen nodupkey out=raopen;
by extract_hesid;
run;
data raevar;
set ra6evar
ra7evar
ra8evar
ra9evar;
run;
proc sort data=raevar nodupkey out=raevar;
```

```
by extract_hesid;
run;
data eaopen;
set ea6open
ea7open
ea8open
ea9open;
run;
proc sort data=eaopen nodupkey out=eaopen;
by extract_hesid;
run;
data eaevar;
set ea6evar
ea7evar
ea8evar
ea9evar;
run;
proc sort data=eaevar nodupkey out=eaevar;
by extract_hesid;
run;
data aaa.eaevar;
set eaevar;
run;
data aaa.allfu;
set aaa.allfu;
vas=(oper1 in:('L161', 'L162', 'L168', 'L169', 'L411', 'L412', 'L413', 'L414', 'L415', 'L416', 'L418', 'L419',
'L421', 'L422', 'L423', 'L424', 'L428', 'L429', 'L431', 'L432', 'L433', 'L434', 'L435', 'L438', 'L439', 'L451', 'L452',
'L453',
'L454', 'L458', 'L459', 'L461', 'L462', 'L463', 'L464', 'L468', 'L469', 'L471', 'L472', 'L473', 'L474', 'L478', 'L479',
'L761', 'L762', 'L763', 'L764', 'L765', 'L766', 'L767', 'L768', 'L769', 'L891', 'L892', 'L893', 'L894', 'L895', 'L896',
'L898', 'L899',
'L481', 'L482', 'L484', 'L485', 'L486', 'L488', 'L489', 'L491', 'L492', 'L493', 'L494', 'L495', 'L496', 'L498', 'L499',
'L501', 'L502', 'L503', 'L504', 'L505', 'L506', 'L508', 'L509', 'L511', 'L512', 'L513', 'L514', 'L515', 'L516', 'L518',
'L519',
'L521', 'L522', 'L528', 'L529', 'L531', 'L532', 'L538', 'L539', 'L541', 'L542', 'L543', 'L544', 'L548', 'L549', 'L652',
'L561', 'L562', 'L563', 'L564', 'L565', 'L566', 'L567', 'L568', 'L569', 'L571', 'L572', 'L573', 'L574', 'L575', 'L576',
'L577', 'L578', 'L579',
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'L581', 'L582', 'L583', 'L584', 'L585', 'L586', 'L587', 'L588', 'L589', 'L591', 'L592', 'L593', 'L594', 'L595', 'L596',
'L597', 'L598', 'L599',

'L601', 'L602', 'L603', 'L604', 'L608', 'L609', 'L621', 'L622', 'L623', 'L624', 'L628', 'L629', 'L631', 'L632', 'L633',
'L634', 'L635', 'L638', 'L639',

'L653', 'L661', 'L662', 'L663', 'L664', 'L665', 'L667', 'L668', 'L669', 'L681', 'L682', 'L683', 'L684', 'L688', 'L689',

'L701', 'L702', 'L703', 'L704', 'L705', 'L708', 'L709', 'L711', 'L712', 'L713', 'L714', 'L715', 'L716', 'L717', 'L718',
'L719'));

redo=(oper1 in:('L221' 'L222' 'L223' 'L224' 'L228' 'L229' 'L651' 'L658' 'L659',

'L265', 'L266', 'L267', 'L268', 'L269', 'L271', 'L272', 'L273', 'L274', 'L275', 'L276', 'L278', 'L279',

'L281', 'L282', 'L283', 'L284', 'L285', 'L286', 'L288', 'L289',

'L181', 'L182', 'L183', 'L184', 'L185', 'L186', 'L188', 'L189', 'L201', 'L202', 'L203', 'L204', 'L205', 'L206', 'L208',
'L209',

'L191', 'L192', 'L193', 'L194', 'L195', 'L196', 'L198', 'L199', 'L211', 'L212', 'L213', 'L214', 'L215', 'L216', 'L218',
'L219', 'L254', 'L255'));

run;

proc freq data=aaa.allfu;

table vas redo;

run;

data two;

set aaa.allfu;

if vas=1;

run;


proc sort data=two nodupkey out=two;

by extract_hesid admidate;

run;

data two;

set two;

los=(total_los+1);

run;

proc transpose data=two out=two prefix=los;

by extract_hesid;

var los;

run;


data two;

set two;
```

```
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;

run;
data two;
set two;
vas_fu=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11);
run;
proc freq data=two;
table vas_fu;
run;

data two;
set two;
keep extract_hesid vas_fu;
run;
proc sort data=two nodupkey out=two;
by extract_hesid;
run;
proc sort data=eaopen;
by extract_hesid;
run;
data one;
merge eaopen(in=a) two(in=b);
by extract_hesid;
if a;
run;
```

```
data aaa.eaopen;
set one;
run;
proc sort data=aaa.eaevar;
by extract_hesid;
run;
data one;
merge eaevar(in=a) two(in=b);
by extract_hesid;
if a;
run;
data aaa.eaevar;
set one;
run;
proc sort data=aaa.raevar;
by extract_hesid;
run;
data aaa.raevar;
merge aaa.raevar(in=a) two(in=b);
by extract_hesid;
if a;
run;
proc sort data=aaa.raopen;
by extract_hesid;
run;
data aaa.raopen;
merge aaa.raopen(in=a) two(in=b);
by extract_hesid;
if a;
run;
data two;
set aaa.allfu;
if redo=1;
run;

proc sort data=two nodupkey out=two;
```

```
by extract_hesid admidate;
run;
data two;
set two;
los=(total_los+1);
run;
proc transpose data=two out=two prefix=los;
by extract_hesid;
var los;
run;

data two;
set two;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;

run;
data two;
set two;
redo_fu=sum(L1,L2,L3,L4,L5);
run;
proc freq data=two;
table redo_fu;
run;

data two;
set two;
keep extract_hesid redo_fu;
run;
proc sort data=two nodupkey out=two;
by extract_hesid;
run;
proc sort data=aaa.eaopen;
```

```
by extract_hesid;
run;
data aaa.eaopen;
merge aaa.eaopen(in=a) two(in=b);
by extract_hesid;
if a;
run;

proc sort data=aaa.eaevar;
by extract_hesid;
run;
data aaa.eaevar;
merge aaa.eaevar(in=a) two(in=b);
by extract_hesid;
if a;
run;

proc sort data=aaa.raevar;
by extract_hesid;
run;
data aaa.raevar;
merge aaa.raevar(in=a) two(in=b);
by extract_hesid;
if a;
run;
proc sort data=aaa.raopen;
by extract_hesid;
run;
data aaa.raopen;
merge aaa.raopen(in=a) two(in=b);
by extract_hesid;
if a;
run;
data two;
set aaa.allfu;
if emerg=0;
```

```
run;

proc sort data=two nodupkey out=two;
by extract_hesid admidate;
run;
data two;
set two;
los=(total_los+1);
run;
proc transpose data=two out=two prefix=los;
by extract_hesid;
var los;
run;
proc freq data=two;
table los50;
run;

data two;
set two;
if los1=>1 then L1=1;
if los2=>1 then L2=1;
if los3=>1 then L3=1;
if los4=>1 then L4=1;
if los5=>1 then L5=1;
if los6=>1 then L6=1;
if los7=>1 then L7=1;
if los8=>1 then L8=1;
if los9=>1 then L9=1;
if los10=>1 then L10=1;
if los11=>1 then L11=1;
if los12=>1 then L12=1;
if los13=>1 then L13=1;
if los14=>1 then L14=1;
if los15=>1 then L15=1;
if los16=>1 then L16=1;
if los17=>1 then L17=1;
```

```
if los18=>1 then L18=1;
if los19=>1 then L19=1;
if los20=>1 then L20=1;
if los21=>1 then L21=1;
if los22=>1 then L22=1;
if los23=>1 then L23=1;
if los24=>1 then L24=1;
if los25=>1 then L25=1;
if los26=>1 then L26=1;
if los27=>1 then L27=1;
if los28=>1 then L28=1;
if los29=>1 then L29=1;
if los30=>1 then L30=1;
if los31=>1 then L31=1;
if los32=>1 then L32=1;
if los33=>1 then L33=1;
if los34=>1 then L34=1;
if los35=>1 then L35=1;
if los36=>1 then L36=1;
if los37=>1 then L37=1;
if los38=>1 then L38=1;
if los39=>1 then L39=1;
if los40=>1 then L40=1;
if los41=>1 then L41=1;
if los42=>1 then L42=1;
if los43=>1 then L43=1;
if los44=>1 then L44=1;
if los45=>1 then L45=1;
if los46=>1 then L46=1;
if los47=>1 then L47=1;
if los48=>1 then L48=1;
if los49=>1 then L49=1;
if los50=>1 then L50=1;
run;
data two;
set two;
```

```
elec_fu=sum(L1,L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12,L13,L14,L15,L16,L17,L18,L19,L20,L21,L22,L23,L24,L25,L26,L
27,L28,L29,
L30,L31,L32,L33,L34,L35,L36,L37,L38,L39,L40,L41,L42,L43,L44,L45,L46,L47,L48,L49,L50);
run;
proc freq data=two;
table elec_fu;
run;

data two;
set two;
keep extract_hesid elec_fu;
run;
proc sort data=two nodupkey out=two;
by extract_hesid;
run;
proc sort data=aaa.eaopen;
by extract_hesid;
run;
data aaa.eaopen;
merge aaa.eaopen(in=a) two(in=b);
by extract_hesid;
if a;
run;

proc sort data=aaa.eaevar;
by extract_hesid;
run;
data aaa.eaevar;
merge aaa.eaevar(in=a) two(in=b);
by extract_hesid;
if a;
run;

proc sort data=aaa.raevar;
by extract_hesid;
run;
```

```
data aaa.raevar;
merge aaa.raevar(in=a) two(in=b);
by extract_hesid;
if a;
run;
proc sort data=aaa.raopen;
by extract_hesid;
run;
data aaa.raopen;
merge aaa.raopen(in=a) two(in=b);
by extract_hesid;
if a;
run;
data aaa.raevar;
set aaa.raevar;
elec_fu=sum(elec_fu,0);
run;
data aaa.raevar;
format extract_hesid hyr01 hyr02 hyr03 hyr04 hyr05 tlos01 tlos02 tlos03 tlos04 tlos05 yr1 yr2 yr3 yr4 yr5;
set aaa.raevar;
run;
proc freq data=aaa.eaevar;
table hyr01 hyr02 hyr03 hyr04 hyr05;
run;
data aaa.eaevar;
set aaa.eaevar;
if hyr05=>3 then hos5=1;
else hos5=0;
run;
data aaa.eaevar;
set aaa.eaevar;
hos=sum(hos1,hos2,hos3,hos4,hos5);
run;
proc freq data=aaa.eaevar;
table hos;
run;
```

```
data aaa.eaevar;
set aaa.eaevar;
if hos=>4 then h4=1;
else h4=0;
run;
proc freq data=aaa.eaevar;
table acs ethnicgroup itu living_alone redo_prod other_vas rf uti bleed gi_comp rti hypobp ihd hf af sepsis
anemia dementia
delirium mood c_arrest cabg_pci rrt wound_inf wound_dis graft_inf prod_comp dm stroke ht pvd acute_pvd
marfan
rrt_dial para_lysis bleed dd;
run;
proc freq data=aaa.eaevar;
table acs ethnic other_vas inf gi_comp rf ihd hf af mood_dis prod dm stroke ht pvd charlson quintile age
hac_total los_cat;
run;
proc univariate data=aaa.eaevar;
var los;
run;
data aaa.eaevar;
set aaa.eaevar;
if (los<3) then los_cat=1;
if (3<=los<12) then los_cat=2;
if (los>=12) then los_cat=3;
run;
data aaa.eaevar;
set aaa.eaevar;
if charlson=0 then charl=0;
if (0<charlson=<4) then charl=1;
if (charlson>4) then charl=2;
run;

data aaa.eaevar;
set aaa.eaevar;
if ethnicgroup>1 then ethnic=2;
else ethnic=1;
run;
```

```
proc freq data=aaa.eaevar;
table mood_dis wound prod;
run;

data aaa.eaevar;
set aaa.eaevar;
if acs>0 then acs=1;
else acs=0;
run;
data aaa.eaevar;
set aaa.eaevar;
if rti=1 then inf=1;
else if uti=1 then inf=1;
else if sepsis=1 then inf=1;
else inf=0;
run;
data aaa.eaevar;
set aaa.eaevar;
if wound_inf=1 then wound=1;
else if wound_dis=1 then wound=1;
else wound=0;
run;
data aaa.eaevar;
set aaa.eaevar;
if prod_comp=1 then prod=1;
else if bleed=1 then prod=1;
else if anemia=1 then prod=1;
else if wound_inf=1 then prod=1;
else if wound_dis=1 then prod=1;
else prod=0;
run;
data aaa.eaevar;
set aaa.eaevar;
if dementia=1 then mood_dis=1;
else if delirium=1 then mood_dis=1;
else if mood=1 then mood_dis=1;
```

```
else mood_dis=0;
run;
proc freq data=aaa.eaevar;
table acs stroke dd ethnic other_vas inf gi_comp rf ihd hf af prod dm ht pvd charl quintile age los_cat;
run;


proc traj data=aaa.eaevar out=OF outplot=OP outstat=OS outest=OE;
ID extract_hesid;
var hyr01-hyr05;
INDEP yr1-yr5;
model ZIP;
NGROUPS 5;
order 2 3 3 3 2;
refgroup 2;
risk acs ethnic other_vas inf gi_comp rf ihd hf af prod dm stroke ht pvd charl quintile age hac_total los_cat;
run;
%TRAJPLOT(OP,OP,'Hospital care VS Time','Readmission rate','Readmission rate','Time/years')
refgroup 2;
risk acs ethnic other_vas inf gi_comp rf ihd hf af prod dm stroke ht pvd charl quintile age hac_total los_cat;
proc freq data=of;
table acs*group ethnic*group other_vas*group inf*group gi_comp*group rf*group ihd*group
hf*group af*group prod*group dm*group stroke*group ht*group pvd*group charl*group quintile*group;
run;
data eaevar;
set eaevar;
if redo_fu>0 then redofu=1;
else redofu=0;
run;
proc sort data=aaa.eaevar;
by extract_hesid;
run;
proc sort data=OF;
by extract_hesid;
run;
data eaevar;
```

```
merge OF(in=a) aaa.eaevar(in=b);
by extract_hesid;
if a and b;
run;
data aaa.eaevar_seq;
set eaevar;
run;

proc freq data=eaevar;
table group*h3;
run;
proc means data=eaevar;
var admiage los;
run;
proc freq data=eaevar;
table dd living_alone ons_deathall1826;
run;
proc glm data=aaa.eaevar_seq;
class group;
model quintile=group;
means group;
run;
quit;
proc freq data=eaevar;
tables group*redofu/chisq;
run;
proc freq data=aaa.eaevar_seq;
tables group*ihd;
run;
proc freq data=eaevar;
tables redo_fu vas_fu elec_fu;
run;

ods html image_dpi=1000;
proc traj data=elective out=OF outstat=crimstat outplot=crimplot ci95m;
ID extract_hesid;
```

```
var hyr01-hyr05;
INDEP yr1-yr5;
model ZIP;
NGROUPS 2;
order 3 3;
run;
%trajplotnew (crimplot,crimstat, 'Hospital care use vs. Time','Hospital Care use','Mean readmission rate','Time/years')
ods graphics close;
data aaa.elective;
set elective;
run;
data aaa.
data aaa.eaopen;
set aaa.eaopen;
if hyr01>0 then open=1;
else open=1;
run;
proc freq data=elective;
table hyr01 hyr02 hyr03 hyr04 hyr05 yr1 yr2 yr3 yr4 yr5 hes1 hes2 hes3 hes4 hes5;
run;
data elective;
set aaa.eaopen
        aaa.eaevar;
        run;


proc means data=of;
class group;
var GRP1PRB;
run;
proc means data=of;
class group;
var GRP2PRB;
run;
proc means data=of;
```

```
class group;
var GRP3PRB;
run;
proc means data=of;
class group;
var GRP4PRB;
run;
proc means data=of;
class group;
var GRP5PRB;
run;
proc means data=of;
class group;
var GRP6PRB;
run;
proc means data=of;
class group;
var GRP7PRB;
run;
proc freq data=aaa.eaopen;
table hyr01 hyr02 hyr03 hyr04 hyr05;
run;
data aaa.eaopen;
set aaa.eaopen;
if hyr05=>3 then hos5=1;
else hos5=0;
run;
data aaa.eaopen;
set aaa.eaopen;
hos=sum(hos1,hos2,hos3,hos4,hos5);
run;
proc freq data=aaa.eaopen;
table hos;
run;
data aaa.eaopen;
set aaa.eaopen;
```

```
if hos=>1 then h1=1;
else h1=0;
run;

data aaa.eaopen;
set aaa.eaopen;
if ethnicgroup>1 then ethnic=2;
else ethnic=1;
run;
proc freq data=aaa.eaevar;
table mood_dis wound prod;
run;

data aaa.eaopen;
set aaa.eaopen;
if acs>0 then acs=1;
else acs=0;
run;
data aaa.eaopen;
set aaa.eaopen;
if rti=1 then inf=1;
else if uti=1 then inf=1;
else if sepsis=1 then inf=1;
else inf=0;
run;
data aaa.eaopen;
set aaa.eaopen;
if wound_inf=1 then wound=1;
else if wound_dis=1 then wound=1;
else wound=0;
run;
data aaa.eaopen;
set aaa.eaopen;
if prod_comp=1 then prod=1;
else if bleed=1 then prod=1;
else if anemia=1 then prod=1;
```

```
else if wound_inf=1 then prod=1;
else if wound_dis=1 then prod=1;
else prod=0;
run;
data aaa.eaopen;
set aaa.eaopen;
if prod_comp=1 then prod_only=1;
else if graft_comp=1 then prod_only=1;
else if bleed=1 then prod_only=1;
else if anemia=1 then prod_only=1;
else if graft_inf=1 then prod_only=1;
else prod_only=0;
run;

data aaa.eaopen;
set aaa.eaopen;
if dementia=1 then mood_dis=1;
else if delirium=1 then mood_dis=1;
else if mood=1 then mood_dis=1;
else mood_dis=0;
run;
proc freq data=aaa.eaopen;
table acs ethnicgroup itu living_alone redo_prod other_vas rf uti bleed gi_comp rti hypobp ihd hf af sepsis
anemia dementia
delirium mood c_arrest cabg_pci rrt wound_inf wound_dis graft_inf prod_comp dm stroke ht pvd acute_pvd
marfan
rrt_dial para_lysis bleed dd;
run;
proc freq data=aaa.eaopen;
table acs ethnic other_vas rf uti gi_comp rti sepsis hypobp ihd hf af mood_dis wound prod_only dm stroke ht
pvd
dd charl quintile los_cat;
run;
data aaa.raevar;
set aaa.raevar;
if hyr01>0 then evar=1;
else evar=1;
```

```
run;
proc freq data=open;
table evar;
run;
data open;
set aaa.raopen
        aaa.raevar;
        run;
data aaa.elective;
set elective;
run;
data aaa.raaa;
set open;
run;



proc traj data=open out=OF outplot=OP outstat=OS outest=OE;
ID extract_hesid;
var hyr01-hyr05;
INDEP yr1-yr5;
model ZIP;
NGROUPS 4;
order 2 2 2 1;
run;
%TRAJPLOT(OP,OP,'Hospital care VS Time','Readmission rate','Readmission rate','Time/years')
refgroup 2;
risk acs ethnic other_vas other_prod rf inf gi_comp ihd hf af wound prod_only dm ht pvd charl quintile los_cat
hac_total;
proc traj data=aaa.eaopen out=OF outstat=crimstat outplot=crimplot ci95m;
ID extract_hesid;
var hyr01-hyr05;
INDEP yr1-yr5;
model ZIP;
NGROUPS 5;
order 2 3 3 3 3;
```

```
run;
%trajplotnew (crimplot,crimstat, 'Hospital care use vs. Time','Hospital Care use','Readmission
rate','Time/years')


proc freq data=eaopen;
table acs*group ethnic*group other_vas*group other_prod*group inf*group gi_comp*group rf*group
ihd*group
hf*group af*group wound*group prod_only*group dm*group ht*group pvd*group charl*group;
run;

proc sort data=aaa.eaopen;
by extract_hesid;
run;
proc sort data=OF;
by extract_hesid;
run;
data eaopen;
merge OF(in=a) aaa.eaopen(in=b);
by extract_hesid;
if a and b;
run;
data aaa.eaopen_seq;
set eaopen;
run;
proc freq data=eaopen;
table group*h3;
run;
proc means data=of;
class group;
var GRP1PRB;
run;
proc means data=of;
class group;
var GRP2PRB;
run;
```

```
proc means data=of;
class group;
var GRP3PRB;
run;
proc means data=of;
class group;
var GRP4PRB;
run;
proc means data=of;
class group;
var GRP5PRB;
run;
proc means data=of;
class group;
var GRP6PRB;
run;
data eaopen;
set eaopen;
if redo_fu>0 then redofu=1;
else redofu=0;
run;
proc means data=eaopen;
var admiage los;
run;
proc freq data=eaopen;
table dd living_alone ons_deathall1826;
run;
proc glm data=eaopen;
class group;
model vas_fu=group;
means group;
run;
quit;
proc freq data=eaopen;
tables redo_fu vas_fu elec_fu;
run;
```

```
proc freq data=eaopen;
tables group*ons_deathall1826/chisq;
run;
proc freq data=eaopen;
table dd living_alone ons_deathall1826 other_prod other_vas redo_prod;
run;
proc freq data=aaa.allpts;
table other_prod;
run;
data allpts;
set aaa.allpts;
keep extract_hesid graft_comp;
run;
proc sort data=allpts;
by extract_hesid;
run;
proc sort data=aaa.raevar;
by extract_hesid;
run;

proc freq data=aaa.raopen;
table hyr01 hyr02 hyr03 hyr04 hyr05;
run;
data aaa.raopen;
set aaa.raopen;
if hyr05=>3 then hos5=1;
else hos5=0;
run;
data aaa.raopen;
set aaa.raopen;
hos=sum(hos1,hos2,hos3,hos4,hos5);
run;
proc freq data=aaa.raopen;
table hos hos3 hos2 hos4 hos5;
run;
data aaa.raopen;
```

```
set aaa.raopen;
if hos=>3 then h3=1;
else h3=0;
run;

proc univariate data=aaa.raopen;
var los;
run;

data aaa.raopen;
set aaa.raopen;
if ethnicgroup>1 then ethnic=2;
else ethnic=1;
run;
proc freq data=aaa.raopen;
table mood_dis wound prod prod_only prod_comp graft_comp graft_inf bleed wound_inf wound_dis;
run;

data aaa.raopen;
set aaa.raopen;
if acs>0 then acs=1;
else acs=0;
run;
data aaa.raopen;
set aaa.raopen;
if rti=1 then inf=1;
else if uti=1 then inf=1;
else if sepsis=1 then inf=1;
else inf=0;
run;
data aaa.raopen;
set aaa.raopen;
if wound_inf=1 then wound=1;
else if wound_dis=1 then wound=1;
else wound=0;
run;
```

```
data aaa.raopen;
set aaa.raopen;
if prod_comp=1 then prod=1;
else if bleed=1 then prod=1;
else if anemia=1 then prod=1;
else if wound_inf=1 then prod=1;
else if wound_dis=1 then prod=1;
else if graft_inf=1 then prod=1;
else if graft_comp=1 then prod=1;
else prod=0;
run;
data aaa.raopen;
set aaa.raopen;
if prod_comp=1 then prod_only=1;
else if graft_comp=1 then prod_only=1;
else if bleed=1 then prod_only=1;
else if anemia=1 then prod_only=1;
else if graft_inf=1 then prod_only=1;
else prod_only=0;
run;

data aaa.raopen;
set aaa.raopen;
if dementia=1 then mood_dis=1;
else if delirium=1 then mood_dis=1;
else if mood=1 then mood_dis=1;
else mood_dis=0;
run;
proc freq data=aaa.eaopen;
table acs ethnic itu living_alone redo_prod other_prod other_vas rf uti bleed gi_comp rti hypobp ihd hf af
sepsis anemia dementia
delirium mood c_arrest cabg_pci rrt wound_inf wound_dis graft_inf prod_comp dm stroke ht pvd acute_pvd
marfan
rrt_dial para_lysis bleed dd;
run;
proc freq data=aaa.eaopen;
```

```
table acs ethnic other_vas rf uti gi_comp rti sepsis hypobp ihd hf af mood_dis wound prod_only dm stroke ht
pvd
dd charl quintile los_cat;
run;


proc traj data=aaa.raopen out=OF outplot=OP outstat=OS outest=OE;
ID extract_hesid;
var hyr01-hyr05;
INDEP yr1-yr5;
model ZIP;
NGROUPS 5;
order 2 2 2 2 1;
refgroup 3;
risk acs ethnic other_vas other_prod rf gi_comp inf ihd hf af wound dm prod_only ht pvd charl
age los_cat quintile hac_total;
run;
%TRAJPLOT(OP,OP,'Hospital care VS Time','Readmission rate','Readmission rate','Time/years')

proc traj data=aaa.raopen out=OF outstat=crimstat outplot=crimplot ci95m;
ID extract_hesid;
var hyr01-hyr05;
INDEP yr1-yr5;
model ZIP;
NGROUPS 5;
order 2 2 2 2 1;
run;
%trajplotnew (crimplot,crimstat, 'Hospital care use vs. Time','Hospital Care use','Readmission
rate','Time/years')


proc freq data=raopen;
table acs*group ethnic*group other_vas*group other_prod*group rti*group uti*group sepsis*group
gi_comp*group rf*group ihd*group
hf*group af*group wound*group prod_only*group stroke*group dm*group ht*group pvd*group charl*group;
run;
proc freq data=of;
```

```
table group*hf group*acs group*rf group*ethnic;
run;
proc sort data=aaa.raopen;
by extract_hesid;
run;
proc sort data=OF;
by extract_hesid;
run;
data raopen;
merge OF(in=a) aaa.raopen(in=b);
by extract_hesid;
if a and b;
run;
proc means data=raopen;
var quintile;
class group;
run;
data aaa.raopen_seq;
set raopen;
run;

proc freq data=raopen;
table group*h2;
run;
proc means data=of;
class group;
var GRP1PRB;
run;
proc means data=of;
class group;
var GRP2PRB;
run;
proc means data=of;
class group;
var GRP3PRB;
run;
```

```
proc means data=of;
class group;
var GRP4PRB;
run;
proc means data=of;
class group;
var GRP5PRB;
run;
proc means data=of;
class group;
var GRP6PRB;
run;
data raopen;
set raopen;
if redo_fu>0 then redofu=1;
else redofu=0;
run;
proc means data=raopen;
var admiage los;
run;
proc freq data=raopen;
table dd living_alone ons_deathall1826;
run;
proc glm data=raopen;
class group;
model quintile=group;
means group;
run;
quit;
proc freq data=raopen;
tables redo_fu vas_fu elec_fu;
run;
proc freq data=raopen;
tables group*redofu/chisq;
run;
proc freq data=raopen;
```

```
table other_prod other_vas redo_prod;
run;

proc freq data=aaa.raevar;
table hyr01 hyr02 hyr03 hyr04 hyr05;
run;
data aaa.raevar;
set aaa.raevar;
if hyr05=>3 then hos5=1;
else hos5=0;
run;
data aaa.raevar;
set aaa.raevar;
hos=sum(hos1,hos2,hos3,hos4,hos5);
run;
proc freq data=aaa.raevar;
table hos hos3 hos2 hos4 hos5;
run;
data aaa.raevar;
set aaa.raevar;
if hos=>3 then h3=1;
else h3=0;
run;

proc univariate data=aaa.raevar;
var los;
run;

data aaa.raevar;
set aaa.raevar;
if ethnicgroup>1 then ethnic=2;
else ethnic=1;
run;
proc freq data=aaa.raevar;
table mood_dis wound prod prod_only prod_comp graft_comp graft_inf bleed wound_inf wound_dis;
run;
```

```
data aaa.raevar;
set aaa.raevar;
if acs>0 then acs=1;
else acs=0;
run;
data aaa.raevar;
set aaa.raevar;
if rti=1 then inf=1;
else if uti=1 then inf=1;
else if sepsis=1 then inf=1;
else inf=0;
run;
data aaa.raevar;
set aaa.raevar;
if wound_inf=1 then wound=1;
else if wound_dis=1 then wound=1;
else wound=0;
run;
data aaa.raevar;
set aaa.raevar;
if prod_comp=1 then prod=1;
else if bleed=1 then prod=1;
else if anemia=1 then prod=1;
else if wound_inf=1 then prod=1;
else if wound_dis=1 then prod=1;
else if graft_inf=1 then prod=1;
else if graft_comp=1 then prod=1;
else prod=0;
run;
data aaa.raevar;
set aaa.raevar;
if prod_comp=1 then prod_only=1;
else if graft_comp=1 then prod_only=1;
else if bleed=1 then prod_only=1;
else if anemia=1 then prod_only=1;
```

```
else if graft_inf=1 then prod_only=1;
else prod_only=0;
run;

data aaa.raevar;
set aaa.raevar;
if dementia=1 then mood_dis=1;
else if delirium=1 then mood_dis=1;
else if mood=1 then mood_dis=1;
else mood_dis=0;
run;
proc freq data=aaa.raevar;
table acs ethnic itu living_alone redo_prod other_prod other_vas rf uti bleed gi_comp rti hypobp ihd hf af
sepsis anemia dementia
delirium mood_dis c_arrest cabg_pci rrt wound_inf wound_dis graft_inf prod_comp dm stroke ht pvd
acute_pvd marfan
rrt_dial para_lysis bleed dd inf wound prod prod_only;
run;



proc traj data=aaa.raevar out=OF outplot=OP outstat=OS outest=OE;
ID extract_hesid;
var hyr01-hyr05;
INDEP yr1-yr5;
model ZIP;
NGROUPS 2;
order 1 1;
risk acs ethnic other_vas other_prod rf gi_comp inf ihd hf af wound stroke dm prod_only ht pvd charl
age los_cat quintile hac_total;
run;
%TRAJPLOT(OP,OP,'Hospital care VS Time','Readmission rate','Readmission rate','Time/years')

proc traj data=aaa.raevar out=OF outstat=crimstat outplot=crimplot ci95m;
ID extract_hesid;
var hyr01-hyr05;
INDEP yr1-yr5;
```

```
model ZIP;
NGROUPS 2;
order 1 1;
run;
%trajplotnew (crimplot,crimstat, 'Hospital care use vs. Time','Hospital Care use','Readmission rate','Time/years')


proc freq data=raevar;
table acs*group ethnic*group other_vas*group other_prod*group rti*group uti*group sepsis*group gi_comp*group rf*group ihd*group
hf*group af*group wound*group prod_only*group stroke*group dm*group ht*group pvd*group charl*group dd*group;
run;
proc freq data=of;
table group*dm;
run;

proc sort data=aaa.raevar;
by extract_hesid;
run;
proc sort data=OF;
by extract_hesid;
run;
data raevar;
merge OF(in=a) aaa.raevar(in=b);
by extract_hesid;
if a and b;
run;
data aaa.raevar_seq;
set raevar;
run;

proc freq data=raevar;
table group*h2;
run;
proc means data=of;
```

```
class group;
var GRP1PRB;
run;
proc means data=of;
class group;
var GRP2PRB;
run;
proc means data=of;
class group;
var GRP3PRB;
run;
proc means data=of;
class group;
var GRP4PRB;
run;
proc means data=of;
class group;
var GRP5PRB;
run;
proc means data=of;
class group;
var GRP6PRB;
run;
data raevar;
set raevar;
if redo_fu>0 then redofu=1;
else redofu=0;
run;
proc means data=raevar;
var admiage los;
run;
proc freq data=raevar;
table dd living_alone ons_deathall1826 other_prod other_vas elec_fu;
run;
proc glm data=revar;
class group;
```

```
model los=group;
means group;
run;
quit;

proc freq data=raevar;
tables group*redofu/chisq;
run;
ods html image_dpi=300;
proc traj data=aaa.elective out=OF outstat=crimstat outplot=crimplot ci95m;
ID extract_hesid;
var hyr01-hyr05;
INDEP yr1-yr5;
model ZIP;
NGROUPS 2;
order 3 3;
run;
%trajplotnew (crimplot,crimstat, 'Hospital care use vs. Time','Hospital Care use','Mean readmission
rate','Time/years')

proc freq data=aaa.elective;
table acs admiage itu charlson los quintile sex living_alone hdvt hpe redo_prod other_vas rf uti bleed gi_comp
rti hypobp
ihd ht rf sepsis anemia dementia delirium mood c_arrest cabg_pci rrt wound_inf wound_dis graft_inf
graft_comp
prod_comp dm stroke hf pvd acute_pvd marfan para_lysis hac_total dd open charl ethnic inf wound prod
mood_dis
prod_only other_prod;
run;

data aaa.raaa;
set aaa.raaa;
if hpe=1 then pedvt=1;
else if hdvt=1 then pedvt=1;
else pedvt=0;
run;
data aaa.raaa;
```

```
set aaa.raaa;
gender=sum(sex,0);
run;

proc contents data=aaa.elective;
run;

proc traj data=aaa.elective out=OF outstat=crimstat outplot=crimplot ci95m;
ID extract_hesid;
var hyr01-hyr05;
INDEP yr1-yr5;
model ZIP;
NGROUPS 2;
order 3 3;
risk admiage itu charlson los quintile living_alone pedvt redo_prod other_vas rf uti bleed gi_comp rti hypobp
ihd ht anemia c_arrest wound_inf wound_dis graft_inf graft_comp
prod_comp dm stroke hf pvd acute_pvd hac_total dd open ethnic mood_dis other_prod gender;
run;

proc freq data=of;
table group*itu group*living_alone group*pedvt group*redo_prod group*other_vas group*rf group*uti
group*bleed group*gi_comp group*rti group*hypobp
group*ihd group*ht group*anemia group*c_arrest group*wound_inf group*wound_dis group*graft_inf
group*graft_comp
group*prod_comp group*dm group*stroke group*hf group*pvd group*acute_pvd group*dd
group*open group*ethnic group*mood_dis group*other_prod group*gender;
run;
proc means data=of;
var admiage charlson los quintile hac_total;
class group;
run;
data of;
set of;
keep extract_hesid group;
run;
proc sort data=of;
```

```
by extract_hesid;
run;
proc sort data=aaa.elective;
by extract_hesid;
run;
data elective;
merge aaa.elective(in=a) of(in=b);
by extract_hesid;
if a and b;
run;
data aaa.elective;
set elective;
run;
proc univariate data=aaa.elective;
var hyr01 hyr02 hyr03 hyr04 hyr05;
run;
/* the validation set consisted of readmissions =>2 becaues it is 75% percentile for hyr01-hyr05 for high-impact users
and also 90% of percentile for the whole population*/
data aaa.elective;
set aaa.elective;
if h6=> then h6_4=1;
else h6_4=0;
run;
proc freq data=aaa.elective;
table group*h6_2 group*h6_3 group*h6_4 group*h6_1;
run;

ods html image_dpi=300;
proc traj data=aaa.raaa out=OF outstat=crimstat outplot=crimplot ci95m;
ID extract_hesid;
var hyr01-hyr05;
INDEP yr1-yr5;
model ZIP;
NGROUPS 3;
order 3 3 2;
```

```
run;

%trajplotnew (crimplot,crimstat, 'Hospital care use vs. Time','Hospital Care use','Mean readmission
rate','Time/years')


proc freq data=aaa.raaa;

table acs admiage itu charlson los quintile sex living_alone hdvt hpe redo_prod other_vas rf uti bleed gi_comp
rti hypobp

ihd ht rf sepsis anemia dementia delirium mood c_arrest cabg_pci rrt wound_inf wound_dis graft_inf
graft_comp

prod_comp dm stroke hf pvd acute_pvd marfan para_lysis hac_total dd open charl ethnic inf wound prod
mood_dis

prod_only other_prod;

run;

data aaa.raaa;

set aaa.raaa;

if quintile=6 then quintile=0;

else quintile=quintile;

run;

proc freq data=aaa.raaa;

table quintile;

run;

ods html image_dpi=100;

proc traj data=aaa.raaa out=OF outstat=crimstat outplot=crimplot ci95m;

ID extract_hesid;

var hyr01-hyr05;

INDEP yr1-yr5;

model ZIP;

NGROUPS 3;

order 3 3 2;

refgroup 2;

risk admiage itu charlson los quintile other_vas rf uti gi_comp rti hypobp

ihd ht anemia wound graft dm stroke hf pvd_all hac_total open ethnic mood_dis other_prod gender;

run;

ods _all_ close;

ods html;

data aaa.check_r;

set aaa.check_r;
```

```
if pvd=1 then pvd_all=1;
else if acute_pvd=1 then pvd_all=1;
else pvd_all=0;
run;
proc freq data=of;
table group*itu group*other_vas group*rf group*uti
 group*gi_comp group*rti group*hypobp
group*ihd group*ht group*anemia group*wound group*graft group*dm group*stroke group*hf
group*pvd_all
group*open group*ethnic group*mood_dis group*other_prod group*gender;
run;
proc means data=of;
var admiage charlson los quintile hac_total;
class group;
run;
data of;
set of;
keep extract_hesid group;
run;
proc sort data=of;
by extract_hesid;
run;
proc sort data=aaa.raaa;
by extract_hesid;
run;
data raaa;
merge aaa.raaa(in=a) of(in=b);
by extract_hesid;
if a and b;
run;
data aaa.raaa;
set raaa;
run;
proc univariate data=aaa.raaa;
var hyr01 hyr02 hyr03 hyr04 hyr05;
class group;
```

```
run;
/* the validation set consisted of readmissions =>2 becaues it is 75% percentile for hyr01-hyr05 for high-impact users
and also 95% of percentile for the whole population*/
data aaa.raaa;
set aaa.raaa;
if h6=>4 then h6_4=1;
else h6_4=0;
run;
proc freq data=aaa.raaa;
table group*h6_2 group*h6_3;
run;
proc freq data=aaa.raaa;
table group;
run;
proc freq data=aaa.raaa;
table group*ons_deathall1826/chisq;
run;
```

7.3 Appendix 3. Examples of model selection based on chosen criteria.

Ischaemic stroke					
Number of groups	BIC	Trajectory shape	Av PP	Proportion of patients (%)	OCC
2	**-127547**	**3**	**0.96**	**82**	**5.2**
		3	**0.88**	**18**	**35.8**
3	-124903	3	0.92	74	4.0
		3	0.78	15	20.0
		3	0.85	11	45.8
4	-122429	3	0.84	17	25.6

		2	0.9	65	4.6
		3	0.72	15	14.5
		3	0.89	1.85	441.4
5	-121744	2	0.88	61.6	4.5
		2	0.78	18.9	15.1
		2	0.84	3.7	8.9
		2	0.74	15.6	16.1
		2	0.94	0.2	767.6
6		The program was unable to classify population into subgroups			

Example of selection of best model fit for patients with ischaemic stroke based on selection criteria (smallest BIC number that is least negative, Av PP [Average posterior probability] > 0.70, OCC > 5). The selected model is highlighted.

TIA					
Number of groups	BIC	Trajectory shapes	Av PP	Proportion of patients (%)	OCC
2	**-76497**	**3**	**0.96**	**80**	**6.0**
		3	**0.92**	**20**	**46.2**
3	-74891	3	0.9	75	3.0
		2	0.8	11	32.3
		2	0.9	12	66.0
4	-73475	3	0.84	17	25.6
		3	0.89	67	4.1

		3	0.78	13	23.7
		2	0.89	2	396.4
5	-73115	3	0.77	11	27.0
		3	0.89	66	4.0
		3	0.72	9	26.0
		3	0.76	11	25.6
		2	0.88	2	359.3
6	-72947	1	0.85	56	4.45
		1	0.69	15	12.6
		3	0.79	5	71.4
		3	0.75	21	11.2
		3	0.81	1.7	246.5
		2	0.93	0.4	318.8

Example of selection of best model fit for patients with TIA based on selection criteria (smallest BIC number that is least negative, Av PP [Average posterior probability] > 0.70, OCC > 5).

Non-traumatic intra-cranial haemorrhage					
Number of groups	BIC	Trajectory shape	Av PP	Proportion of patients (%)	OCC
2	The program was unable to classify population into subgroups				
3	-9344	1	0.9	59	6.2
		1	0.8	37	6.8
		1	0.9	4	216.0
4	The program was unable to classify population into subgroups				
5	**-9135**	**1**	**0.85**	**53**	**5.6**

		1	**0.75**	**28**	**7.7**
		2	**0.85**	**5**	**107.6**
		2	**0.72**	**12**	**18.8**
		2	**0.92**	**0.5**	**218.5**
6	The program was unable to classify population into subgroups				

Example of selection of best model fit for patients with non-traumatic intra-cranial haemorrhage based on selection criteria (smallest BIC number that is least negative, Av PP [Average posterior probability] > 0.70, OCC > 5).

Elective AAA repair					
Number of groups	BIC	Trajectory shape	Av PP	Proportion of patients (%)	OCC
2	**-58828**	**3**	**0.96**	**82**	**600.0**
		3	**0.87**	**18**	**51.4**
3	-60212	3	0.85	10	37.7
		3	0.94	78	261.1
		3	0.79	11	17.9
4	-59462	3	0.91	70	112.3
		3	0.81	16	22.4

		2	0.78	12	16.1
		2	0.88	1.5	61.1
5	-58997	3	0.78	11	16.1
		3	0.89	69	73.5
		3	0.73	10	10.0
		3	0.8	8.5	20.0
		3	0.87	1.5	51.4
6	The program was unable to classify population into subgroups				

Example of selection of best model fit for patients with non-traumatic intra-cranial haemorrhage based on selection criteria (smallest BIC number that is least negative, Av PP [Average posterior probability] > 0.70, OCC > 5).

Ruptured AAA repair					
Number of groups	BIC	Trajectory shape	Av PP	Proportion of patients (%)	OCC
3	-9936	3	0.83	10	28.71972
		3	0.97	82	1077.778
		2	0.76	7.4	13.19444

Details of the best fit model for the patients who had repair for ruptured AAA.

Heart failure patients - multi-trajectory model of readmission rates and out-of-hours GP visits							
Number of groups	BIC	Trajectory shape for readmission rates	Trajectory shape for out-of-hours GP visits	Av PP	Proportion of patients (%)	OCC (readmission rate)	OCC (out-of-hours GP visits)
5	-45296	2	1	0.76	13	21.1	75.2
		2	1	0.82	15	25.8	26.1
		2	1	0.92	66.5	5.7	15.3
		1	1	0.87	2.4	272.1	456.0
		2	2	0.86	3.3	180.0	132.2

Details of the best fit model for the patients who had repair for ruptured AAA.