Factors influencing the uptake of cardiac rehabilitation by cardiac patients with a comorbidity of stroke

A.S. Harrison a,⇑, N.J. Gaskins b, L.A. Connell b,c, P. Doherty a

a The University of York, United Kingdom
b Faculty of Health and Wellbeing, University of Central Lancashire, United Kingdom
c East Lancashire Hospitals NHS Trust, Burnley General Hospital, United Kingdom

1. Introduction

Cardiac rehabilitation (CR) is an integral part of the treatment offered to people diagnosed with coronary heart disease (CHD). It is a complex secondary prevention intervention that aims to reduce risk factors, promote a healthy lifestyle and improve quality of life [1]. Patients become eligible for assessment for CR following diagnosis of a cardiac event, such as myocardial infarction (MI) or heart failure, or after coronary revascularization. The effectiveness of CR was summarised in a recent Cochrane review of trials which reported a reduction in CV mortality and readmissions [2] and Cardiac Rehabilitation Outcome Study (CROS) which used robust registry based observational studies concluding on CR benefiting overall mortality [3].

However, although CR is a well-established intervention, only 50% of the eligible population take up the offer to attend [4]. Previous research has investigated predictors of attendance for similar interventions in different populations and specific treatment groups such as Percutaneous Coronary Intervention (PCI) in CR [5].

In a study looking at the whole CR population, analysis split by gender identified that age, ethnicity and social deprivation were all significantly associated with starting CR [6]. Older patients, being of South Asian or other ethnicity, single and residing in a higher deprived area were all associated with a reduced likelihood of attendance.

In an aging population with an increasing prevalence of comorbidities, it is important to explore the predictors for attending CR in populations with particular comorbidities. CHD is categorised as a cardiovascular disease, as are peripheral arterial disease and stroke [7]. Stroke has been reported as a comorbidity in some of those people eligible for CR [4] and shares similar aetiology and modifiable risk factors with CHD [9–10].

People post-stroke often suffer from poor cardiovascular health and may have physical, cognitive and psychosocial impairments [12,12]. There is emerging evidence that CR is both feasible and beneficial for people post-stroke [11,13–15] although it is potentially underused for this population [14]. It is therefore important to identify factors that influence attendance at CR in this population. In the UK, 5.3% of the attending CR population have a comorbidity of stroke [4].

The aim of this study was to identify and evaluate factors contributing to the likelihood of a cardiac patient with comorbid stroke attending CR in the UK.

2. Methods

This observational study utilised data collected for the National Audit of Cardiac Rehabilitation (NACR). Patient and service-level characteristics were included in the analysis to identify significant associations of patients with comorbid stroke attending CR. Hierar-
archical logistic regression models were built to assess the extent of the associations.

2.1. Data

The study's data is from a routinely collected audit of CR, the National Audit of Cardiac Rehabilitation (NACR). The NACR collects data from CR programmes across the UK and has a 74% coverage for electronic data entry [4]. The electronic data was acquired in a link-anonymised format from 229 programmes, which collected data on patient's demographics, risk factors and baseline measures prior to starting CR. The data collection of patient information is covered by 251 exemption that is reviewed annually by NHS Digital. The rationale for data collection is to improve the quality of CR service delivery for public benefit. Patients were included if they had an initiating cardiac event, such as myocardial infarction, between 1st January 2013 and 30th Jan 2019.

The primary variable of interest is whether the patient started Core CR (Phase 3); defined as the point where patients are assessed, goals agreed and patients begin their formal structured CR programme.

2.2. Statistical analysis

The analyses were conducted in IBM statistical package SPSS V.25. (SPSS, Chicago, Illinois, USA)

Correlation and group comparisons utilised t-tests and Pearson correlation respectively. Subject to having sufficient data to fulfil statistical distribution assessments (N > 30) all potential covariates were investigated in the analysis. Backwards stepwise logistic regression models were built to investigate whether, accounting for covariates, the patient-level and service factors were associated with the patient attending CR.

Relevant important covariates were included in the analysis, where they were evidenced in the literature or significant in preliminary analysis. Age (years), gender (male/female) and marital status (single/partnered) have been shown to influence the outcomes following a variety of different rehabilitation interventions, including CR. Marital status was documented as 'single' for patients who were single, widowed or separated, and 'partnered' for those married, partnered or in civil partnership. Length of hospital stay, source of referral and local index of multiple deprivation (IMD) were all included as previous studies showed an association with engagement and attending CR [5,6]. The IMD was split into quintiles, and compared the highest deprived areas to the 2nd, 3rd, 4th and 5th deprived quintiles accordingly. Service-level covariates including the multidisciplinary team and staff hours were analysed. A multidisciplinary team (MDT) was defined as having three or more different staff disciplines which aligns with the BACPR [11] core components of delivering CR. Staff hours along with relative size of programme were also input into the model as continuous variables.

Patient’s comorbidity status was included in the univariate analysis and in the regression analysis. Comorbidities were grouped into similar conditions as shown in Table 3 (detailed list provided in Appendix 1).

Statistical level for significance was p < 0.05 and actual significant values were expressed as reported up to 0.001. Due to the large number of univariate analyses performed, the p values in the univariate analysis were adjusted using Bonferroni correction which accounted for the sum of analyses 13, this changed the threshold to 0.004. Data model checking was performed to ensure that the models were a good fit through assumptions associated with the regressions.

3. Results

The total number of patients entered into the CR audit during the time period was 402,405, of which 23,297 (5.3%) had a comorbidity of stroke. Valid case selection for the regression resulted in 6,342 in the final regression model (Fig. 1).

Table 1 shows the descriptive of the population with comorbid stroke. This sub-population was divided into two groups: those who attended CR (44.46%) and those who did not (55.54%).

The average age was 72 years old, higher than in the wider CR population (67 years) and younger than the average age within the wider stroke population (77 years) [16]. Those who did not take up the offer of CR were on average 4 years older than those who did.

The gender split within the population was 67% male and 33% female, which is comparable with the wider CR population. However, this gender split is very different to the stroke population that had approximately 50/50 split across the time period. There were a greater number of females (60.7%) than males in the non-attender group in those with comorbid stroke. Similar to the full CR population, those in the stroke population of white ethnicity and having a partner dominated the total population (68.6%-84.5%). The non-attender group had a higher proportion of non-white and single (p =<0.001 and p=<0.001).

Deprivation, source of referral and any treatment during their admission influenced attendance at CR. High deprivation, referral from a hospital setting and lack of CVD treatment, e.g. PCI, CABG or other, were all negatively associated with attendance with a greater proportion in the non-attender group.

The programme specific data suggested that absence of an MDT, less staff hours per week and a greater number of total patients were associated with a reduction in uptake of CR. Attending a hospital where there was no MDT was linked with a 10% reduction in the number attending CR (p = <0.001).

Table 2 shows the comorbidity groups of those with comorbid stroke divided into attenders and non-attenders. The musculoskeletal, psychosocial problems and erectile dysfunction groups show a greater proportion of attenders, with the remaining groups showing reduced numbers.

![Flow diagram of the study population.](image-url)
The logistic regression model shown in Table 3 included 6,342 cases. The model identified 9 variables that were statistically significant associated with participation in CR. Patients’ age and ethnicity were negatively associated with participation with every year increase in age resulting in a 2.5% reduced likelihood of attendance. Those who were of non-white ethnicity had a 11.6% reduced likelihood (Age OR 0.975 p = <0.001 and Ethnicity OR 0.884 p = <0.001) of attendance.

If patients were partnered or had had a CHD treatment, there was a positive association with participation in CR. Having a partner increased likelihood of attendance by 19.4% (OR 1.194 p = 0.003) and having any treatment had an 87.7% to 356.9% increased likelihood (Other OR 1.877 P = <0.001 CABG OR 3.569 P = <0.001).

The level of deprivation was significantly associated with patients’ participation, with reduction in deprivation incrementally increasing the likelihood. Moving from the most deprived to the second had a 24.3% increased likelihood, whereas for the most to the least deprived had a 93% increased likelihood (2nd OR 1.243 p = 0.015 5th OR 1.930 p = <0.001).

### Table 1

| Did the Patient Start Rehab | Not Attending | Attending | Total |
|----------------------------|---------------|-----------|-------|
| Mean/SD Count Mean/SD Count Mean/SD Count | Mean/SD | Count | Mean/SD | Count | Mean/SD | Count | Mean Difference | P-value |
| Age Years | 74 (11.39) 12,938 | (11.39) 70 (10.55) 10,359 | (11.19) 72 (11.19) 23,297 | 3.867 <0.001 |
| Hospital Length of Stay days | 11 (19.94) 9862 | 12 (26.99) 8371 | 12 (23.44) 18,233 | 0.601 0.084 |
| Proportion of Stroke patients in Programme (%) | 7.10 (2.47) 12,938 | 6.86 (2.56) 10,359 | 6.99 (5.51) 23,297 | 0.245 <0.001 |
| Patients By Week | 17.71 (11.85) 12,938 | 16.59 (11.26) 10,359 | 17.21 (11.60) 23,297 | 1.119 <0.001 |
| Staff Hours Per Patient | 12.44 (20.01) 9895 | 16.09 (26.49) 7641 | 14.03 (23.13) 17,536 | 3.648 <0.001 |
| Gender | Male | 8198 53.00% 7280 47.00% 15,478 67.00% | 124.382 <0.001 |
| Ethnicity | White | 9497 54.10% 8047 45.90% 17,544 75.30% | 56.598 <0.001 |
| Marital Status | Single | 3097 59.40% 2120 40.60% 5217 31.40% | 119.295 <0.001 |
| Previous Cardiac Event | No | 5851 56.10% 4818 45.90% 10,669 45.80% | 3.838 0.05 |
| IMD quintiles | Lowest Quintile | 2370 65.40% 1254 34.60% 3624 19.00% | 172.181 <0.001 |
| Multidisciplinary Team (MDT) | No MDT | 2050 63.40% 1184 36.60% 3234 17.40% | 115.825 <0.001 |
| Referring Staff | Hospital Based | 9726 55.60% 7753 44.40% 17,479 88.20% | 16.818 <0.001 |
| Recode Treatment as None, PCI, CABG, other | None | 3444 72.20% 1329 27.80% 4773 20.49% | 893.941 0.001 |

### Table 2

Comorbidities - grouped.

| Did the Patient Start Rehab | No | Yes | Total |
|----------------------------|----|-----|-------|
| Count | % | Count | % | Count | % |
| Musculoskeletal Comorbidities | No | 10,126 58.4% | 7222 41.6% | 17,348 74.5% |
| Yes | 2812 47.3% | 3137 42.7% | 5949 25.5% |
| Ischemia Comorbidities | No | 9598 55.5% | 7682 44.5% | 17,280 74.2% |
| Yes | 3340 55.5% | 2677 44.5% | 6017 25.8% |
| Metabolic Comorbidities | No | 7027 56.1% | 5507 43.9% | 12,534 53.8% |
| Yes | 5911 54.9% | 4852 45.1% | 10,763 46.2% |
| Cancer | No | 11,762 55.7% | 9343 44.3% | 21,105 90.6% |
| Yes | 1176 53.6% | 1016 46.4% | 2192 9.4% |
| Hypertension | No | 5841 55.8% | 4934 44.2% | 10,775 45.0% |
| Yes | 7237 55.9% | 7475 44.1% | 14,712 55.0% |
| COPD + Asthma | No | 10,721 55.2% | 8709 44.8% | 19,430 83.4% |
| Yes | 2217 57.3% | 1650 42.7% | 3867 16.6% |
| Psychosocial Problems | No | 12,205 57.0% | 9193 43.0% | 21,398 90.6% |
| Yes | 733 38.6% | 1166 61.4% | 1899 8.2% |
| Erectile Dysfunction | No | 12,384 56.0% | 9734 44.0% | 22,118 94.9% |
| Yes | 554 47.0% | 625 53.0% | 1179 5.1% |
The comorbidity groups that were significant included musculoskeletal, ischaemic, cancer, COPD, social problems and erectile dysfunction.

The service-level factors, including proportion of stroke patients attending a programme, total number of patients at the site, MDT and total staff hours, were all statistically significant. The proportion of people with stroke and number of patients seen were negatively associated with 0.6% and 0.14% reduced likelihood respectively (p = <0.001). The MDT and total staff hours were positively associated with a 1.9% increased likelihood for every hour increase and 63.8% increase if a MDT was present (p =<0.001).

The model was a good fit with Hosmer Lemeshow p value = 0.865, the predictive power was 63.8%, the model assumptions were all met.

4. Discussion

This paper compared the sub-population of CR patients with comorbid stroke with the wider CR and stroke populations and identified and evaluated patient and service characteristics influencing likelihood of uptake of CR for these patients. This analysis included 23,297 patients with comorbid stroke, of which 6,342 cases were input into the regression model. The model identified that a mix of key patient and service-level factors were significantly associated with these patients attending CR.

The patient-level factors that were significant included age, ethnicity, marital status, treatment and local deprivation score. Presence of comorbidities such as musculoskeletal, cancer, psychosocial and erectile dysfunction in addition to stroke were associated with greater attendance, whereas having ischemic or COPD comorbidities were associated with reduced likelihood. CHD treatment, such as PCI or CABG, was linked with a 187.7–356.9% increased likelihood of attendance. Parallels exist with recent stroke research where those who had acute medical treatment (thrombolysis) received more intensive physiotherapy [17], although it is recognised that the provision of in-patient rehabilitation is different to the attendance at a CR programme. People from a less deprived area also had an increased likelihood.

This study’s results are similar to that of previous work in other CR populations, including PCI only patients, which suggested key patient predictors such as gender, age and ethnicity play an important role in patients taking part in CR [5,6]. Previous research looking at the whole CR population or percutaneous coronary intervention (PCI) especially highlighted similar patient-level predictors to attend CR, however, this is the first time that these were found when programme variables were included. The severity of stroke can also impact on rehabilitation as those with mild or moderate stroke may receive more intensive physiotherapy, and therefore rehabilitation, than those with severe stroke [17].

In terms of service-level factors it was anticipated that a CR programmes’ staffing would be associated with the attendance rate. This study showed that, when factoring in the relative size (number of patients within the programme), for every hour increase of staff time there was a linked 1.9% increased likelihood of attendance by the patients. In addition to this, a programme with an MDT was associated with 63.8% greater likelihood of attendance. The unique findings of this study indicate that programmes with a more comprehensive and well-resourced MDT are more likely to succeed in increasing the attendance of patients with a comorbidity of stroke. In contrast with patient-level factors such as age and ethnicity, staffing is a modifiable factor. Investment in staffing may be a means of improving the attendance rate for people with comorbid stroke. What is not known from this study is whether poorer performing programmes have difficulties with staff recruitment in comparison with those which are performing well. Based on service-level criteria higher quality CR programmes have a greater uptake by people with comorbid stroke [18]. If staff recruitment is challenging then other models of delivery and service reorganisation need to be explored. This would require future qualitative research around different settings and intervention timings and content.

Stroke and CHD are intrinsically linked in their aetiology and modifiable risk factors. Research has shown that stroke patients...
benefit from adapted CR so the unequal provision of this intervention for people with comorbid stroke is not justifiable. The knowledge of modifiable service-level factors provided by this study is invaluable for future research investigating service reorganisation for the benefit of a diverse population such as this.

4.1. Limitations

Although this study was conducted well and accounted for multiple analysis, there were two limitations that have impacted the study. The first of these are the level of missing data. Key variables such as area of residence and staffing profile including profession and level of expertise lead to a reduction in sample size when valid case analysis was used for the model. Even though the missing variables lead to a reduction in the sample, all cases were compared against the wider CR population and stroke population which allowed the authors to conclude that there was little chance of selection bias.

The second was the variable of comorbidity of stroke. This was a binary categorical variable which allowed the study to select the 5.3% of patients who had stroke in additional to their cardiovascular event. However, it would have been beneficial to also know the time since stroke and severity of the stroke amongst attenders and non-attenders. This information could be included in future research.

5. Conclusion

This study concluded that both patient- and service-level factors contributed to the likelihood of cardiac patients with comorbid stroke attending CR. The patient-level variables are consistent with wider CR literature on CR uptake, suggesting different models of delivery need to be explored to meet the diversity of the population. CR programmes with a more comprehensive and well-resourced MDT are more likely to succeed in increasing the attendance of patients with comorbidity of stroke. This highlights inequity of provision that is not justifiable. Strategies to overcome these modifiable factors should be explored.

6. Authorship statement

This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

Funding

This study and the NACR data is funded by the British Heart Foundation grant (040/PSS/17/18/NACR). This work was also supported by a grant from the Chartered Society of Physiotherapy Charitable Trust (Grant No. PRF/17/B01).

Declaration of Competing Interest

No conflicts of interest were present

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijcheartvasc.2020.100471.

References

[1] British Association for Cardiovascular Prevention and Rehabilitation, BACPR standards and core components for cardiovascular disease prevention and rehabilitation, 3rd ed., British Cardiovascular Society, London, 2017.
[2] L. Anderson, N. Oldridge, D.R. Thompson, et al., Exercise-Based Cardiac Rehabilitation for Coronary Heart Disease: Cochrane Systematic Review and Meta-Analysis, J. Am. Coll. Cardiol. 67 (2016) 1–12, https://doi.org/10.1016/j.jacc.2015.10.044.
[3] B. Rauch, C.H. Davos, P. Doherty, et al., The prognostic effect of cardiac rehabilitation in the era of acute revascularisation and statin therapy: A systematic review and meta-analysis of randomized and non-randomized studies - The Cardiac Rehabilitation Outcome Study (CROS), Eur. J. Prev. Cardiol. 23 (2016) 1914–1939, https://doi.org/10.1177/2047487316671181, 2016/10/25.
[4] British Heart Foundation, The National Audit of Cardiac Rehabilitation (NACR) Quality and Outcomes report UK. 2018, London, British Heart Foundation
[5] A. Al Quait, P. Doherty, N. Gutacker, et al., In the modern era of percutaneous coronary intervention: Is cardiac rehabilitation engagement purely a patient or a service level decision?, Eur J. Preventive Cardiol. 24 (2017) 1351–1357, https://doi.org/10.1177/2047487317717064.
[6] P.M. Galdas, A.S. Harrison, P. Doherty, Gender differences in the factors predicting initial engagement at cardiac rehabilitation, Open Heart 5 (2018) e000764, https://doi.org/10.1136/openhrt-2017-000764.
[7] National Health Service (NHS), Cardiovascular Disease. (2018) https://www.nhs.uk/conditions/cardiovascular-disease/ (accessed 17 June 2019).
[8] British Heart Foundation, British Heart Foundation UK Factsheet 2018 https://www.bhf.org.uk/what-we-do/our-research/heart-statistics (accessed 17 June 2019)
[9] O. Lennon, C. Blake, Cardiac rehabilitation adapted to transient ischaemic attack and stroke (CRAFTS): a randomised controlled trial, BMC Neurology 9 (2009) 9, https://doi.org/10.1186/1471-2377-9-9.
[10] P.L. Prior, V. Hachinski, K. Unsworth, et al., Comprehensive cardiac rehabilitation for secondary prevention after transient ischemic attack or mild stroke: I. feasibility and risk factors, Stroke 42 (2011) 3207–3213, https://doi.org/10.1161/STROKEAHA.111.620187.
[11] Stroke Association, State of the Nation Stroke Statistics. February 2018. https://www.stroke.org.uk/system/files/sotn_2018.pdf (Accessed 17 June 2019)
[12] I. Bært, D. Daly, E. Dejaeger, et al., Evolution of Cardiorespiratory Fitness After Stroke: A 1-Year Follow-Up Study. Influence of Prestroke Patients' Characteristics and Stroke-Related Factors, Arch. Phys. Med. Rehabil. 93 (2012) 669–676, https://doi.org/10.1016/j.apmr.2011.09.022.
[13] H. Kirk, P. Kersten, P. Crawford, et al., The cardiac model of rehabilitation for reducing cardiovascular risk factors post transient ischaemic attack and stroke: a randomized controlled trial, Clin. Rehabilitation 28 (n.d.) 339–349.
[14] A. Tang, S. Marzolini, P. Oh, et al., Feasibility and effects of adapted cardiac rehabilitation after stroke: a prospective trial, BMC Neurol. 10 (2010) 10–40, https://doi.org/10.1186/1471-2377-10-40.
[15] A. Tang, V. Closson, S. Marzolini, et al., Cardiac rehabilitation after stroke: a randomized controlled trial, Clin. Rehabilitation 28 (2014) 339–349.
[16] A. Salman, P. Doherty, To what extent is the variation in cardiac rehabilitation quality associated with patient characteristics?, BMC Health Serv. Res. 19 (2019) 3, https://doi.org/10.1186/s12913-018-3831-1.