RESEARCH PAPER

Stroke patients admitted within normal working hours are more likely to achieve process standards and to have better outcomes

Melanie Turner,[1] Mark Barber,[2] Hazel Dodds,[3] Martin Dennis,[4] Peter Langhorne,[5] Mary-Joan Macleod,[1] on behalf of the Scottish Stroke Care Audit

[1]Division of Applied Medicine, Department of Medicine and Therapeutics, University of Aberdeen, Aberdeen, UK
[2]Stroke Unit, Monklands General Hospital, Airdrie, UK
[3]Information Services Division, NHS National Services Scotland, Edinburgh, UK
[4]Division of Clinical Neurosciences, University of Edinburgh, Western General Hospital, Edinburgh, UK
[5]Academic Section of Geriatric Medicine, University of Glasgow, Royal Infirmary, Glasgow, UK

Correspondence to
Dr Mary-Joan Macleod, Division of Applied Medicine, Department of Medicine and Therapeutics, Polwarth Building, Foresterhill, University of Aberdeen, Aberdeen AB25 2ZD, UK;
m.j.macleod@abdn.ac.uk

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ABSTRACT

Background The presence of a 'weekend' effect has been shown across a range of medical conditions, but has not been consistently observed for patients with stroke.

Aims We investigated the impact of admission time on a range of process and outcome measures after stroke.

Methods Using routine data from National Scottish data sets (2005–2013), time of admission was categorised into weekday, weeknight and weekend/public holidays. The main process measures were swallow screen on day of admission (day 0), brain scan (day 0 or 1), aspirin (day 0 or 1), admission to stroke unit (day 0 or 1), and thrombolysis administration. After case-mix adjustment, multivariable logistic regression was used to estimate the OR for mortality and discharge to home/usual place of residence.

Results There were 52 276 index stroke events. Compared to weekday, the adjusted OR (95%CI) for early stroke unit admission was 0.81 (0.77 to 0.85) for weeknight admissions and 0.64 (0.61 to 0.67) for weekend/holiday admissions; early brain scan 1.30 (0.87 to 1.94) and 1.43 (0.95 to 2.18); same day swallow screen 0.86 (0.81 to 0.91) and 0.85 (0.81 to 0.90); thrombolysis 0.85 (0.75 to 0.97) and 0.85 (0.75 to 0.97), respectively. Seven-day mortality, 30-day mortality and 30-day discharge for weekend admission compared to weekday was 1.17 (1.05 to 1.30); 1.08 (1.00 to 1.17); and 0.90 (0.85 to 0.95), respectively.

Conclusions Patients with stroke admitted out of hours and at weekends or public holidays are less likely to be managed according to current guidelines. They experience poorer short-term outcomes than those admitted during normal working hours, after correcting for known independent predictors of outcome and early mortality.

INTRODUCTION

A higher rate of mortality following weekend admission to hospital, the 'weekend effect', has been shown in numerous studies across a range of medical conditions.[1–6] A number of international studies have investigated the effect specifically in stroke care.[7–10] These have suggested differences in access to stroke expertise and facilities and also worse outcomes across a range of indicators for patients with stroke admitted at weekends, including increased mortality and a reduction in patients returning to their usual place of residence. After adjustment for age, sex, stroke severity, hospital facilities or stroke specialist involvement, increased mortality has still remained significant.[8 9 11] However, this association has not been consistently observed.[3 7 12–14] Variations in results may be explained in part by methodological bias, how selection bias has been accounted for in analyses and definition of out-of-hours/weekend. In addition, the incidence of stroke has been shown to increase during weekends and other stressful calendar days, when hospitals face shortages of staff and specialised services during these times.[15 16] Few studies have investigated weeknight admission or longer-term outcomes of patients admitted to hospitals out-with weekday normal working hours.

The Scottish Stroke Care Audit (SSCA) collects information about stroke care in all hospitals managing acute stroke in Scotland. Data collection has covered all hospitals in Scotland since 2005 and includes case-mix adjustors. Cases are ascertained and data extracted from case notes locally in each hospital by trained audit staff, and entered in a web-based database held centrally by Information Services Division (ISD). The SSCA feeds back data on compliance with published standards to each hospital monthly, and publishes an annual report on stroke care in each acute hospital in Scotland.[17] The ISD of NHS Scotland also collects routine data on hospital admissions, diagnoses and mortality. These comprehensive data sets give the opportunity to link hospital admission with stroke to subsequent outcomes.

The aim of this study was to examine the impact of time of admission (weekday, weeknight and weekend/holidays) on processes of stroke care and the outcomes of mortality and discharged home to usual place of residence in a national cohort.

METHODS

This is a historical prospective cohort study. We obtained data from ISD of NHS National Services Scotland and the General Register Office (GRO) for Scotland.

The SSCA covers 36 acute hospitals across Scotland that admit patients with acute stroke. Information was obtained for all patients with stroke admitted between 1 January 2005 and 31 December 2013 at all of these acute hospitals. The GRO records information relating to all deaths, including cause of death, in Scotland. The use of a unique patient identifier, the Community Health Index number, allows all records from SSCA and

the GRO death registry to be linked. Linkage was carried out by ISD Scotland and then pseudoanonymised prior to release to our research group for data analysis.

Data variables

We included all index stroke events, defined as ischaemic stroke or primary intracerebral haemorrhage at final discharge diagnosis and occurring between 1 January 2005–31 December 2013 for all outcomes apart from 1 year mortality. For this outcome index stroke events between 1 January 2005 and 15 August 2013 were used due to availability of 1 year follow-up data at the time of data linkage.

From date and time of admission we were able to generate three categories for time of admission; weekday as admission Monday to Friday within the hours of 8:00 to 17:00, weeknight as admission out-with the hours of 8:00 to 17:00 Monday to Friday, and weekend as admission between midnight Friday to midnight Sunday. We classified holidays (25/26 December, 1/2 January, Easter Monday, May Day holiday) as weekend admission.

We classified patients as either survival/no survival by 7, 30 and 365 days after hospital admission or after stroke occurrence if already hospitalised. Length of stay was defined as the time from hospital admission or stroke occurrence if already hospitalised, until death or discharge from hospital. Discharge destination in the data set includes discharged home or to usual place of residence, to another acute hospital, care home, NHS continuing care, an over-riding diagnosis, death, rehabilitation and other. For the purpose of this study, discharge at 30 days was classified as discharge home or to the usual place of residence.

We investigated admission time and how it affects process measures, such as brain scan day of admission (day 0) or day following (day 1), swallow screen day 0 and aspirin day 0 or 1, stroke unit admission day 0 or day 1, and thrombolysis administration. We also looked at the impact of admission time on short-term and long-term survival of patients at 7, 30 and 365 days following admission. Data on thrombolysis were only available for admission dates between 2010 and 2013.

Controlling for bias

Patients who died on the day of and day after admission to hospital and those who were discharged on day of admission were removed from the data set prior to initial demographic analysis, as it is unlikely that the time of admission and type of care they received would impact on the measured outcomes. Previous work shows that this results in more conservative estimates of effect.[18]

Ethics approval

The study was approved by Scotland A Research Ethics Committee, Ref. No.=10/MRE00/76 and the Privacy Advisory Committee of the ISD, NHS Scotland, Ref 76/11.

Statistical methods

We performed data management and statistical analyses using SPSS V.20 and SAS V.9.2. Data are shown using standard descriptive statistics.

We used logistic regression to estimate the OR for the process and outcome measures. Multivariable logistic regression models were fitted to the data set to adjust for covariates including year of admission, hospital of admission and the validated six simple variable (SSV) model (age in years at time of admission, living alone, independent in activities of daily living, able to lift both arms at first assessment, able to talk, able to walk).[19] Age was a continuous variable, while the others were categorical. Hospital random effects were calculated using random intercepts with two levels using PROC GLIMMIX.

Complete data were available for all outcome measures. Thirteen per cent had ≥1 of the case-mix adjustment variables missing, and exploratory analysis was performed to assess missing data patterns.

To assess whether missing case-mix variables would affect the results, we performed missing data imputation using the Markov chain Monte Carlo method with five iterations. The adjusted ORs with 95% CI for outcomes restricted to the cases with complete case-mix information were more conservative than the results for all cases with imputation of missing data. All estimates were therefore focused on analyses of complete cases.

RESULTS

There were 52 276 index stroke events recorded in Scotland between 1 January 2005 and 31 December 2013, after excluding those who died day 0 or 1 (n=1134), were discharged on day 0 (n=1404) or had no recorded admission time (n=5612).

A total of 21 285 (40.7%) were admitted on a weekday, 15 705 (30.1%) on a weeknight, and 15 286 (29.2%) at the weekend or on a holiday. Baseline characteristics for all patients and for each category of admission time are shown in table 1. There were no differences in the mean and median age at admission across the three categories.

Process and outcome measures in relation to admission time category are shown in table 2. A lower percentage of patients admitted on weekends (77.4%) had a brain scan on day 0 or 1 of admission in comparison to those admitted on a weekday (86.5%) or weeknight (82.2%). They were also less likely to have a same day swallow screen. Table 3 shows that aspirin was given on day 0 or 1 for a similar proportion of each admission group.

Admission to stroke unit on day 0 or 1 of admission was lower for patients admitted on a weeknight or a weekend compared to weekday and mortality was higher for patients admitted on a weekend. 30-day discharge home or to usual place of residence was lower for those admitted on a weekend.

Thrombolysis rates were similar at weekends compared to weekday and weeknight (table 4).

Adjusted ORs for the process and outcome measures are shown in table 5. Although the proportion of patients having a brain scan were lower out of hours, after adjustment for the SSV, year of admission and hospital random effects, the adjusted OR for brain scan is similar for weekend/holiday and weeknight admissions. However, the OR for admission to a stroke unit and swallow screen are lower for both weekend/holiday and weeknight admissions compared to weekday admissions. Adjusting for stroke unit admission day 0 or day 1 removed any difference in swallow screen at weekend/holidays, but a difference within or outwith normal weekday working hours persisted.

For 7-day mortality, the ORs for weekend/holiday and weeknight admissions are higher and for 30-day discharge home/usual place of residence are lower compared to weekday admissions. Adjusting for stroke unit admission day 0 or day 1 removed any difference in 7-day stroke mortality between weekday and weekend/holiday periods.

Although thrombolysis rates were similar in and out of hours, after adjustment for stroke severity, hospital level effects and year of admission, thrombolysis was marginally less likely to be administered out of hours or at weekends/holidays. Adjusting

Table 1 Baseline patient characteristics

Characteristic	All eligible patients (n=52 276)	Weekday (n=21 285)	Weeknight (n=15 705)	Weekend/holiday (n=15 286)
Age at admission (mean/median)	73.4/75.6	73.5/75.7	72.8/74.9	73.6/75.9
Male gender	25 561 (48.9)	10 344 (48.6)	7832 (49.9)	7385 (48.3)
Admitted from home	47 407 (90.7)	19 489 (91.6)	14 257 (90.8)	13 661 (89.4)
Living alone	18 777 (35.9)	7837 (36.8)	5477 (34.9)	5463 (35.7)
Current AF	11 448 (21.9)	4558 (21.4)	3414 (21.7)	3476 (22.7)
Independent preadmission	40 488 (77.5)	16 421 (77.1)	12 224 (77.8)	11 843 (77.5)
Lift both arms	31 388 (60.0)	13 126 (61.7)	9364 (59.6)	8898 (58.2)
Can walk	20 698 (39.6)	8795 (41.3)	6065 (38.6)	5838 (38.2)
Orientated	31 315 (59.9)	13 180 (61.9)	9247 (58.9)	8888 (58.1)
Can talk	37 408 (71.6)	15 463 (72.6)	11 263 (71.7)	10 682 (69.9)
Length of stay (mean/median)	27.7/11	26.2/11	27.6/12	28.6/12
Ischaemic stroke	44 954 (86.0)	18 601 (87.4)	13 251 (84.4)	13 102 (85.7)

Values are numbers (percentages) of column totals of patients unless stated otherwise.

for early stroke unit admission removed the difference between weekdays and weekends/holidays.

DISCUSSION

This observational study of a national cohort confirms that patients with stroke admitted out with normal working hours, whether during the week or at weekends, are less likely to have a swallow screen or be admitted to a stroke unit on day 0 or 1 after admission. Uncorrected data suggest that CT scan day 0 or 1 was less likely to occur out of hours than in hours, but after correction for year of admission, hospital of admission and the SSV there was no effect seen. Most patients had a CT scan early, so once hospital random effects are included the CIs are wide. The improved availability of thrombolysis services, and recognition of the cost-effectiveness of early scanning may be influencing CT provision.

Early swallow screen assessment is essential to reduce the risk of pneumonia and has been shown to improve survival in some studies.[20 21] We have previously shown that this standard was the one least likely to be achieved and that this is associated with increased mortality.[18] Fewer patients having an early swallow screen out of hours suggests the need for review of current practices to help facilitate this. This may be also linked to early stroke unit admission, also known to reduce mortality,[18] which was also less likely out of hours, particularly at weekends.

Patients admitted out of hours also experience poorer short-term outcomes than those admitted during weekday hours, after correction for the well-validated SSV, which includes an estimate of initial stroke severity. This suggests there may be a less structured pathway for out of hours admissions even during the week, which impacts on their ongoing care.

Although most previous studies do not include deaths post-discharge, two studies have reported a significant increase in the risk of death at 7 days[11] and 30 days.[22] Previous studies have attributed higher mortality risk with out of hours admission in part to the expectation of more severe patients presenting at these times.[23] This might fit with the slightly higher proportion of patients with a diagnosis of haemorrhage presenting out of hours, and the poorer prognosis suggested by the individual SSV variables. By adjusting with the SSV model,[19] some of the severity of stroke presentation will have been accounted for, but there was still an increase in the case-fatality at 7 days for both weekend and weekday out of hours admissions. In our population, corrected OR for mortality at 30 days was not increased when hospital and year of admission were also taken into account.

While an effect is seen at earlier time points, there were no differences in mortality odds for 365 days across the three admission time categories observed. A recent study has investigated whether distinct patterns exist for patients depending on the relative contribution of poorer quality of care or case selection bias for patients presenting on weekends. Looking at 7 days postadmission time patterns of excess mortality following weekend admission for stroke and other cerebrovascular disorders, a spike in mortality was associated with weekend admission, which reduced on exposure to weekday care, but remained

Table 2 Process and outcome measures in relation to admission time category

Measure	All eligible patients (n=52 276)	Weekday (n=21 285)	Weeknight (n=15 705)	Weekend/holiday (n=15 286)
Brain scan on day 0 or 1	43 141 (82.5)	18 403 (86.5)	12 914 (82.2)	11 824 (77.4)
Stroke unit admission on day 0 or 1	32 559 (62.3)	14 329 (67.3)	9573 (61.0)	8657 (56.6)
Swallow screen on day 0	38 513 (73.7)	16 191 (76.1)	11 264 (71.7)	11 058 (72.3)
7-day all-cause mortality	2674 (5.1)	970 (4.6)	822 (5.2)	882 (5.8)
7-day stroke mortality	1850 (3.5)	677 (3.2)	575 (3.7)	598 (3.9)
30-day all-cause mortality	6494 (12.4)	2493 (11.7)	1948 (12.4)	2053 (13.4)
30-day stroke mortality	4164 (8.0)	1604 (7.5)	1261 (8.0)	1299 (8.5)
365-day all-cause mortality	14 017 (28.0)	5542 (27.4)	4252 (28.2)	4223 (28.8)
365-day stroke mortality	6756 (13.5)	2639 (13.0)	2056 (13.6)	2061 (14.0)
30-day discharge home/usual place of residence	28 387 (54.3)	12 032 (57.0)	8438 (53.7)	7917 (51.8)

Values are numbers (percentages) of column totals of patients.

Table 3 Aspirin started day 0 or day 1 for patients with ischaemic stroke

Measure	All patients with ischaemic stroke (n=44 954)	Weekday (n=18 601)	Weeknight (n=13 251)	Weekend/ holiday (n=13 102)
Aspirin started day 0 or 1	38 014 (84.6)	15 794 (84.9)	11 119 (83.9)	11 101 (84.7)

Values are numbers (percentages) of column totals of patients.

elevated.[24] It was suggested that both quality of care and patient effects contributed to this excess mortality. It is conceivable that beyond 30 days post admission these effects have diminished.

Early access to brain imaging is essential to the delivery of appropriate stroke care. An association between evening and weekend admission and a delay in CT scanning has previously been shown.[25] Our data suggest that CT scan day 0 or 1 was as likely to occur out of hours as in hours once stroke severity, year of admission and hospital effect were included. This suggests that hospital systems may be changing to facilitate scanning for all patients and not just those eligible for thrombolysis.

Tissue plasminogen activator must be administered to patients with acute ischaemic stroke within 4.5 h of symptom onset. Similar to other studies,[7 12 13 22] higher rates of thrombolysis treatment for patients admitted at weekends were observed compared to weekdays, although this is not significant. In fact the likelihood of thrombolysis is marginally lower when SSV, hospital and year of admission are taken into consideration, although this is ameliorated by early stroke unit admission. This study was only able to investigate thrombolysis treatment for 2010–2013, with a total number of 2248 patients being thrombolysed, thus low numbers might account for these findings. In other studies where there are similar findings several explanations have been offered: these include more severe strokes on weekends, reduced traffic and work obligations and more rapid access to imaging and stroke evaluation outside of normal work schedules.[7 12 22] A reduction in primary care provision at weekends might result in more patients presenting directly to emergency departments in a timely fashion. These positive drivers may offset the reduction in hospital staffing levels associated with weekends.

Variations in study design may account for differences from previous studies which found no weekend effect. Some studies include all ischaemic stroke diagnoses at admission, while in this study it was limited to the index stroke event and included both ischaemic and haemorrhagic strokes. Holiday admissions were included in the weekend category, which few studies have previously done.[22] Differences between definitions of out-of-hours/weekend and the inability to differentiate times of admissions may also contribute to previous studies not observing a weekend effect. Our results suggest that analysing combined data from within and out-with normal working hours during weekdays may be masking some actual variation in care. A previous study comparing day and night shifts found that 7-day mortality rates were higher during Sunday and Monday evening shifts and all night shifts compared to a Monday day shift.[10] We also took hospital effect into consideration. This had relatively little impact on the OR obtained for mortality (data not shown), suggesting variation in hospital services does not explain the effect.

Table 4 Thrombolysis in relation to admission time categories

Measure	All patients with ischaemic stroke (n=24 228)	Weekday (n=10 822)	Weeknight (n=6961)	Weekend/ holiday (n=6445)
Thrombolysis	2248 (9.3)	998 (9.2)	639 (9.2)	611 (9.5)

Values are numbers (percentages) of column totals of patients. These data were only available for admission dates between 2010 and 2013.

A reduction in the quality of care out-with normal hours has previously been suggested. Although we have demonstrated that patients are less likely to have an early swallow screen completed and less likely to be admitted to a stroke unit, scanning, and aspirin administration are not affected, and thrombolysis provision only marginally impacted. Previous studies have shown there are less experienced and fewer staff available, a reduction in guideline adherence, poorer access to investigations, procedures and fast-track discharge pathways.[1 3 26 27] In addition, facilities such as nutritional services, physical, occupational, and speech/swallow therapy, may be short staffed on weekends. Previous studies investigated the potential role of comprehensive stroke centres with 24/7 availability, advanced brain imaging, and ongoing training and surveillance of specialised nursing care and suggested they may ameliorate the 'weekend effect' in patients with stroke.[13 22] A recent English study investigated mortality risk in relation to staffing levels for patients with stroke admitted to a stroke unit. They found no significant difference in mortality risk between patients admitted to a unit with physician rounds 7 days a week and patients admitted to a unit with rounds fewer than 7 days per week. They did, however, show that patients admitted on a weekend to a stroke unit with 1.5 nurses per 10 beds had a 30-day mortality risk of 15.2%, whereas patients admitted to a unit with 3.0 nurses per 10 beds had a mortality risk of 11.2%.[28] Although the findings in the current study may be explained by variations in the processes of care and access to stroke unit, no information on staffing levels, expertise or availability was available.

This study moves beyond the traditional weekday/weekend classification, by the inclusion of investigating weeknight. It also looks at longer term outcomes, 1 year mortality and a combination of process and outcome measures. The large sample size, use of a whole country database, being able to include out-of-hospital deaths, longer mortality outcome measures and discharge to home/or usual place of residence are significant strengths. We have previously shown that achieving standards has improved over the years of the audit, and this is associated with better outcomes.[18] For this reason we corrected for year of admission in analysis.

There are, however, several limitations. Although the database is relatively robust, potential confounding variables that may account for some of the observations presented in this study have not been collected. Case-mix adjustment has been carried out, but there will still be some residual confounding, which could lead to either an overestimation or underestimation of risk particularly around 7-day mortality. There were fewer patients admitted at the weekend and predicted prognostic indicators such as being able to lift arms or walk were worse than within the normal working hours' group. In particular, this study did not collect information on comorbidities, which may have potentially identified other explainable reasons for mortality rates. It is possible that some of these unmeasured confounders could explain or mask some of the observations. Some hospitals may be more selective for stroke unit admissions than

Table 5 Adjusted ORs for the process and outcome measures according to admission time category

Measure	Weeknight vs weekday Adjusted OR (95% CI)*	Weeknight vs weekday Adjusted OR (95% CI)†	Weekend/Holiday vs weekday Adjusted OR (95% CI)*	Weekend/holiday vs weekday Adjusted OR (95% CI)†
Brain scan on day 0 or 1	1.30 (0.87 to 1.94)	1.02 (0.86 to 1.20)	1.43 (0.95 to 2.18)	0.97 (0.83 to 1.14)
Stroke unit admission on day 0 or 1	**0.81 (0.77 to 0.85)**		**0.64 (0.61 to 0.67)**	
Swallow screen on day 0	**0.86 (0.81 to 0.91)**	**0.92 (0.87 to 0.98)**	**0.85 (0.81 to 0.90)**	1.01 (0.96 to 1.08)
Aspirin started day 0 or 1	0.96 (0.89 to 1.02)	0.97 (0.91 to 1.04)	1.01 (0.94 to 1.08)	1.05 (0.98 to 1.13)
Thrombolysis	**0.85 (0.75 to 0.97)**	**0.87 (0.76 to 0.99)**	**0.85 (0.75 to 0.97)**	0.89 (0.78 to 1.02)
7-day all-cause mortality	**1.15 (1.03 to 1.29)**	**1.13 (1.02 to 1.27)**	**1.17 (1.05 to 1.30)**	**1.13 (1.01 to 1.26)**
7-day stroke mortality	**1.15 (1.01 to 1.31)**	1.13 (0.99 to 1.29)	**1.17 (1.03 to 1.33)**	1.14 (0.99 to 1.29)
30-day all-cause mortality	1.06 (0.98 to 1.14)	1.05 (0.97 to 1.13)	1.08 (1.00 to 1.17)	1.05 (0.97 to 1.13)
30-day stroke mortality	1.08 (0.99 to 1.19)	1.08 (0.98 to 1.18)	1.08 (0.98 to 1.18)	1.06 (0.97 to 1.16)
365-day all-cause mortality	1.05 (0.98 to 1.11)	1.03 (0.97 to 1.10)	0.98 (0.93 to 1.05)	0.95 (0.90 to 1.01)
365-day stroke mortality	1.07 (0.99 to 1.15)	1.06 (0.98 to 1.14)	1.03 (0.96 to 1.12)	1.02 (0.94 to 1.10)
30-day discharge home/usual place of residence	**0.93 (0.88 to 0.99)**	**0.94 (0.89 to 0.99)**	**0.90 (0.85 to 0.95)**	**0.93 (0.88 to 0.98)**

*Adjusted for SSV, hospital level effects and year of admission.
†Adjusted for SSV, hospital level effects, year of admission, and stroke unit admission.
SSV, six simple variables.

others, taking into account additional comorbidities at admission, but we have tried to address this by taking admitting hospital into account in analysis. Admission to a stroke unit is also dependent on the availability of a bed at the time of a patient's arrival. This could introduce further bias on outcomes as suggested by the effect of stroke unit admission on likelihood of early swallow screen and thrombolysis at weekends.

Despite the limitations, this work provides further evidence that the time a patient has their stroke and presents to hospital may influence their outcome. Further exploration of the causative factors for this finding with appropriate service redesign to minimise the impact may help to improve outcomes for a significant proportion of patients who have had a stroke.

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Collaborators On behalf of the Scottish Stroke Care Audit.

Contributors All authors designed the study. MT performed data analysis, MT and M-JM wrote initial draft and all authors commented on the manuscript.

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Data sharing statement SSCA data has been linked to other data sets within NHS Information Services Division. The linked anonymised data set is currently held within the Grampian Safehaven, and data is available to investigators who wish to apply to use it, via the SSCA website.

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