

Did the Acute Frailty Network improve outcomes for older people living with frailty? A staggered difference-in-difference panel event study^{*†}

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Abstract

Objectives To evaluate whether the Acute Frailty Network (AFN) was more effective than usual practice in supporting older people living with frailty to return home from hospital sooner and healthier.

Design Staggered difference-in-difference panel event study allowing for differential effects across intervention cohorts.

Setting All English National Health Service (NHS) acute hospital sites.

Participants All 1,410,427 NHS patients aged 75+ with high frailty risk who had an emergency hospital admission to acute, general or geriatric medicine departments between 1 January 2012 to 31 March 2019.

Intervention Membership of the AFN, a Quality Improvement Collaborative designed to support acute hospitals in England deliver evidence-based care for older people with frailty. 66 hospital sites joined the AFN in six sequential cohorts, the first starting in January 2015, the sixth in May 2018. Usual care was delivered in the remaining 248 control sites.

Main outcome measures Length of hospital stay, in-hospital mortality, institutionalisation, hospital readmission.

Results No significant effects of AFN membership were found for any of the four outcomes nor were there significant effects for any individual cohort.

Conclusions To realise its aims, the AFN might need to develop better resourced intervention and implementation strategies.

Summary bullet points

What is already known on this topic

- Comprehensive Geriatric Assessment (CGA) saves lives and reduces institutionalisation for older people admitted to acute hospitals but is inconsistently and inadequately offered.
- There have been few large-scale efforts to optimise the delivery of CGA in acute hospitals using Quality Improvement Collaboratives (QICs).
- Quasi-experimental evaluative designs of QICs are common but subject to methodological flaws in establishing baselines, identifying controls, and defining objective outcome measures.

What this study adds

- This study assesses the effectiveness of the Acute Frailty Network (AFN), by comparing outcomes for patients cared for in AFN sites with patients cared for in sites that were not part of the AFN.
- Membership of the AFN and adoption of the best practice principles was not found to have a significant effect on length of stay; in-hospital mortality; institutionalisation; or hospital readmission.

How this study might affect research, practice or policy

- The AFN has attempted to improve processes across the NHS in order to improve outcomes; the result of this study suggest a review of structures (eg staffing, age-attuned environments) and of implementation might be worthy of future enquiry.
- Future research should evaluate the fidelity of CGA interventions and focus on optimal implementation strategies.

1 Introduction

The global increase in the ageing population is a testament to advances in public health [1; 2]. However, longstanding efforts to compress morbidity have not yet been shown to be successful [3; 4]. As a consequence, many older people develop increasing degrees of frailty in the final decade of their lives [5; 6]. Solutions to minimise crises in older people living with frailty, and the often-associated hospital admission, remain elusive [7; 8]. Consequently, many older people living with frailty are admitted to hospitals across the world with crises such as falls, fractures, or delirium [9; 10; 11]. Patient experience [12; 13] and outcomes following crisis admission to hospital are poor [10; 13], with data from many countries showing high rates of in-patient harm, readmission (often relating to inadequate assessment and care during the index admission [14; 15; 16; 17]) and institutionalisation [18; 19; 20].

Holistic care, namely Comprehensive Geriatric Assessment (CGA), is one of the few evidence-based approaches shown to attenuate some of these poor outcomes and improve patient experience [21; 22]. CGA is most commonly defined as a multidimensional, multidisciplinary process which identifies each patient's medical, social and functional needs, and involves development of an integrated/coordinated care plan to meet those needs [23]. Typically, CGA involves a team undertaking a multidimensional assessment which should address: diagnoses, as there will usually be multiple interacting comorbidities with associated polypharmacy; physical function and activities of daily living; psychological function, especially confusion and mood; environment in which the individual functions; and social support networks, either present or required to maintain on-going function.

Systematic reviews have consistently shown that CGA delivered to older people in acute care reduces admission to long term care and saves lives [21; 24; 25; 26]. Yet despite being supported by international expert reports [27; 28; 29; 30; 31], CGA is not routinely available for older people admitted to hospital in many countries [32]. In England there have been considerable efforts to support and promote CGA in the acute care context using a combination of policy levers [33; 34; 35] and, in 2015, by establishing the Acute Frailty Network (AFN). To our knowledge, the AFN is the largest international quality improvement collaborative (QIC) focused upon acute care for older people. The AFN has done some work in Australia, Holland, Canada and Ireland but these countries are at a much earlier stage in their journey compared with the United Kingdom. The AFN meets the five essential features of a QIC model [36] as it: (1) focuses on an area with large variation between current and best practice; (2) includes experts providing best practice and improvement ideas; (3) involves multidisciplinary teams of health professionals from different places working together; (4) uses an agreed improvement model with targets, measurement, and learning-by-doing; and (5) promotes collaborative activities and knowledge exchange among members.

The AFN focused upon identifying and responding to frailty in the first 72 hours of an acute hospital attendance by using the ten best practice principles of CGA (see Table 1), with an emphasis on early discharge [37]. The intention was that membership of the AFN and adoption of the best

practice principles would: reduce length of stay (LoS) in hospital; reduce in-hospital mortality; help people return to their own homes rather than a care home or hospice; and reduce the risk of hospital readmission. The objective of this paper was to determine the causal effects of AFN membership on these four outcomes. To this end we analysed patient-level administrative data and adopted a quasi-experimental event study design, comparing outcomes for patients cared for in AFN sites with patients cared for in sites that were not part of the AFN or before sites became members.

2 Methods

2.1 Context

Similar to many other countries, the UK is slowly learning how to adapt its healthcare systems to the needs of a growing and increasingly frail older population [3]. In the acute care context, a number of policy initiatives have called for a greater focus on the delivery of evidence-based care for older people with urgent care needs, notably CGA [27; 28; 29; 31; 35]. Despite these policy initiatives, the delivery of CGA for older people in acute care remains highly variable and sub-optimal [38], and service and patient outcomes remain persistently poor [10; 12; 13; 18; 39]. In response, the AFN was initiated to apply quality improvement at scale to improve outcomes for older people with acute care needs. Described in detail elsewhere [37] the AFN intervention had two overarching aims (i) to deliver CGA for older people with acute care needs and (ii) to support sites with improvement and implementation methods.

The AFN best practice principles outline the key elements (as judged by expert consensus and informed by the evidence base) necessary to embed frailty attuned pathways in the acute setting. These include defining the population (frailty identification), configuring teams to deliver CGA as soon as possible upon the patient's arrival, minimising unwarranted clinical variation and ensuring a person-centred approach. The AFN principles reflect both the delivery of evidence-based care (frailty identification, CGA, and person-centred care) and implementation strategies (quality improvement, stakeholder engagement, leadership).

The AFN used a specific quality improvement approach, primarily the Model for Improvement [40], focusing on Plan-Do-Study-Act cycles to create change. Four national events were held annually, attended by all participating hospital teams, as well as a set of masterclasses and webinars to support teams and enable sharing of experience. Each hospital team had an allocated 'coach' and access to measurement expertise to help plan, deliver and measure change locally, as well as support from national clinical experts to guide the redesign of services. The AFN gained increasing prominence over time, becoming well known across the NHS. The factors that precipitated a site joining were multifactorial, including perceived benefit, local pride and ownership of services, and the ability to persuade the site leaders to pay the membership fee (£20,000 per annum).

Regarding the selected outcomes, the link between CGA and reduction in mortality and in institutionalisation is drawn from the systematic reviews underpinning the AFN's approach [41; 21]. The links to LoS and to readmission is more related to the policy context of minimising unnecessary time

spent in hospital for older people in order to prevent iatrogenic harms such as deconditioning. The hope of the AFN was that by delivering CGA to older people as early as possible in their acute care episode, these joint outcomes might be achieved.

2.2 Study design

Hospital sites joined the AFN in six sequential cohorts, the first starting in January 2015, the sixth in May 2018 (Table 2). Two other cohorts joined later, after the period covered by our data, so were not included in the analysis. We accounted for this differential phasing of entry into the AFN by employing a staggered difference-in-difference (DiD) panel event study approach. Traditional DiD estimates the effects of an intervention by comparing an exposed (treated) group to unexposed (untreated) group. The staggered DiD design generalizes this traditional approach to multiple exposed groups that differ according to the timing of their exposure to the event [42], marked here by when sites became members of the AFN collaborative. In our application we also adopted a recent methodological innovation by Callaway and Sant’Anna that recognises that effects may have varied across cohorts, according to when sites became members [43]. Full technical details are provided in the Appendix but summarised here.

All patients seen at sites after they joined the AFN were exposed to the intervention and, therefore, are considered cases. Control patients were defined as patients from sites that never became AFN members (termed “never-treated” sites) and patients cared for in sites before they became AFN members (termed “not-yet-treated” sites). The analytical objective was to calculate the "average treatment effect on the treated" (ATT) of the intervention by comparing outcomes for cases and controls.

The standard event study methodology assumes that the impact of the intervention is common across all cohorts. But this assumption may not hold, particularly for interventions that evolve over time. This might be the case for the AFN membership model, for two reasons. First, there may have been selection effects, such as organisational characteristics influencing when sites decided to join the network. For instance, those that joined early might have had pre-existing features that were more closely aligned with those of the AFN and may have been more enthusiastic about the network’s aims than those that joined later. Second, there may have been evolutionary effects, such as changes over time in the way that the AFN operated and worked with its members. In recognition of these possibilities we apply the Callaway and Sant’Anna estimator which relaxes the assumption of common cohort effects [43]. This means that the ATT estimate of the intervention is calculated both for the AFN overall and for each cohort. The estimates are reported as average marginal effects (AMEs). For LoS, the AMEs can be interpreted as the difference in the number of days in hospital due to being treated in an AFN rather than non-AFN site. For the other three outcomes, the AMEs indicate the difference in the probability of dying, being institutionalised or being readmitted for those treated in AFN sites compared to those in control sites.

In our main analysis, we made the following decisions. First, we applied the same pre-intervention period of 36 months to all AFN cohorts. Second, we applied the same post-intervention period of 11 months to all cohorts. This ensured that the post-intervention period was the same across cohorts, the last month of available data being eleven months from enrolment for those sites in cohort six. Third, patients

in the control group were drawn from both "never-treated" sites that never joined the AFN and from "not-yet-treated" sites that subsequently enrolled.

2.3 Robustness checks

We conducted three types of robustness check to assess the sensitivity of our results to our analytical choices. The first concerned the length of intervention period, set for all cohorts as 11 months in the main analysis. Instead, we allowed the intervention period to vary by cohort, thereby analysing (i) long term effects, by running analyses to the last month for which data were available (March 2019), and (ii) effects after 12 months, though data for cohort six were censored at 11 months.

Our second robustness check restricted controls to "never-treated" patients, those cared for in hospital sites that never joined the ANF. In this robustness check, patients in the "not-yet-treated" sites were dropped from the analysis.

Our third robustness check applied a tighter definition of the AFN intervention, focusing on the most engaged sites, defined as those with above average adoption and implementation of the AFN best practice principles listed in Table 1. On average, joining the AFN was associated with the adoption of an additional four of the principles. Using this information we ran two checks. We first restricted the intervention group to those AFN sites that adopted four or more of the principles after joining the collaborative network. Second, we ran a set of ten analyses that considered adoption of each best practice principle in turn, with only those sites that adopted the specific principle being defined as intervention sites. This meant dropping from these analyses those AFN sites that had already adopted the principle prior to joining the AFN and those sites that did not adopt the principle upon joining.

2.4 Data

We analysed anonymised patient-level data from the Hospital Episode Statistics (HES) which contains details of all admissions to NHS hospitals [44]. The AFN focused on the acute care needs of older people living with frailty so we identified all patients in HES aged 75+ with a high Hospital Frailty Risk Score (HFRS), this being the age group for which the HFRS was originally developed [45; 46], who had an emergency hospital admission to acute, general or geriatric medicine departments between 1 January 2012 to 31 March 2019. We constructed four outcome variables for each patient, namely: their length of stay; whether or not they died in hospital; whether or not they were admitted from their own home but discharged to a care home or a hospice; and whether or not they were readmitted as an emergency to hospital within 30 days of being discharged.

The analyses controlled for patient age, gender and, in preliminary analyses, the relative socio-economic conditions of the neighbourhood in which they lived [47]. While all patients were categorised as having high frailty risk, we accounted for their actual HFRS score [45; 46]. Clinical complexity was captured using the Charlson comorbidity index [48; 49; 50], and counts of the number of diagnosis codes and of the number of emergency admissions in the previous year. Details

about the construction of the outcome and control variables are provided in the Appendix.

3 Results

3.1 Descriptive statistics

As Table 2 and Appendix Figure A1 show, the total dataset consisted of 1,410,427 patient observations, though there were some missing values, particularly for 30-day readmission because data were censored at 31 March 2019. 968,900 (68.7%) patients were cared for at hospital sites that never became AFN members, hence being "never-treated" controls. 336,236 (23.8%) patients were treated at sites before they became AFN members, so were considered "not-yet-treated" controls. 105,292 (7.5%) patients were treated at sites after they become AFN members and, hence, were subject to the intervention. The lower panel of Table 2 reports the number by cohort.

Descriptive statistics for patients from the intervention and ("never-treated" plus "not-yet-treated") control sites are provided in Table 3. *t* tests show that patients cared for at sites that were AFN members had significantly shorter LoS, and lower proportions died in hospital or were institutionalised. There are also significant differences in patient characteristics, notably in that the intervention group comprised patients with higher frailty risk scores, more Charlson comorbidities, and more diagnoses. This necessitates balancing these characteristics between intervention and control groups via propensity score weighting when applying the Callaway and Sant'Anna estimator.

3.2 Main regression analysis

The results of applying the event study model to the four outcomes (LoS, mortality, institutionalisation, and readmission) are presented in Figure 1 and Table 4 for the patient characteristics. Column (1) shows that older people and those with more Charlson comorbidities had shorter LoS, perhaps because these patients might disproportionately represent care home residents, for whom early supported discharge might be easier, as they came from and could return to a place of safety. LoS was longer for those with a higher HFRS and more diagnoses.

As shown in column (2), older people, men, those with a lower HFRS, and those with a higher Charlson comorbidity burden were more likely to die in hospital. Column (3) reports results for the analysis of those that changed their institutional status, having been admitted from their homes but discharged to care homes or hospices. This change was more likely for older patients, women, and those with a higher HFRS, but less likely for those with more Charlson comorbidities and diagnoses. Finally, column (4) shows that older people, women, those with a higher HFRS, more Charlson comorbidities, fewer previous admissions and more diagnoses were less likely to be readmitted within 30-days.

Figure 2 shows the difference in outcomes for intervention and control sites in the pre- and post-intervention periods. For all four graphs, pre-intervention trends in outcomes were the same in the intervention and control sites as confirmed by all 95% confidence intervals overlapping ATT=0 in this period. All confidence intervals also overlap ATT=0 in the post-intervention period, implying that AFN

membership had no significant impact on any outcome. This is confirmed in the upper panel of Table 5 where the ATTs are not significant for any of the four outcomes. The middle panel of Table 5 reports the ATTs for each cohort, none of which is significant, suggesting that there were no effects of the AFN intervention on the four outcomes for any of the six cohorts.

3.3 Robustness checks

We subjected the overall effect of AFN membership on the four outcomes to a series of robustness checks, producing 56 test statistics reported in the upper panels of Appendix Tables A3, A6, A9 and A13 and in Appendix Table A14. Only one of these indicated a significant effect. This was from the sub-group analysis of the 27 most engaged AFN sites that met the threshold of having adopted four or more of the AFN principles. In this analysis (reported in the ATT row of Appendix Table A13) a higher percentage of AFN patients were discharged to a care home or hospice (0.004, $p<0.05$).

The main regression analysis revealed no significant cohort effects for the four outcomes. Our robustness checks for cohort effects yielded 96 test statistics reported in the middle panels of Appendix Tables A3, A6, A9 and A13, of which eight were significant. In the analysis of long-term effects (reported in Appendix Table A3), patients in cohort four had a longer LoS (1.201 days more, $p<0.05$) and a lower percentage of those in cohort five died in hospital (-0.008, $p<0.05$). In the analysis of 12-month effects (see Appendix Table A6), a lower percentage of patients in cohort two were re-admitted within 30 days (-0.013, $p<0.05$).

In the three most engaged sites from cohort two (Appendix Table A13), a significantly lower percentage of patients were readmitted within 30-days (-0.024, $p<0.001$). Patients in the four most engaged sites in cohort three had a significantly longer LoS (1.75 days, $p<0.05$) and a higher percentage were discharged to a care home or hospice (0.011, $p<0.05$). Patients in the three engaged sites from cohort six had a significantly shorter LoS (6.579 days, $p<0.001$) and a higher percentage were discharged to a care home or hospice (0.014, $p<0.001$).

Appendix Table A14 reports the results of analysing each best practice principle in turn, which found no statistically significant effects on the four outcomes associated with adoption of any particular one of these ten principles.

4 Discussion

4.1 Key findings

This paper reports analysis of the effect of AFN membership on LoS, in-hospital mortality, institutionalisation and hospital readmission for older patients living with frailty. The policy intention was that AFN membership would lead to reductions in each of these outcomes, as a consequence of members receiving support from national clinical and quality improvement experts and of their adoption

of ten principles of best practice. We applied staggered difference-in-difference panel event study methodology to determine the overall causal effect of AFN membership on these four outcomes. Baseline pairwise comparisons suggested that patients at AFN sites had significantly shorter LoS, and were less likely to die or be institutionalised than those cared for in non-AFN sites. However, after controlling for patient and site characteristics and temporal factors, no significant effects of AFN membership were found for any of the four outcomes and nor were there significant effects for any individual cohort. The lack of an effect was generally robust to a series of robustness checks, with only 9 of the 156 (6%) tests proving significant at $p < 0.05$.

4.2 Strengths

The study has notable strengths compared to other QIC evaluations. First, the study is large and comprehensive, as it exploits data from the English Hospital Episode Statistics. From this we were able to identify every person aged 75+ with high frailty risk admitted to every NHS hospital site in England between 1 January 2012 and 31 March 2019. This yielded a dataset of 1,410,427 patients, of which 105,292 were subject to the intervention in 66 hospital sites and 1,305,136 were cared for in 248 control sites.

Second, we constructed four measures of outcome from the data. This overcomes a criticism of QIC studies that they might be subject to reporting bias, as many rely on self-reported clinical data rather than objective measures [51].

The third strength was our research study approach. As AFN membership was not randomly determined, we adopted a quasi-experimental approach for the evaluation, applying an event study methodology designed to identify causal effects of interventions that are subject to phased implementation in non-randomised settings. Further, we implemented the Callaway and Sant'Anna estimator in order to identify differential effects across AFN cohorts. This improves upon QIC evaluations that suffer methodological flaws, with differences in baseline measurement, limited data about site characteristics, possible contaminating spillover effects to control sites [52] and insufficient detail of randomisation and concealment procedures for RCTs [51].

4.3 Limitations

There are limitations with our study. First, we used a retrospective observational study design but the gold standard method would have been a stepped wedge cluster randomised trial [53]. In the absence of randomisation the Callaway & Sant'Anna estimator attempts to approach a stepped wedged design by correcting for the confounding inherent in observational data. Our application of the estimator makes these corrections by controlling for patient characteristics via propensity score matching to ensure balance between intervention and control groups across cohorts, for site characteristics using fixed effects, and for temporal effects by month of admission.

A second limitation is that sites joined the AFN voluntarily, raising the prospect of selection bias. However, intervention and control sites were subject to parallel trends during the pre-intervention period, implying selection was not a concern. Third, the hope was that the positive effects of joining the AFN would be revealed within 12 months of membership. However, only 11 months of data were available for cohort six so, for consistency, in the main analysis we adopted an 11-month post-intervention period across all cohorts. Nevertheless, results were generally robust to applying longer follow-up periods. Fourth, two further cohorts of hospital sites subsequently enrolled in the AFN, but after the period covered by our data, so could not be included in the analysis. Fifth, the patient-level outcomes were limited to routinely available service metrics. These may not capture all potential benefits of the AFN, particularly those reported by patients themselves.

Finally, and perhaps most critically, we could not establish definitively whether the lack of significant effects was due to the intervention itself or a failure of implementation exactly as intended. We attempted to address this by examining the relationship between outcomes and adoption of the AFN's best practice principles. But we found no evidence of a relationship, whether we focused on the most engaged sites (with above average adoption) or adoption of each principle individually. This however was an imperfect way to assess implementation of the best practices because the data were self-reported rather than objectively observed or measured.

4.4 Implications for practice and policy

There have been several systematic reviews of studies evaluating the effectiveness of QICs [36; 51; 52; 54; 55; 56], which suggest that their effectiveness is "positive but limited" [36]. But authors of these reviews note the possibility of publication bias, studies with non-significant findings (such as this one) being less likely to be published [55; 56]. There are two possible reasons for limited effectiveness. First QIC processes alone might be insufficient to bring about improvements. Nadeem et al [54] identified fourteen elements used in QICs, including learning sessions, data reporting, leadership, training in quality improvement methods, and multidisciplinary quality improvement teams, all of which were included in the AFN. But even if QICs that adopt these elements improve care processes, this may not impact outcomes if the necessary structures are lacking. Adequate staffing, age-attuned environments and access to early supported discharge services are all necessary to improve outcomes for older people with frailty who have crisis admissions to hospital [57]. Yet these are not consistently available, even in relatively well-resourced health care systems such as the NHS [38]. Expecting acute geriatric services to improve outcomes for older people without these structural elements is akin to expecting a surgeon to improve hip fracture outcomes without an operating theatre or associated team.

Second, even though something might appear effective, it may not always work in practice if the implementation strategy is inadequate [58]. Although membership of the AFN did not lead to improved outcomes older people in acute hospital settings, robust systematic review evidence demonstrates that the underlying intervention, namely CGA, is effective [21]. This suggests that future research should consider how best to support those involved in implementation of CGA, perhaps by applying planning and

evaluation frameworks designed by implementation scientists to help translate scientific advances into practice [59].

In summary, this study found no clear evidence that the AFN succeeded in meeting its aims to support older people living with frailty in the UK to return home from hospital sooner and healthier, over and above the experience of patients cared for in hospital sites that were not part of the network. This implies a more concerted effort is required to configure acute care services to meet the needs of this vulnerable population. To realise its aims, the AFN might need to develop more tailored and better resourced implementation strategies. Given the importance of the issue of acute care for older people, further methodologically robust studies of mechanisms to implement evidence-based models of care to improve outcomes for older people living with frailty are warranted.

References

- [1] Rechel B, Grundy E, Robine JM, Cylus J, Mackenbach JP, Knai C, et al. Ageing in the European Union. *The Lancet*. 2013;381(9874):1312-22.
- [2] World Health Organisation. WHO clinical consortium on healthy ageing 2021. WHO; 2022. [accessed: 17.03.2023] <https://www.who.int/publications/i/item/9789240055254>.
- [3] Kingston A, Comas-Herrera A, Jagger C. Forecasting the care needs of the older population in England over the next 20 years: estimates from the Population Ageing and Care Simulation (PACSim) modelling study. *The Lancet Public Health*. 2018;3(9):e447-e55.
- [4] Kingston A, Robinson L, Booth H, Knapp M, Jagger C, MODEM project. Projections of multi-morbidity in the older population in England to 2035: estimates from the Population Ageing and Care Simulation (PACSim) model. *Age and Ageing*. 2018;47(3):374-80.
- [5] Howlett S, Rutenberg A, Rockwood K. The degree of frailty as a translational measure of health in aging. *Nature Aging*. 2021;1(8):651-65.
- [6] Welstead M, Jenkins N, Russ T, Luciano M, Muniz-Terrera G. A Systematic Review of Frailty Trajectories: Their Shape and Influencing Factors. *The Gerontologist*. 2020;15(61):e463-75.
- [7] Blom JW, Van den Hout WB, Den Elzen WPJ, Drewes YM, Bleijenberg N, Fabbriotti IN, et al. Effectiveness and cost-effectiveness of proactive and multidisciplinary integrated care for older people with complex problems in general practice: an individual participant data meta-analysis. *Age and Ageing*. 2018;47(5):705-14.
- [8] Bleijenberg N, Drubbel I, Schuurmans M, Dam H, Zuithoff N, Numans M, et al. Effectiveness of a proactive primary care program on preserving daily functioning of older people: a cluster randomized controlled trial. *J Am Geriatr Soc*. 2016;64(9):1779-88.
- [9] Elliott A, Taub N, Banerjee J, Aijaz F, Jones W, Teece L, et al. Does the clinical frailty scale at triage predict outcomes from emergency care for older people? *Annals of Emergency Medicine*. 2021;77(6):620-7.
- [10] Keeble E, Roberts H, Williams C, Van Oppen J, Conroy S. Outcomes of hospital admissions among frail older people: a 2-year cohort study. *Br J Gen Pract*. 2019;69(685):e555- 60.

- [11] Hubbard R, Peel N, Samanta M, Gray L, Mitnitski A, Rockwood K. Frailty status at admission to hospital predicts multiple adverse outcomes. *Age and Ageing*. 2017;1(46):801-6.
- [12] Phelps K, Regen E, van Oppen JD, Riley P, Lalseta J, Martin G, et al. What are the goals of care for older people living with frailty when they access urgent care? Are those goals attained? A qualitative view of patient and carer perspectives. *International Emergency Nursing*. 2022;63:101189.
- [13] Regen E, Phelps K, van Oppen JD, Riley P, Lalseta J, Martin G, et al. Emergency care for older people living with frailty: patient and carer perspectives. *Emergency Medicine Journal*. 2022;39(10):726-32. Available from: <https://emj.bmj.com/content/39/10/726>.
- [14] van Galen L, Brabrand M, Cooksley T, van de Ven P, Merten H, So R, et al. Patients' and providers' perceptions of the preventability of hospital readmission: a prospective, observational study in four European countries. *BMJ Qual Saf*. 2017;26(12):958-969.
- [15] Zisberg A, Shadmi E, Gur-Yaish N, Tonkikh O, Sinoff G. Hospital-associated functional decline: the role of hospitalization processes beyond individual risk factors. *J Am Geriatr Soc*. 2015;63(1):55-62.
- [16] Garcia-Perez L, Linertova R, Lorenzo-Riera A, Vazquez-Diaz J, Duque-Gonzalez B, Sarria-Santamera A. Risk factors for hospital readmissions in elderly patients: a systematic review. *QJM*. 2011;104(8):639-51.
- [17] Borenstein J, Aronow H, Bolton L, Choi J, Bresee C, Braunstein G. Early recognition of risk factors for adverse outcomes during hospitalization among Medicare patients: a prospective cohort study. *BMC Geriatr*. 2013;8(13):13-72.
- [18] Wou F, Gladman J, Bradshaw L, Franklin M, Edmans J, Conroy S. The predictive properties of frailty-rating scales in the acute medical unit. *Age and Ageing*. 2013;42(6):776-81.
- [19] Yao J, Fang J, Lou Q, Anderson R. A systematic review of the identification of seniors at risk (ISAR) tool for the prediction of adverse outcome in elderly patients seen in the emergency department. *Int J Clin Exp Med*. 2015;15(8):4778-86.
- [20] Tsugawa Y, Jena AB, Figueroa JF, Orav EJ, Blumenthal DM, Jha AK. Comparison of Hospital Mortality and Readmission Rates for Medicare Patients Treated by Male vs Female Physicians. *JAMA Internal Medicine*. 2017;177(2):206-13.
- [21] Ellis G, Gardner M, Tsiachristas A, Langhorne P, Burke O, Harwood R, et al. Comprehensive geriatric assessment for older adults admitted to hospital. *Cochrane Database of Systematic Reviews*. 2017;9:CD006211.
- [22] Parker SG, McCue P, Phelps K, McCleod A, Arora S, Nockels K, et al. What is Comprehensive Geriatric Assessment (CGA)? An umbrella review. *Age and Ageing*. 2017;47(1):149-55.
- [23] Rubenstein L, Rubenstein L. Multidimensional assessment of elderly patients. *Advances in internal medicine*. 1991;36:81-108.
- [24] Jay S, Whittaker P, McIntosh J, Hadden N. Can consultant geriatrician led comprehensive geriatric assessment in the emergency department reduce hospital admission rates? A systematic review. *Age and Ageing*. 2016;46(3):366-72.
- [25] Ellis G, Langhorne P. Comprehensive geriatric assessment for older hospital patients. *British Medical Bulletin*. 2005;71(1):45-59.
- [26] Van Craen K, Braes T, Wellens N, Denhaerynck K, Flamaing J, Moons P, et al. The effectiveness

of inpatient geriatric evaluation and management units: a systematic review and meta-analysis. *Journal of the American Geriatrics Society*. 2010;58(1):83- 92.

[27] British Geriatrics Society. Silver Book II Quality care for older people with urgent care needs; 2021. [accessed: 28.10.2021]. <https://www.bgs.org.uk/resources/resource-series/silver-book-ii>.

[28] Banerjee J, Conroy S, O’Leary V, Rawstorne S, Wenman J, Walker A, et al. The Silver Book: quality care for older people with urgent emergency care needs.; 2012. [accessed: 30.09.2020]. <https://www.bgs.org.uk/resources/silver-book>.

[29] Bertfield, D and Conroy, S. Acute care for older people living with frailty. London: Royal College of Physicians; 2020.

[30] NHS Benchmarking network. Older people’s care in acute settings benchmarking report; 2016. [accessed: 28.10.2021]. https://www.bgs.org.uk/pdfs/1216_op_benchmarking_report.pdf.

[31] Getting It Right First Time (GIRFT). GIRFT national report on geriatric medicine; 2017. [accessed: 31.08.2022]. <https://www.gettingitrightfirsttime.co.uk/medical-specialties/geriatric-medicine/>.

[32] Mooijaart S, Nickel C, Conroy S, Lucke J, van Tol L, Olthof M, et al. A European research agenda for geriatric emergency medicine: a modified Delphi study. *Eur Geriatr Med*. 2021;12(2):413-22.

[33] NHS England. The NHS Long Term Plan; 2019. [accessed: 01.2019]. www.longtermplan.nhs.uk.

[34] NHS Right Care. NHS Right Care: frailty toolkit. London: NHS England; 2019. [accessed: 17.03.2023] <https://www.england.nhs.uk/rightcare/wp-content/uploads/sites/40/2019/07/frailty-toolkit-june-2019-v1.pdf>

[35] NHS Improvement. Ambulatory emergency care guide: same day acute frailty services: same day acute frailty services; 2019. [accessed: 17.03.2023] https://www.england.nhs.uk/wp-content/uploads/2021/02/SDEC_guide_frailty_May_2019_update.pdf

[36] Schouten LMT, Hulscher MEJL, Everdingen JJEv, Huijsman R, Grol RPTM. Evidence for the impact of quality improvement collaboratives: systematic review. *BMJ*. 2008;336(7659):1491-4.

[37] van Oppen JD, Thompson D, Tite M, Griffiths S, Martin FC, Conroy S. The Acute Frailty Network: experiences from a whole-systems quality improvement collaborative for acutely ill older patients in the English NHS. *European Geriatric Medicine*. 2019;10(4):559-65.

[38] NHS Benchmarking Network. Managing frailty and delayed transfers of care in the acute setting bespoke report 2020 (2019/20). NHS Benchmarking Network; 2020. [accessed: 17.03.2023] <https://www.nhsbenchmarking.nhs.uk/news/2019-managing-frailty-results>

[39] Van Oppen JD, Keillor L, Mitchell Á, Coats TJ, Conroy SP. What older people want from emergency care: a systematic review. *Emergency Medicine Journal*. 2019;36(12):754-761.

[40] Langley, GL and Moen, R and Nolan, KM and Nolan, TW and Norman, CL and Provost, LP. The Improvement Guide: A Practical Approach to Enhancing Organizational Performance. San Francisco: Jossey-Bass Publishers; 2009.

[41] Ellis G, Gardner M, Tsiachristas A, et al. Comprehensive geriatric assessment for older adults admitted to hospital. *Cochrane Database of Systematic Reviews* 2017(9) doi: 10.1002/14651858.CD006211.pub3

[42] Clarke, D., & Tapia-Schythe, K. Implementing the panel event study. *Stata Journal*. 2021;21(4):853-84.

- [43] Callaway B, Sant'Anna PH. Difference-in-Differences with multiple time periods. *Journal of Econometrics*. 2021;225(2):200-30.
- [44] NHS Digital. Hospital EpisodeStatistics data dictionary 2022. [accessed: 02.03.2023]. <https://digital.nhs.uk/data-and-information/data-tools-and-services/data-services/hospital-episode-statistics/hospital-episode-statistics-data-dictionary>.
- [45] Gilbert T, Neuburger J, Kraindler J, Keeble E, Smith P, Ariti C, et al. Development and validation of a Hospital Frailty Risk Score focusing on older people in acute care settings using electronic hospital records: an observational study. *Lancet*. 2018;391:1775-82.
- [46] Street A, Maynou L, Gilbert T, Stone T, Mason S, Conroy S. The use of linked routine data to optimise calculation of the Hospital Frailty Risk Score on the basis of previous hospital admissions: a retrospective observational cohort study. *The Lancet Healthy Longevity*. 2021;2(3):e154-62.
- [47] Ministry of Housing, Communities and Local Government. The English Indices of Deprivation 2019; 2019. [accessed: 02.03.2023]. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/835115/IoD2019_Statistical_Release.pdf.
- [48] Charlson M, Pompei P, Ales K, MacKenzie C. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40(5):373-83.
- [49] Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi JC, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Medical Care*. 2005;43(11):1130-9.
- [50] Stagg V. Charlson: Stata module to calculate Charlson index of comorbidity. *Statistical Software Components*, Boston College Department of Economics. 2017;S456719.
- [51] Zamboni K, Baker U, Tyagi M, Schellenberg J, Hill Z, Hanson C. How and under what circumstances do quality improvement collaboratives lead to better outcomes? A systematic review. *Implementation Science*. 2020;15(1):27.
- [52] Hulscher MEJL, Schouten LMT, Grol RPTM, Buchan H. Determinants of success of quality improvement collaboratives: what does the literature show? *BMJ Quality & Safety*. 2013;22(1):19-31.
- [53] Hooper R, Eldridge SM. Cutting edge or blunt instrument: how to decide if a stepped wedge design is right for you. *BMJ Quality & Safety*. 2021;30(3):245-50. Available from: <https://qualitysafety.bmj.com/content/qhc/30/3/245.full.pdf>.
- [54] Nadeem E, Olin SS, Hill LC, Hoagwood KE, Horwitz SM. Understanding the components of Quality Improvement Collaboratives: a systematic literature review. *The Milbank Quarterly*. 2013;91(2):354-94.
- [55] Wells S, Tamir O, Gray J, Naidoo D, Bekhit M, Goldmann D. Are quality improvement collaboratives effective? A systematic review. *BMJ Quality & Safety*. 2018;27(3):226-40.
- [56] de la Perrelle L, Radisic G, Cations M, Kaambwa B, Barbary G, Laver K. Costs and economic evaluations of Quality Improvement Collaboratives in healthcare: a systematic review. *BMC Health Services Research*. 2020;20(1):155.
- [57] Preston L, van Oppen JD, Conroy SP, Ablard S, Buckley Woods H, Mason SM. Improving outcomes for older people in the emergency department: a review of reviews. *Emergency Medicine Journal*. 2021; 38(12), 882-888.
- [58] Curran, G.M. Implementation science made too simple: a teaching tool. *Implement Sci Commun* 1,

27 (2020).

[59] Glasgow RE, Harden SM, Gaglio B, et al. RE-AIM Planning and Evaluation Framework: Adapting to New Science and Practice With a 20-Year Review. *Frontiers in Public Health* 2019;7

Tables and Figures

Table 1: Acute Frailty Network best practice principles

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- 1 Early identification of patients with frailty
 - 2 Multi-disciplinary team response with Comprehensive Geriatric Assessment initiated within an hour
 - 3 Rapid response system for frail older people in urgent care settings
 - 4 Adopt clinical professional standards to reduce unnecessary variation
 - 5 Developing a measurement mindset
 - 6 Strengthen links with services both inside and outside of hospital
 - 7 Put in place appropriate education and training for staff
 - 8 Identify clinical change champions
 - 9 Patient & Public Involvement
 - 10 Identify an executive sponsor and underpin with robust project management
-

Table 2: Number of Control and Intervention patients (Pre-intervention months=36, Post-intervention months=11)

	2012	2013	2014	2015	2016	2017	2018	2019	Total	% of total
Total patients	104,049	142,206	181,938	227,258	238,918	236,664	230,428	48,966	1,410,427	100
Controls (never treated)	91,481	108,395	119,770	128,638	136,944	157,313	179,988	46,371	968,900	68.7
Controls (not yet treated)	12,568	33,811	62,168	87,654	72,012	47,573	20,449	0	336,235	23.8
Intervention	0	0	0	10,966	29,962	31,778	29,991	2,595	105,292	7.5
Cohort 1 - Jan 2015	0	0	0	10,966	0	0	0	0	10,966	0.8
Cohort 2 - Jan 2016	0	0	0	0	23,122	0	0	0	23,122	1.6
Cohort 3 - Sept 2016	0	0	0	0	6,840	12,401	0	0	19,241	1.4
Cohort 4 - May 2017	0	0	0	0	0	12,787	5,500	0	18,287	1.3
Cohort 5 - Oct 2017	0	0	0	0	0	6,590	16,956	0	23,546	1.7
Cohort 6 - May 2018	0	0	0	0	0	0	7,535	2,595	10,130	0.7

Table 3: Descriptive statistics

	Intervention	Controls (not yet treated and never treated)	<i>p</i> value
N observations	105,292	1,305,135	
N sites	66	248	
Outcomes			
LoS (days)	15.57 (18.57)	16.33 (19.85)	<0.001
In-hospital mortality (%)	4.44 (20.61)	4.95 (21.70)	<0.001
Institutionalisation (%)	2.15 (14.50)	2.73 (16.30)	<0.001
30-day readmission (%)	17.46 (37.96)	17.24 (37.77)	0.08
Covariates			
Age	86.20 (5.72)	86.13 (5.69)	<0.001
Age 75-80 (%)	14.18 (34.88)	14.20 (34.91)	0.81
Age 80-85 (%)	25.07 (43.34)	25.66 (43.67)	<0.001
Age 85-90 (%)	31.17 (46.32)	30.99 (46.24)	0.22
Age 90-95 (%)	21.88 (41.34)	21.88 (41.34)	0.99
Age 95+ (%)	7.71 (26.67)	7.28 (25.97)	<0.001
Female (%)	60.09 (48.97)	60.71 (48.84)	<0.001
HFRS high risk score	23.03 (6.52)	22.43 (6.15)	<0.001
Charlson=0 (%)	9.56 (29.41)	10.67 (30.87)	<0.001
Charlson=1 (%)	23.85 (42.61)	25.33 (43.49)	<0.001
Charlson=2 (%)	22.08 (41.48)	22.03 (41.44)	0.71
Charlson=3+ (%)	44.51 (49.70)	41.98 (49.35)	<0.001
N prev adm=0 (%)	31.36 (46.40)	29.78 (45.73)	<0.001
N prev adm=1 (%)	32.96 (47.01)	33.39 (47.16)	0.004
N prev adm=2 (%)	19.07 (39.29)	19.94 (39.96)	<0.001
N prev adm=3+ (%)	16.61 (37.22)	16.89 (37.46)	0.02
N diagnoses	12.79 (4.73)	11.92 (4.54)	<0.001

Notes: Mean (std dev). Years: 2012-2019. For intervention, pre-intervention months=36, post-intervention months=11. N: Number, LoS: Length of stay, HFRS: Hospital Frailty Risk Score; N prev adm: number of previous admissions. There are only two missing values in LoS and 8 in being female. Data were censored at 31 March 2019 so 30-day readmission could not be calculated for 18,309 observations who were not discharged before 2 March 2019. *P*-values derived from *t* tests.

Table 4: Regression Analysis: Event Study Covariate Estimates for the Four Major Outcomes in the Acute Frailty Network

	(1) LoS	(2) In-hospital mortality	(3) Institutionalisation	(4) 30-day readmission
Age 80-85	-0.437*** (0.057)	0.003** (0.001)	0.002*** (0.001)	-0.003* (0.001)
Age 85-90	-0.658*** (0.066)	0.009** (0.001)	0.004*** (0.001)	-0.003* (0.001)
Age 90-95	-0.962*** (0.073)	0.017** (0.001)	0.007*** (0.001)	-0.008*** (0.002)
Age 95+	-1.314*** (0.098)	0.028** (0.001)	0.009*** (0.001)	-0.017*** (0.002)
Female	0.089 (0.054)	-0.009** (0.001)	0.003*** (0.0004)	-0.011*** (0.001)
HFRS high risk score	0.172*** (0.008)	-0.0002** (0.00004)	0.001*** (0.0004)	-0.001*** (7.02e-05)
Charlson=1	-1.123*** (0.094)	0.010** (0.001)	0.005*** (0.001)	-0.009*** (0.001)
Charlson=2	-2.321*** (0.116)	0.017** (0.001)	0.005*** (0.001)	-0.002 (0.002)
Charlson=3+	-4.491*** (0.161)	0.029** (0.001)	0.004*** (0.001)	0.002 (0.001)
N prev adm=1	-2.264*** (0.083)	0.005** (0.001)	-0.003*** (0.0004)	0.028*** (0.001)
N prev adm=2	-3.349*** (0.104)	0.004** (0.001)	-0.005*** (0.001)	0.058*** (0.001)
N prev adm=3+	-4.037*** (0.115)	-0.001 (0.001)	-0.005*** (0.001)	0.116*** (0.002)
N diagnoses	1.945*** (0.045)	-0.0001 (0.0002)	-0.002*** (0.0001)	-0.001*** (0.0002)
Died during period	-6.233*** (0.239)		-0.034*** (0.002)	-0.179*** (0.002)
N observations	1,410,417	1,410,419	1,410,419	1,392,110
N sites	249	249	249	249
Cluster sites	Yes	Yes	Yes	Yes
Months (leads/lags)	-36/+11	-36/+11	-36/+11	-36/+11
Years	2012-2019	2012-2019	2012-2019	2012-2019

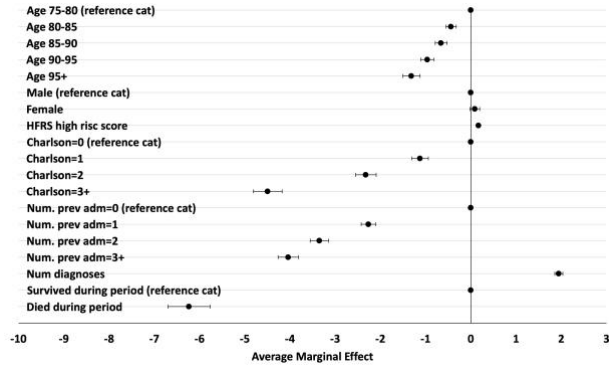
Notes: Coefficients reported as average marginal effects and standard errors reported in brackets. Significance levels: *** p<0.001, ** p<0.01, * p<0.05, no star = not significant. N: Number, HFRS: Hospital Frailty Risk Score; N prev adm: number of previous admissions. Covariates: age, female, HFRS high risk score, Charlson Comorbidity Index, Number of previous admissions, number of unique diagnoses and died (except for model 2).

Table 5: Callaway & Sant'Anna results (Pre-intervention months=36, Post-intervention months=11)

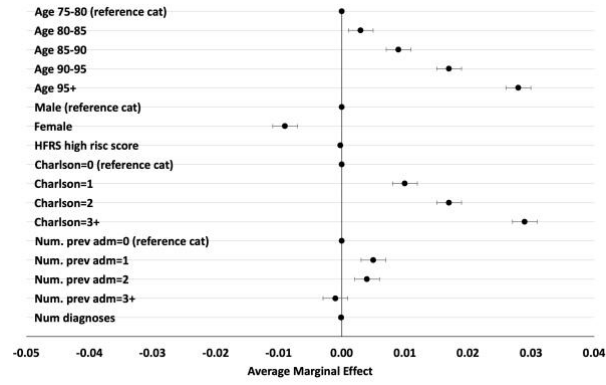
	(1) LoS	(2) In-hospital mortality	(3) Institutionalisation	(4) 30-day readmission
ATT	0.099 (0.346)	-0.001 (0.002)	0.001 (0.002)	-0.004 (0.005)
ATT cohort 1	-0.317 (0.903)	0.002 (0.005)	-0.002 (0.005)	-0.003 (0.007)
ATT cohort 2	0.734 (0.877)	0.001 (0.005)	0.001 (0.003)	-0.012 (0.007)
ATT cohort 3	-0.769 (0.933)	-0.002 (0.005)	-0.0003 (0.004)	0.001 (0.012)
ATT cohort 4	0.757 (0.613)	-0.006 (0.006)	0.003 (0.003)	0.0004 (0.016)
ATT cohort 5	-0.048 (0.491)	-0.005 (0.004)	0.001 (0.004)	0.009 (0.008)
ATT cohort 6	-0.039 (0.945)	0.009 (0.007)	0.003 (0.003)	-0.032 (0.021)
N observations	1,409,862	1,409,864	1,409,864	1,391,555
N sites	249	249	249	249
Covariates	Yes	Yes	Yes	Yes
Cluster sites	Yes	Yes	Yes	Yes
Controls	never + not yet	never + not yet	never + not yet	never + not yet
Treated leads/lags	-36/+11	-36/+11	-36/+11	-36/+11
Years	2012-2019	2012-2019	2012-2019	2012-2019

Notes: ATT: average treatment effect on the treated. Coefficients reported as average marginal effects and standard errors reported in brackets. Significance levels: *** p<0.001, ** p<0.01, * p<0.05, no star = not significant. N: Number. Covariates: age, female, HFRS high risk score, Charlson Comorbidity Index, Number of previous admissions, number of unique diagnoses and died (except for model 2).

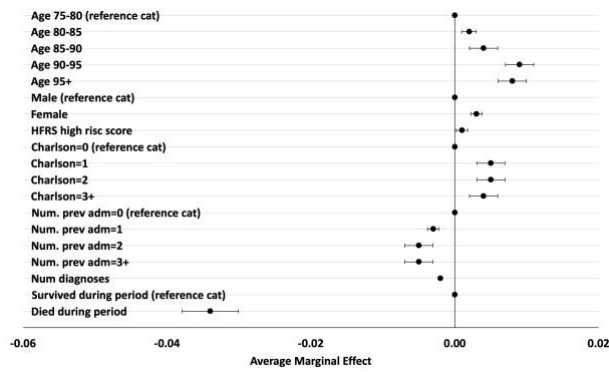
Figure 1: Event-study results: covariates



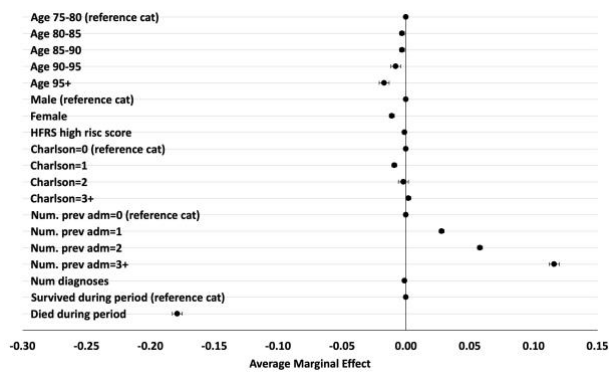
(I) - Length of stay



(II) - In-hospital mortality

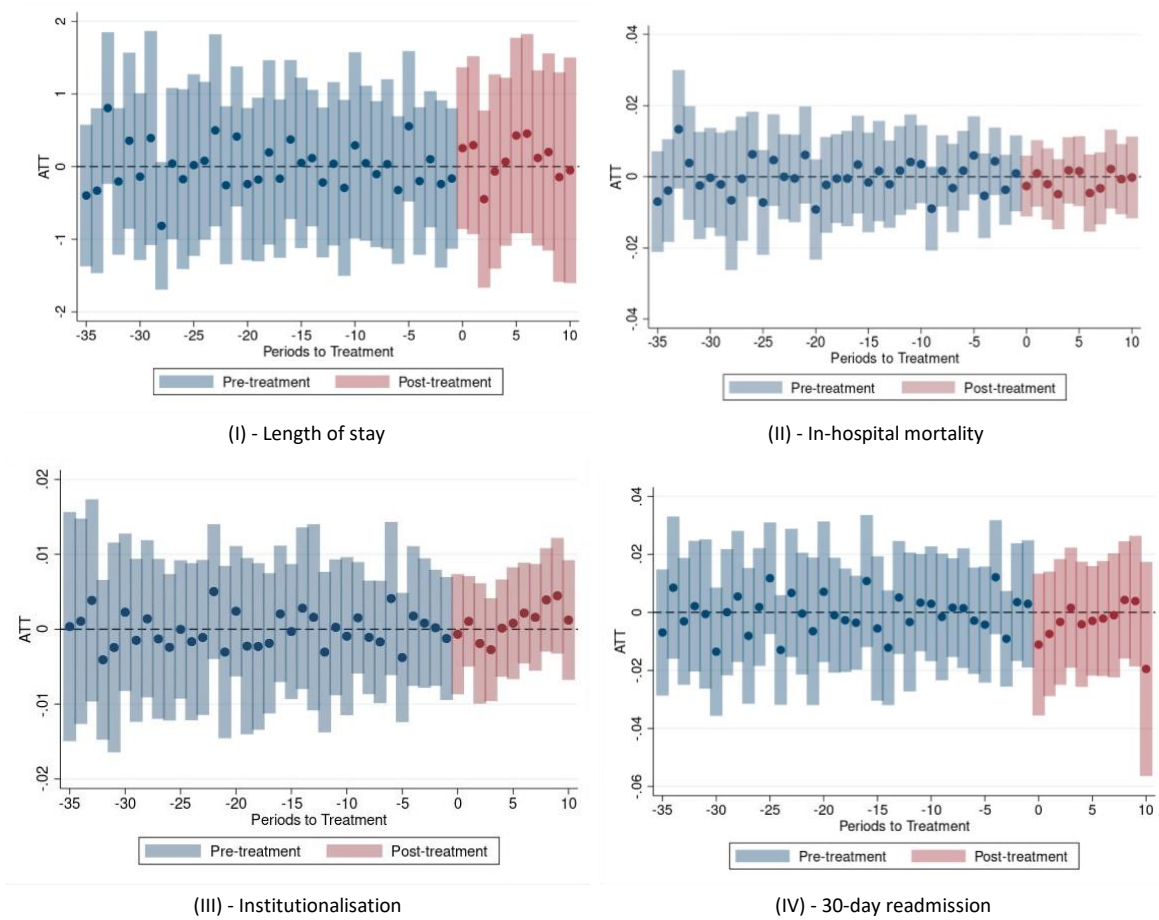


(III) - Institutionalisation



(IV) - 30-day readmission

Figure 2: Callaway & Sant'Anna figures (Pre-intervention months=36, Post-intervention months=11)



Notes: The dot represents the mean conditional outcome for those subject to intervention relative to the controls, with the length of the bars indicating the 95% confidence limits.