# Case finding and intensive care management of elderly people in primary care may increase secondary care costs: cost-consequences analysis of the South London Integrated Care Pilot.

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# Case finding and intensive care management of elderly people in primary care may increase secondary care costs: cost-consequences analysis of the South London Integrated Care Pilot.

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**Objectives**. To estimate the impact on hospital utilisation and costs of a multi-faceted primary care intervention for older people identified as being at risk of avoidable hospitalisation.

**Design**. Observational study: controlled time series analysis; estimation of costs and cost-consequences of the programme. GP practice level data were analysed from 2009 to 2016 (intervention operated from 2012-2016). Mixed effect Poisson regression models of hospital utilisation included comparisons with control practices and background trends in addition to within-practice comparisons. Cost estimation used standard tariff values.

**Setting**: 94 practices in Southwark and Lambeth, 263 control practices from other parts of England.

**Main outcome measures**: Hospital utilisation: emergency department attendance, emergency admissions, emergency admissions for ambulatory sensitive conditions, outpatient attendance, elective admission, length of stay.

**Results**: By the fourth year of the programme there were reductions in A&E attendance (rate ratio 0.944, 95%CI 0.913-0.976), outpatient attendances (rate ratio 0.938 95%CI 0.902-0.975) and elective admissions (rate ratio 0.921 95%CI 0.908-0.935) but there was no evidence of reduced emergency admissions. The costs of the programme were £149 per resident aged 65 and over but savings in hospital costs were only £86 per resident aged 65 and over, equivalent to a net increase in health service expenditure of £64 per resident, though the programme was nearly cost-neutral if set-up costs were excluded. Holistic Assessments carried out by GPs and consequent Integrated Care Management were associated with increases in elective activity and costs; £126 and £936 increase in outpatient attendance and elective admission costs per Holistic Assessment carried out, and £576 and £5,858 increase in outpatient and elective admission costs per patient receiving Integrated Care Management.

**Conclusions**: The Older People's Programme was not cost-saving. Some aspects of the Programme were associated with increased costs of elective care, possibly through the identification of unmet need.

**Strengths and limitations of this study**

- There have been many attempts to reduce hospital costs, in particular emergency admissions, generally with mixed results
- This ambitious multi-faceted district wide intervention for older people failed to reduce emergency admissions, and the costs of the programme exceeded the savings in secondary care costs.
- Health assessments and care management of older people increased the costs of outpatient attendance and elective admission.
- Despite strong local managerial and financial support, the programme was slower to be implemented than originally planned.
- Although we carefully selected controls, the analysis, like any observational study, is potentially biased by unmeasured confounders.

**Introduction**

It is widely recognised that care of elderly people falls short of the ideal. Reasons for this include failure to identify developing medical problems and failure to provide well-coordinated care for people with multiple complex problems, both of which may lead to avoidable emergency admissions.[1,2] A wide range of initiatives have been developed in recent years but most include, in some form, identifying patients in need of more intensive or coordinated management and then intervening with proactive packages of care designed to maximise patients' abilities to self-manage their conditions and anticipate preventable deteriorations in health. Risk profiling and intensive case management form common parts of these approaches.[3,4,5,6,7]

In 2012, the Southwark and Lambeth Integrated Care (SLIC) Older People's Programme was set up to maximise the health and independence of older people and minimise avoidable hospital utilisation.[8] SLIC brought together general practitioners (GPs), hospitals and local authorities to redesign services and provide better integrated care for people aged 65 and over. The Older People's Programme ('the Programme') consisted of many different activities, which addressed a range of aspects of health and social care, summarised in the box:

**Box. Summary of the main elements of the SLIC Older People's Programme**

- Holistic assessments (HAs) for older people
- Integrated care management plans for older people identified as 'at risk' (ICM)
- Community based multi-disciplinary team meetings
- 'Hotline' to consultants for advice
- 'Hot clinic' to enable urgent geriatric assessment older people
- Admission avoidance through community based enhanced rapid response services
- Improved hospital discharge procedures
- Enhanced community reablement services
- Redesigned clinical pathways including for falls and dementia

Holistic Assessments (HAs) were to be carried out by all GPs in the two boroughs. Each HA included assessment of the patient's physical health, mental health and social care needs, as well as wider social aspects of daily living (e.g. benefits and housing). At the outset, the intention of the Programme was that GPs would undertake an HA with half of all their patients aged 65 and over. However, recruitment to HAs was much lower than planned and in April 2014 the target population for HAs was changed to all people aged 80 or over and people over 65 who were either housebound or had not been seen by a GP for 15 months. Extra multi-disciplinary team support was provided for patients identified through the HA process as likely to benefit from Integrated Care Management.

This evaluation was commissioned to run in parallel with the Programme from August 2012 until the end of the Programme in March 2016, with the principle aim of examining changes in hospital utilisation by people aged 65 and over registered with GPs in Southwark and Lambeth following implementation of the Programme. In most respects it was not possible to single out which elements of the Programme were more or less successful in achieving the wide range of aims originally set out by the SLIC partners. However, we were able to estimate the overall effect of the Programme on hospital utilisation and, because of the particular way the programme developed, we were able to isolate the effects of HAs and Integrated Care Management plans for those identified as 'at risk'.

## Method

Using Hospital Episode Statistics (HES) [9] provided by NHS Digital, which contains details of all admissions, outpatient appointments and A&E attendance at NHS hospitals in England, we considered five outcome measures of hospital utilisation for people aged 65 and over registered at a GP practice in Southwark and Lambeth:

1. accident and emergency (A&E) attendance;
2. emergency hospital admissions;
3. emergency hospital admissions for patients with admissions for 'ambulatory care sensitive' (ACS) conditions recorded as one of the diagnoses on discharge[10]. ACS conditions are those for which, in principle, crises leading to emergency admissions that might be prevented by improved care in the community.
4. outpatient attendance;
5. elective hospital admissions

A series of analyses were performed using a Poisson regression based approach that allowed for the longitudinal and clustered nature of the data. Data were analysed for the three years prior to and the four years following the start of the Programme (2nd quarter of 2009 to 1st quarter of 2016) in 5-year age-band by gender strata. By analysing rates of hospital utilisation across different age and gender groups, we allow for potential changes in the age profile of the population over the course of the study period. In addition to age and gender, models also adjusted individual practice characteristics and for the effect of the time of year (seasonality). Further details of the methods and full regression results are shown in the appendix. We carried out sensitivity analyses excluding small numbers of practices with unusually high rates of admission or mean length of stay, but none of these made a material difference to our conclusions and they are not reported here. In addition to these outcomes, we also analysed length of stay and found no effect of any of the interventions (full results of the length of stay analysis are in appendix tables A11 and A12).

In our first analysis we compared trends in these practices with those in a matched group of control practices from other parts of England. Originally control practices were matched with a ratio of five controls for every intervention practice with replacement meaning that control practices could appear more than once in the comparison dataset. However, due to the extended period of analysis we found a significant number of practices had closed meaning it would be impossible to maintain exact matching. As a consequence, we felt the advantage of including duplicate records for some practices was minimal and only a single copy of data from each practice was used. Practices were matched on basis of list size, the proportion of patients registered with the practice over the age of 65, the proportion of patients registered with the practice over the age of 80, the proportion of male patients, the mean years since qualification of GPs, the number of patients per full time equivalent GP (a measure of workload), the proportion of full time equivalent GPs made up by male GPs, practice deprivation score and the proportion of the practice population describing themselves as white. In addition, control practices were matched on baseline admissions/attendance and the rate of change of those admissions/attendance at baseline, in this case not including A&E attendance. Further details of the matching are given in the appendix.

A second set of analyses took account of the variation in the level of activity that occurred between practices in Southwark and Lambeth for two key elements of the Programme –HAs and integrated care management. Since some practices implemented these more rapidly and more comprehensively than others, we were able to look for a 'dose-effect' to see whether the delivery of these two specific elements of the programme appeared to have independent effects on hospital utilisation. We used the percentage of patients aged 65 and over who had received one of the interventions at each of 13 three-month post-intervention time points as a measure of the 'dose' of intervention in that practice at that time (using the cumulative total percentage at each time point). For these analyses we conducted two separate regressions: one estimating the effect of increasing HAs and ICM in comparison to our control group of practices and the second restricting the analysis of increasing HAs and ICM to practices in Southwark and Lambeth. The restricted analysis allows for practices in Lambeth and Southwark being 'special' in some way, for example, particular ethnic profiles, which were different from other parts of the country. We report the latter set of results in the main paper as more reliably estimating differences in primary care activity between practices that have performed more HAs/ICM and those practices performing fewer or none, while the comparison with control practices may also reflect a more general effect of the programme (e.g. changes to budgets, changes in other services including secondary care provision). For completeness, we present both sets of results in the appendix.

For the economic analysis, we drew data on the costs of the SLIC Programme from a Kings College London report[11]. This estimated the costs of the whole Programme over the period at £7.4 million of which £2.9 million were infrastructure or 'enabling' costs associated with the initial establishment of the Programme. Averaging these costs across all residents age 65 and over in Southwark and Lambeth gives SLIC implementation costs per older person of £149 across the life of the Programme, or £91 excluding infrastructure/enabling costs. Hospital utilisation costs were taken from the NHS Improvement Tariff Payment System[12] and the PSSRU cost book[13]. These give average, upper and lower bounds for NHS payments for A&E attendance, emergency and elective admissions and outpatient attendance (see appendix, table A13). In the paper we report the results for estimated average costs incurred, with sensitivity analyses using the upper and lower bounds for both cost and potential impact on hospital utilisation reported in the appendix (table A14). We only estimated costs where there were statistically significant effects on the outcomes and we did not carry out this analysis for ACS conditions to avoid double counting.

We used Stata version 15 for data management and all models were run in SAS version 9.4.

Patient and Public involvement

The analyses of secondary data carried out in this study were specified in the final protocol agreed with the funder. SLIC had its own patient representative group and a member of this group was present at meetings of the SLIC Evaluation Steering Group which reviewed interim findings. There was no other direct patient or public involvement in developing or reporting on the analyses reported in this paper.

## Results

We analysed data from 357 practices, including 94 practices in Southwark and Lambeth and 263 matched control practices.

Overall impact of the SLIC programme on hospital utilisation

Table 1 shows the overall effect of the Programme on the five hospital utilisation outcomes by the end of the programme in 2016. A more detailed year-by-year breakdown of the results is shown in the appendix (tables A1 to A12).

| Outcome | Rate ratio* (95%CI) | p-value | Observed rate for SLIC practices per 1000 patients per year | Expected rate in the absence of SLIC intervention per 1000 patients per year |
|---|---|---|---|---|
| A&E attendance | 0.944 (0.913-0.976) | 0.001 | 144 | 153 |
| Emergency admissions | 1.011 (0.971-1.052) | 0.600 | NS** | NS |
| Emergency admissions for ACSCs ǂ | 1.073 (1.004-1.147) | 0.037 | 20 | 19 |
| Elective admissions | 0.938 (0.902-0.975) | 0.001 | 153 | 164 |
| Outpatient attendance | 0.921 (0.908-0.935) | 0.001 | 1220 | 1324 |

* Rate ratios for model 1 represent the relative change in the rate of admission compared to what would have been expected in the absence of SLIC activity. A rate ratio of 1 indicates no change, while a rate ratio greater than 1 represents an increase, and a rate ratio less than 1 represents a decrease, in admissions.
** No significant change
ǂ Ambulatory Care Sensitive Conditions

*Table 1 Hospital utilisation: comparison with control practices by year 4 of the SLIC programme*

The Programme was associated with a reduction in A&E attendance by patients age 65 and over compared to that expected based on control practices and background trends. This reduction was only evident by the end of the programme: more detailed year-by-year results (appendix, table A1) show a small initial rise in attendance followed by no change in the middle of the programme and a reduction by the fourth year. Compared to that expected based on control practices and background trends there was no evidence of a reduction in emergency admissions (a key aim of the programme) in any of the four years, but a small rise in emergency admissions for ACS conditions, a rise that was evident in all four years of the programme (appendix table A5). There were significant reductions in attendance at outpatients and in elective admissions, neither of which were stated aims of the Programme.

Over the four years of the programme, there was a net reduction in hospital costs of £86 per Southwark and Lambeth resident 65 or over. Against an overall cost of implementing the SLIC programme of £149, this represents a net increase in cost to the NHS of £64 per resident. If the infrastructure/enabling costs are removed (as these might not be ongoing once the programme was established) then the net saving in hospital costs (£86) is very close to the costs of the programme (£91) and sensitivity analyses (table A14) using lower bounds for costs and effect on hospitalisation shows the potential for the Programme to be cost-saving.

Impact of Holistic Assessments and Integrated Care Management on hospital utilisation

At the end of the evaluation in March 2016, 26.9% of the population aged 65 and over had received a HAs, ranging from 0% to 94.1% of the population aged 65 and over in individual general practices. 3.5% of the population aged 65 and over had been referred for ICM, ranging from 0% to 18.3% of the population aged 65 and over in individual general practices.

Table 2 shows the average change in the rate of hospital utilisation for the six outcomes for a 1% increase in the proportion of the population aged 65 and over receiving HAs. The models account for individual practice pre-intervention trends, seasonality and the full range of individual practice characteristics. Table 3 shows similar analyses, this time with ICM as the outcome. In each case we report the additional secondary care costs incurred association with the increased primary care activities.

| Outcome | Rate ratio* (95%CI) | p-value | Expected change per 10,000 Holistic Assessments | Additional hospital costs incurred per Holistic Assessment |
|---|---|---|---|---|
| A&E attendance | 1.000 (0.999-1.001) | 0.760 | NS** | £0 |
| Emergency admissions | 1.001 (1.000-1.002) | 0.201 | NS | £0 |
| Emergency admissions for ACSCs ǂ | 1.001 (0.998-1.003) | 0.516 | NS | £0 |
| Elective admissions | 1.004 (1.003-1.005) | <0.001 | 2399 | £936 |
| Outpatient attendance | 1.002 (1.001-1.002) | <0.001 | 9149 | £126 |

* Rate ratios for model 1 represent the relative change in the rate of admission compared to what would have been expected in the absence of SLIC activity. A rate ratio of 1 indicates no change, while a rate ratio greater than 1 represents an increase, and a rate ratio less than 1 represents a decrease, in admissions.
** No significant change
ǂ Ambulatory Care Sensitive Conditions

*Table 2. Effect of Holistic Assessments and additional hospital costs*

| Outcome | Rate ratio* (95%CI) | p-value | Expected change per 1000 Integrated Care Management cases | Additional hospital costs incurred per patient care managed |
|---|---|---|---|---|
| A&E attendance | 1.000 (0.995-1.006) | 0.911 | NS** | £0 |
| Emergency admissions | 1.005 (0.998-1.011) | 0.190 | NS | £0 |
| Emergency admissions for ACSCs ǂ | 1.005 (0.992-1.017) | 0.476 | NS | £0 |
| Elective admissions | 1.024 (1.018-1.030) | <0.001 | 1501 | £5,858 |
| Outpatient attendance | 1.008 (1.006-1.010) | <0.001 | 4172 | £576 |

* Rate ratios for model 1 represent the relative change in the rate of admission compared to what would have been expected in the absence of SLIC activity. A rate ratio of 1 indicates no change, while a rate ratio greater than 1 represents an increase, and a rate ratio less than 1 represents a decrease, in admissions.
** No significant change
ǂ Ambulatory Care Sensitive Conditions

*Table 3. Effect of Integrated Care Management and additional hospital costs*

These results show no changes in relation to any of the outcomes with the exception of outpatient attendance and elective admissions for which there was a substantial, and unanticipated, increase in hospital utilisation and consequently in secondary care costs associated with the delivery of HAs and ICM.

## Discussion

SLIC's Older People Programme was one of a number of NHS initiatives designed to improve care for older people but had an important additional objective of reducing costs. The rationale for the commonly held belief that better integrated care will reduce costs is that poorly coordinated care may lead to unnecessary healthcare expenditures, for example through avoidable emergency admissions to hospital.

The principal finding of this evaluation was that, compared to that expected based on data from matched control practices and background trends, NHS costs increased rather than decreased over the course of this Programme, although it might have been cost neutral if set-up and infrastructure costs had been excluded. A key aim of the programme to reduce emergency admissions was not achieved, though there was some evidence of reduced A&E attendance towards the end of the Programme. For two key elements of the Programme – HAs and ICM for patients identified as being at higher risk, there was clear evidence that the interventions increased both outpatient attendances and elective admissions and, as a result, led to significant increases in NHS costs. Although we were not able to determine the nature of the conditions giving rise to this increased secondary care activity, it seems reasonable to speculate that this was due to the identification of unmet needs as a result of these enhanced primary care activities that were central to the SLIC programme. If this is true it is an important message; programmes aimed at integration may not always be cost reducing.

There are a number of limitations to the study. This type of observational analysis is always potentially biased by unknown or unmeasured confounders. While it is standard to allow for confounders by using external controls, many areas of England were adopting some sort of initiative to better co-ordinate care. We deliberately avoided some areas with well-known integrated care schemes when selecting controls (e.g. North West London) but problems inevitably remain in identifying matched controls. We addressed this by looking at within-practice changes using random effects models, using a broadly similar set of practices and further adjusting for the practice characteristics, which were included in the matching process. Using this approach, we expect our models to be robust to any systematic differences between control practices and SLIC practices with the exception of the Older Peoples' Programme that was the focus of the evaluation. A further weakness is that, with the exception of HAs and ICM plans, we were unable to relate the changes we found to the wide range of initiatives undertaken by SLIC, some of which developed more slowly than was originally intended. Therefore in order to fully interpret the findings, it would be important to understand which of the original plans (e.g. as shown in Box 1) were actually implemented and to what time-scale and how comprehensively they were implemented.

Full information on this was not available to us and would be needed to draw adequate conclusions about whether individual facets of the intervention ‘worked’ or did not.

Our findings are consistent with several previous studies. For example, a systematic review of interventions to improve coordination in primary care found that around half of studies demonstrated a positive outcome for either health or patient experience, but less than a fifth found any reduction in health service costs[14]. Some studies have found that interventions of a similar type (risk profiling and case management) increase costs initially but that cost savings may accrue after a period, e.g. 18-24 months[15], and we found evidence that reductions in some secondary care activities appeared towards the end of the four year programme. A more recent systematic review of case management of at-risk patients in primary care found no evidence that these interventions produced a reduction in either health service costs or utilisation, though the authors reported ‘very small’ but significant improvements in self-rated health associated with the introduction of case management[16].

The principal implication of these findings for clinicians, NHS managers and policymakers is that the interventions which aim to improve coordination of care, especially if they use some form of population case finding, should focus on improving care rather than reducing costs. Such programmes may identify unmet need and hence lead to potentially appropriate increased use of specialist care. Future studies should focus on improvements in quality of care and not treat the costs of care as being the main outcome of importance.

Checklist

A STROBE checklist is included as a supplementary file.

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Copyright statement



Contributorship statement

All authors contributed to the conception or design of the work, the acquisition, analysis, or interpretation of the data. Gary Abel, Josephine Exley and Silvia Mendonca led on the statistical analysis. Alistair McGuire and José-Luis Fernandez led on the economic analysis. Martin Roland is the guarantor of the study. All authors were involved in drafting and commenting on the paper and have approved the final version.

Ethical approval

Ethical approval was not required for the study as it used standard Hospital Episode Statistics extracts from NHS Digital, fully anonymised and with no sensitive fields

Competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work apart from the research grant from Guy's and St Thomas's charity, no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

Data sharing

No additional data are available.

Transparency declaration.

Professor Roland affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted.

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Open Access statement



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# Case finding and intensive care management of elderly people in primary care: Appendix

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**Further details of statistical methods**

This part of the appendix sets out the technical details of our statistical analysis. We consider four measures of secondary care use: A&E attendances, emergency admissions, outpatient attendances and elective admissions. The same methodology is applied to all four outcome measures. For each outcome we consider overall changes in the rates of admission within Southwark and Lambeth since the introduction of the Older People's Programme relative to what would have been expected based on what happened in areas of the country not implementing such a Programme. The counterfactual scenario was not explicitly calculated but implicitly built into the regression models and was based on practice specific pre-intervention levels and trends, changes seen in control practices over time as well as seasonality and a range of practice characteristics. All our analyses were completed using longitudinal Poisson regression modelling of practice admission/attendance rates.

Matching

The analysis makes use of a set of matched practices. Practices were matched using the so called 'genetic' matching algorithm[1] on baseline admissions/attendances and the rate of change of those admissions/attendances at baseline (with the exception of A&E attendances). The matching also included total list size, the proportion of patients registered with the practice over the age of 65, the proportion of patients registered with the practice over the age of 80, the proportion of patients registered with the practice that were male, the mean years since qualification of GPs, the number of patients per full time equivalent GP (a measure of workload) and the proportion of full time equivalents made up by male GPs, practice deprivation score and the proportion of the practice population describe themselves as white.

The matching was done to obtain five control practices per intervention practice. However, this was done with replacement meaning that one control practice could appear more than once in the comparison set. A total of 263 control practices were identified for the 94 intervention practices. Our original plan was to perform two sets of analyses. The first would include multiple copies of the data for those practices appearing in the matching set more than once. The purpose for doing this was to make the comparison set overall as close to the set of intervention practices as possible and reduce bias. The second set of analyses would only include each of the matched practices once. The reason for this was to avoid any exaggeration of statistical significance due to the artificially enhanced sample size. Unfortunately a number of practices in our analysis data set closed during the period of study and so maintaining an ideally matched overall sample throughout the period was not possible. For this reason we have only conducted the analysis including single copies of control practices. Because we used mixed effects regressions our findings can be interpreted as within-practice changes and so between-practice differences which remain unchanged over time should not confound our observed associations. Furthermore, we adjust for all factors included in the matching process to improve robustness to such confounding.

Data processing

Data on hospital utilisation are taken from Hospital Episode Statistics. Here we make use of three separate datasets: admitted patient care, accident and emergency, and outpatients. Whilst the outpatients and accident and emergency datasets require little preliminary processing, the admitted patient care data does. The admitted patient care data is delimited at the level of the consultant led episode. Given a patient may receive care from more than one consultant's team during their time spent in hospital, it is important to link these episodes of care together to determine the actual number of admissions and the overall length of stay. We use the algorithm developed by the Centre for Health Economics, University of York, to define Continuous Inpatient Spells (CIPS) which also recognise that patients may be transferred between hospitals in anyone admission. Once the CIPS are constructed they are flagged according to whether the admission was elective or an emergency.

Once data pre-processing is complete, admissions or attendances of each type are aggregated for each quarter from April 2009 in groups defined by general practice of patient, age of patient (in five year bands from 65 upwards, up to 85 years old and one group for 85 years and older) and gender of patient. This gives 10 strata per practice at each time point. Data are restricted to those 65 years of age and older and to April 2009 onwards.

In order to model the rates of admissions we need to know the denominator populations to which these admissions refer. These are calculated from the number of patients registered with the practice in the appropriate age by gender strata. The data on practice population are recorded in April each year. These denominators are then applied to each quarter in the calendar year. We excluded data from practices in years in which their practice code did not appear in the denominator data, even when attendances or admissions were attributed to patients at the practice. Further, we excluded the data from practices in the year preceding that where the practice did not appear, in order to exclude practices where mergers or closures may have occurred during the year of analysis. Although such exclusions introduced missing data the model framework used (a longitudinal mixed effects model) is robust to missing data over time under the assumption that the data are missing at random conditional on the covariates in the model.[2]

Statistical analysis

We made use of a series of five models for each of the outcomes of interest to probe the effect of the intervention. The basic structure of each model is the same, differing only in the way in which we operationalise the intervention in the models. We first describe the general model in the absence of the intervention and then describe how the intervention is captured.

*General model*

The models used are mixed effect Poisson models, where the outcome is the number of admissions or attendances in each practice by age group and gender strata. In order to model rates rather than counts, an offset equal to the population denominator for that stratum (see Data section above) is applied in the model. Being a longitudinal model, there are multiple observations for each practice by age group and gender stratum (i.e. one for each quarter of data used). As such we consider the data to be clustered by practice and this is captured using a random intercept.

The models contain strata level categorical fixed effects for age group and gender. They also contain a number of practice level continuous fixed effects describing the practice. These are the total list size, the proportion of patients registered with the practice 65 and over, the proportion of patients registered with the practice aged 80 and over, the proportion of patients registered with the practice that were male, the practice deprivation score, the proportion of the practice population describe themselves as white, the number of GPs at the practice (excluding registrars), the number of full time equivalent GPs, the mean years since qualification of GPs, and the proportion of full time equivalents made up by male GPs. We also include an indicator for SLIC practices in case there remain any systematic differences between them and the control practices.

Background change in the model is captured using four fixed effects and two random effects. Firstly a categorical indicator variable is used for quarter of the year to capture seasonality. This protects against the confounding effect of interventions starting in a particular season and erroneously attributing the seasonal change to the intervention. A quarterly time variable has been created which is the number of quarters from January 2000, which was included as both a squared and cubic terms. Including these three variables as continuous fixed effects allows for the background trend over time to be increasing or decreasing and for this trend to be non-linear. Further, the time variable is included as random effect to allowing the modelled trends over time in admissions to be differential by practice.

*Operationalising the intervention within the general regression model*

Five models were constructed to model the effect of the various interventions on the range of hospital utilisation outcomes.

### Model 1

In this model a categorical variable is included taking a value of 0 for all observations prior to the start of SLIC and for control practices at all time points. For SLIC practices it takes the value of the number of years since the start of the intervention, i.e. 1 in 2012/13, 2 in 2013/14 etc. The resulting rate ratios show on average the relative rate of admission in intervention practices compared to what would have been expected had the effect of the intervention been absent. This rate ratio represents the average difference over a financial year. The model treats all GP practices within the SLIC catchment area as receiving the intervention i.e. includes both practices that are and are not performing HAs/integrated care management.

### Model 2

Recognising that not all practices are performing the intervention at the same level, we decided to perform a dose-response analysis. In order to do that we calculated for each practice at each quarter the cumulative number of HAs that had been performed. This was then divided by the number of over 65 year olds registered at that practice. Whilst in theory patients may have received more than one HA, we interpret this number as the proportion of over 65 year olds who have received an HA. This variable is by definition zero for non-SLIC practice and pre-intervention. Including this variable in our model captures this dose-response effect. The resulting rate ratio is the average change in the rate of admissions or attendances for a 1% increase in the proportion of the population over 65 receiving HA.

### Model 3

As above but restricting the model only to SLIC practices. By doing this the SLIC practices act as their own control, comparing SLIC practices with high volumes of intervention with those with low volumes. Background trends in this model are informed by SLIC practices only.

Model 4 and 5

Models 4 and 5 repeat 2 and 3 but replacing HAs with integrated care management.

A summary of the models and their interpretation is show in the box

**Box. Summary of the five models assessing changes in hospital utilisation.**

**Changes in rates of admissions over time**

Model 1: shows the average practice change in the rate of hospital use on a year-by-year basis relative to what would have been expected with not being part of the SLIC Programme. The model includes both practices that were and were not performing HAs/integrated care management. The results are presented for four financial years' (April to March) data, starting in April 2012 to March 2016.

The resulting rate ratios can be interpreted as the average difference between practices (the relative rate of admission in intervention practices, compared to control practices). A rate ratio of 1 indicates no change, while a rate ratio greater than 1 represents an increase in admissions in the intervention compared to what was expected and a rate ratio less than 1 represents a decrease in admissions in the intervention compared to what was expected.

**Effect of increasing HAs and integrated care management (compared to control practices)**

Model 2: shows the average change in the rate of hospital utilisation for the six outcomes for a 1% increase in the proportion of the population aged 65 and over receiving HA. As above, this model accounts for background changes informed by national trends in our control group of practices, individual practice pre-intervention trends, seasonality and individual practice characteristics. In contrast to model 1, here we treat practices not performing HAs as having zero "dose" of intervention, as with the control group of practices.

Model 4: shows the average change in the rate of hospital utilisation for the six outcomes for a 1% increase in the proportion of the population aged 65 and over receiving integrated care management. As above this model accounts for background changes informed by national trends in our control group of practices, individual practice pre-intervention trends, seasonality and individual practice characteristics. In contrast to model 1, here we treat SLIC practices not undertaking integrated care management as having zero 'dose' of intervention, along with the control group of practices.

**Effect of increasing HAs and integrated care management (analysis restricted to SLIC practices)**

Model 3: repeats analysis of model 2 but is restricted to SLIC practices. It shows the average change in the rate of hospital utilisation for the six outcomes for a 1% increase in the proportion of the population aged 65 and over receiving an HA. Background trends in this model are informed by SLIC practices only.

Model 5: the analysis repeats that of model 4 but is restricted to SLIC practices. It shows the average change the rate of hospital utilisation for the six outcomes for a 1% increase in the proportion of the population aged 65 and over receiving integrated care management. Background trends in this model are informed by SLIC practices only.

The resulting rate ratios for models 2 to 5 can be interpreted as the average difference between two practices, where one is performing HAs/integrated care management on 1% more of its patients aged 65 and over than the other. A rate ratio of 1 indicates no change, while a rate ratio greater than 1 represents an increase, and a rate ratio less than 1 represents a decrease, for example, in admissions.

*Data structure, sample size and sensitivity analysis*

All of the analyses were conducted at the GP practice-level. Outcome data used for the analyses come from Hospital Episode Statistics (HES) – a centrally held data warehouse containing details of all admissions, outpatient appointments and A&E attendances at NHS hospitals in England. Our dataset consists of 357 practices, including 94 practices in Southwark and Lambeth, and covers the time period from the three years prior to, and four years following, the start of the Programme (2$^{nd}$ quarter of 2009 to 1$^{st}$ quarter of 2016). For each GP practice we know the number of admissions and attendances in each five-year age band (5 age groups) for each gender and for each quarter over the seven years (28 quarters). We refer to each of these as a 'stratum', for example, the number of admissions or attendances for women in the age group 65 to 69 years old during the 1st quarter of 2015 in a specific GP practice. In total the data set consisted of 98,081 strata for hospital admissions/attendance, corresponding to a population of between 194,337 and 215,447 at any one time period (the actual population served changed over time). In analyses of admissions and A&E attendance which were restricted to SLIC practices the dataset included 25,702 strata corresponding to populations of between 50,356 and 53,869 in any one time period. When considering inpatient length of stay 87,338 strata were included in the model corresponding to between 35,410 and 45,816 admissions in any one quarter. Inpatient length of stay models restricted to SLIC practices included populations of between 10,542 and 12,596 in any one time period.

Initial inspection of the raw data showed that for some practices there were times where the rates of admission or attendances were very high in one or more of the strata (as above, these are five-year age bands subdivided by gender for each quarter in each of the three years prior to and four years following the start of the Programme). To examine the influence of these high rates we carried out sensitivity analyses excluding data where very high admission/attendance rates or mean lengths of stay were seen (excluding individual strata with more than one admission per person per quarter for A&E attendance and inpatient emergency admissions, more than three admissions per person per quarter for inpatient elective admissions or more than four admissions per person per quarter for outpatient appointments). In the inpatient length of stay analysis we excluded mean lengths of stay longer than 1 year. These sensitivity analyses excluded up to a maximum of 108 patients at risk for A&E admissions, 926 for outpatient appointments, 77 for elective admission and 21 for emergency admissions (these are maximum numbers per quarter, the number of exclusions varies by quarter). For inpatient length of stay a maximum of 160 admissions were excluded in a given quarter. None of the sensitivity analyses made a material difference to our conclusions and the detailed results are therefore not included in the report, but are available on request from the authors.

**Further results of the statistical analysis.**

The main results are summarised in tables 1, 2 and 3 in the main paper. Here we reproduce more detailed outputs which contain analysis for each year in model 1 and full outputs from models 2 to 5. Model outputs are provided for each of the five outcome measures.

In the following tables, rate ratios for model 1 represent the relative change in the rate of admission (or length of stay) compared to what would have been expected in the absence of SLIC activity. In models 2 to 5 the rate ratios represent the average relative difference between two practices, where one is performing HAs or integrated care management on 1% more of its patients aged 65 and over than the other. A rate ratio of 1 indicates no change, while a rate ratio greater than 1 represents an increase, and a rate ratio less than 1 represents a decrease, in admissions. Observed attendance rate refers to the observed attendance rate in patients aged 65 and over across all SLIC practices included in the analysis. The expected rate has been calculated according to the model results and is equal to the observed rate/rate ratio. For Holistic Assessments (HAs) and Integrated Care Management (ICM), the expected change in attendances has been calculated from the model rate ratio for 18.9% of the 65 and over population receiving HAs and for 1.9% of the 65 and over population receiving integrated care management.

*Table A1. A&E attendance: Comparison with control practices*

| Year | Rate Ratio[a] (95% CI)[b] | p-value[c] | Observed rate for SLIC practices (A&E attendances per 1000 patients per year) | Expected rate in the absence of intervention (A&E attendances per 1000 patients per year) |
|---|---|---|---|---|
| 2012/13 | 1.020 (1.002-1.038) | 0.032 | 144 | 141 |
| 2013/14 | 1.001 (0.978-1.025) | 0.931 | No significant change | No significant change |
| 2014/15 | 0.973 (0.946-1.002) | 0.068 | No significant change | No significant change |
| 2015/16 | 0.944 (0.913-0.976) | 0.001 | 144 | 153 |

*Table A2. A&E attendance: Effect of HAs and integrated care management*

| Rate Ratio[a] (95% CI)[b] | p-value[c] | Expected change in number of A&E attendances per 10,000 HAs[e] or per 1,000 ICMs[f] |
|---|---|---|
| *Model 2 – Effect of HAs (cumulative total over four years compared to control practices)* | | |
| 1.000 (0.999-1.000) | 0.306 | No significant change |
| *Model 3 – Effect of HAs (cumulative total over four years – SLIC practices only)* | | |
| 1.000 (0.999-1.001) | 0.760 | No significant change |
| *Model 4 – Effect of integrated care management (ICMs, cumulative total over four years compared to control practices)* | | |
| 1.004 (0.999-1.008) | 0.114 | No significant change |
| *Model 5 – Effect of integrated care management (cumulative total over four years – SLIC practices only)* | | |
| 1.000 (0.995-1.006) | 0.911 | No significant change |

*Table A3. Emergency admissions: Comparison with control practices*

| Year | Rate Ratio[a] (95% CI)[b] | p-value[c] | Observed rate for SLIC practices[d] (emergency admissions per 1000 patients per year) | Expected rate in the absence of intervention[d] (emergency admissions per 1000 patients per year) |
|---|---|---|---|---|
| 2012/13 | 1.043 (1.019-1.067) | <0.001 | 77 | 74 |
| 2013/14 | 1.031 (1.001-1.062) | 0.043 | 77 | 75 |
| 2014/15 | 1.019 (0.983-1.056) | 0.301 | No significant change | No significant change |
| 2015/16 | 1.011 (0.971-1.052) | 0.600 | No significant change | No significant change |

*Table A4. Emergency admissions: Effect of HAs and integrated care management*

| Rate Ratio[a] (95% CI)[b] | p-value[c] | Expected change in number of emergency admissions per 10,000 HAs[e] or per 1,000 ICMs[f] |
|---|---|---|
| *Model 2 – Effect of HAs (cumulative total over four years compared to control practices)* | | |
| 1.000 (0.999-1.001) | 0.497 | No significant change |
| *Model 3 – Effect of HAs (cumulative total over four years – SLIC practices only)* | | |
| 1.001 (1.000-1.002) | 0.201 | No significant change |
| *Model 4 – Effect of Integrated care management (ICM, cumulative total over four years compared to control practices)* | | |
| 1.004 (0.998-1.009) | 0.177 | No significant change |
| *Model 5 – Effect of Integrated care management (ICM, cumulative total over four years – SLIC practices only)* | | |
| 1.005 (0.998-1.011) | 0.190 | No significant change |

*Table A5. Emergency admissions for ambulatory care sensitive conditions: Comparison with control practices*

| Year | Rate Ratio (95% CI)* | p-value | Observed rate for SLIC practices[d] (ACSC admissions per 1000 patients per year) | Expected rate in the absence of intervention[d] (ACSC admissions per 1000 patients per year) |
|---|---|---|---|---|
| 2012/13 | 1.072 (1.026-1.120) | 0.002 | 21 | 19 |
| 2013/14 | 1.118 (1.056-1.184) | <0.001 | 21 | 19 |
| 2014/15 | 1.149 (1.076-1.228) | <0.001 | 22 | 19 |
| 2015/16 | 1.073 (1.004-1.147) | 0.037 | 20 | 19 |

*Table A6. Emergency admissions for ambulatory care sensitive conditions: Effect of HAs and integrated care management*

| Rate Ratio (95% CI)* | p-value | Expected change in number of ACSC admissions per 10,000 HAs[e] or per 1,000 ICMs[f] |
|---|---|---|
| *Model 2 – Effect of HAs (cumulative total over four years compared to control practices)* | | |
| 1.001 (1.000-1.003) | 0.073 | No significant change |
| *Model 3 – Effect of HAs (cumulative total over four years – SLIC practices only)* | | |
| 1.001 (0.998-1.003) | 0.516 | No significant change |
| *Model 4 – Effect of Integrated care management (ICM, cumulative total over four years compared to control practices)* | | |
| 1.008 (0.998-1.017) | 0.127 | No significant change |
| *Model 5 – Effect of Integrated care management (ICM cumulative total over four years – SLIC practices only)* | | |
| 1.005 (0.992-1.017) | 0.476 | No significant change |

*Table A7. Outpatient attendance: Comparison with control practices*

| Year | Rate Ratio[a] (95% CI)[b] | p-value[c] | Observed rate for SLIC practices[d] (outpatient attendances per 1000 patients aged 65 and over per year) | Expected rate in the absence of intervention[d] (outpatient attendances per 1000 patients aged 65 and over per year) |
|---|---|---|---|---|
| 2012/13 | 0.961 (0.954-0.968) | <0.001 | 1093 | 1137 |
| 2013/14 | 1.004 (0.995-1.014) | 0.375 | NS | NS |
| 2014/15 | 0.973 (0.961-0.985) | <0.001 | 1213 | 1247 |
| 2015/16 | 0.921 (0.908-0.935) | <0.001 | 1220 | 1324 |

*Table A8. Outpatient attendance: Effect of HAs and integrated care management*

| Rate Ratio[a] (95% CI)[b] | p-value[c] | Expected change in number of outpatient attendances per 10,000 HAs[e] or per 1,000 ICMs[f] |
|---|---|---|
| *Model 2 – Effect of HAs (cumulative total over four years compared to control practices)* | | |
| 1.000 (1.000-1.000) | 0.557 | No significant change |
| *Model 3 – Effect of HAs (cumulative total over four years – SLIC practices only)* | | |
| 1.002 (1.001-1.002) | <0.001 | 9149 |
| *Model 4 – Effect of Integrated care management (ICM, cumulative total over four years compared to control practices)* | | |
| 1.003 (1.001-1.005) | <0.001 | 1491 |
| *Model 5 – Effect of Integrated care management (ICM, cumulative total over four years – SLIC practices only)* | | |
| 1.008 (1.006-1.010) | <0.001 | 4172 |

*Table A9. Elective admissions: Comparison with control practices*

| Year | | Rate Ratio[a] (95% CI)[b] | p-value[c] | Observed rate for SLIC practices[d] (elective admissions per 1000 patients aged 65 and over per year) | Expected rate in the absence of intervention[d] (elective admissions per 1000 patients aged 65 and over per year) |
|---|---|---|---|---|---|
| 2012/13 | | 1.001 (0.982-1.020) | 0.945 | No significant change | No significant change |
| 2013/14 | | 0.990 (0.965-1.016) | 0.454 | No significant change | No significant change |
| 2014/15 | | 0.955 (0.924-0.987) | 0.005 | 156 | 164 |
| 2015/16 | | 0.938 (0.902-0.975) | 0.001 | 153 | 164 |

*Table A10. Elective admissions: Effect of HAs and integrated care management*

| Rate Ratio[a] (95% CI)[b] | p-value[c] | Expected change in number of elective admissions per 10,000 HAs[e] or per 1,000 CMs[f] |
|---|---|---|
| *Model 2 – Effect of HAs (cumulative total over four years compared to control practices)* | | |
| 1.001 (1.000-1.001) | 0.165 | No significant change |
| *Model 3 – Effect of HAs (cumulative total over four years – SLIC practices only)* | | |
| 1.004 (1.003-1.005) | <0.0001 | 2399 |
| *Model 4 – Effect of Integrated care management (cumulative total over four years compared to control practices)* | | |
| 1.012 (1.007-1.016) | <0.001 | 735 |
| *Model 5 – Effect of Integrated care management (cumulative total over four years – SLIC practices only)* | | |
| 1.024 (1.018-1.030) | <0.0001 | 1501 |

*Table A11. Length of stay for all inpatient admissions: Comparison with control practices*

| Year | Rate ratio for length of stay[a] (95% CI)[b] | p-value[c] | Observed mean length of stay for SLIC practices[d] (in days) | Expected mean length of stay in the absence of SLIC intervention[d] (in days) |
|---|---|---|---|---|
| 2012/13 | 1.073 (1.014-1.134) | 0.014 | 28 | 26 |
| 2013/14 | 1.009 (0.942-1.081) | 0.797 | No significant change | No significant change |
| 2014/15 | 1.004 (0.932-1.083) | 0.907 | No significant change | No significant change |
| 2015/16 | 1.011 (0.937-1.090) | 0.776 | NS | No significant change |

*Table A12. Length of stay for all inpatient admissions: Effect of HAs and integrated care management*

| Rate ratio for length of stay[a] (95% CI)[b] | p-value[c] | Expected change in length of stay per 10,000 HAs or per 1,000 ICMs |
|---|---|---|
| *Model 2 – Effect of HAs (cumulative total over four years compared to control practices)* | | |
| 0.999 (0.997-1.001) | 0.467 | No significant change |
| *Model 3 – Effect of HAs (cumulative total over four years – SLIC practices only)* | | |
| 1.000 (0.997-1.002) | 0.754 | No significant change |
| *Model 4 – Effect of Integrated care management (cumulative total over four years compared to control practices)* | | |
| 0.995 (0.983-1.007) | 0.420 | No significant change |
| *Model 5 – Effect of Integrated care management (cumulative total over four years – SLIC practices only)* | | |
| 0.996 (0.981-1.012) | 0.657 | No significant change |

<u>Further details of the economic analysis</u>

In this part of the appendix we expand on the results shown in the main paper which refer to average NHS costs. In actuality, these vary across the country and routine NHS statistics report lowest and highest costs as well as the average value. In the first table here (table A13), we show the bounds of these tariff values. In the second table (A14) we additionally show as a sensitivity analysis the effect of using upper and lower bounds of costs and also upper, average and lower bounds of activity based on the confidence intervals reported in the statistical analysis.

*Table A13. Low, Average and High standard NHS Tariff Value Range*

| | Lowest | Average | Highest |
|---|---|---|---|
| A&E Attendances | £91 | £184 | £322 |
| Emergency Admissions | £628 | * | £2,953 |
| Elective Admissions | £2,517 | £3,903 | £4,162 |
| Out-patients | £138 | £138 | £138 |

*not available

*Table A14. Net cost in comparison to control practices of the Older People's Programme per Southwark and Lambeth resident ≥65: sensitivity analysis using low, average and high NHS tariffs and lower, average and upper bounds of estimated impact on hospital utilisation*

| | Lower bound of activity | | | Mean bound of activity | | | Upper bound of activity | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lowest tariff | Average tariff | Highest tariff** | Lowest tariff | Average tariff | Highest tariff | Lowest tariff | Average tariff | Highest tariff |
| Total SLIC cost | £149 | £149 | £149 | £149 | **£149** | £149 | £149 | £149 | £149 |
| Total offset | -£103 | -£99 | -£154 | -£70 | **-£86** | -£106 | -£45 | -£15 | -£45 |
| Net Total SLIC cost | £47 | £50 | -£4 | £79 | **£64** | £43 | £105 | £134 | £105 |
| Total SLIC cost (net infrastructure costs) | £91 | £91 | £91 | £91 | **£91** | £91 | £91 | £91 | £91 |
| Net Total SLIC cost | -£12 | -£8 | -£63 | £21 | £5 | -£15 | £46 | £76 | £46 |

*The figures in bold are those presented and discussed in the main paper. ** For A&E attendance the figure of £2953 was used for both upper and average tariff.

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[1] Sekhon JS. Multivariate and propensity score matching software with automated balance optimization: the matching package for R. 2011. Journal of Statistical Software 2011; 42. doi 10.18637/jss.v042.i07

[2] Gibbons RD, Hedeker D, DuToit S. Advances in analysis of longitudinal data. Annu Rev Clin Psychol. 2010; 6: 79–107.

STROBE Statement Case finding and intensive care management of elderly people in primary care may increase secondary care costs: cost-consequences analysis of the South London Integrated Care Pilot.

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract: *Title and abstract include 'controlled time series' and 'cost-consequences analysis'* |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found: *Abstract includes these* |
| **Introduction** | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported. *Introduction (pages 3 and 4) includes these.* |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses. *Objectives and prespecified hypotheses are set out in the method section on page 4. Page 5 explains the rationale for carrying our additional analyses on holistic assessments and integrated case management that were not part of the original protocol.* |
| **Methods** | | |
| Study design | 4 | Present key elements of study design early in the paper. *These are set out in pages 4 and 5 of the paper.* |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection *These are set out in pages 4 and 5 of the paper.* |
| Participants | 6 | *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls. *These are set out in pages 4 and 5 of the paper, with further details on page 2 of the appendix* |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable *Details are given on pages 4 and 5 of the main paper. Further details of assessment methods are described on pages 2-6 of the appendix* |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. *Data sources are set out on page 4 of the main paper. Further details of assessment methods are described on pages 2-6 of the appendix* |
| Bias | 9 | Describe any efforts to address potential sources of bias. *Details of matching and efforts to reduce bias are described on page 2 of the appendix* |
| Study size | 10 | Explain how the study size was arrived at: *This is described on page 5 and 6 of the appendix – the analysis included data for the whole relevant population of the two London boroughs.* |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why *Details are given on pages 4 and 5 of the main paper. Further details are included on pages 2-6 of the appendix* |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding *See response to Q 11* |

| | | |
|---|---|---|
| | | (*b*) Describe any methods used to examine subgroups and interactions *See response to Q 11* |
| | | (*c*) Explain how missing data were addressed *See response to Q 11* |
| | | (d)*Case-control study*—If applicable, explain how matching of cases and controls was addressed |
| | | (*e*) Describe any sensitivity analyses *A sensitivity analysis for practices where there were times where the rates of admission or attendances were very high for one or more of the age-gender strata is described on page 6 of the appendix* |
| **Results** | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. *The number of subjects is described on pages 5/6 of the appendix.* |
| | | (b) Give reasons for non-participation at each stage *N/A* |
| | | (c) Consider use of a flow diagram *Not included* |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders *These are not included as such. For the cases, the population included the whole relevant population of two London boroughs, with matching criteria for controls as described above.* |
| | | (b) Indicate number of participants with missing data for each variable of interest N/A |
| Outcome data | 15* | |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure *These are reported on pages 5/6 of the appendix.* |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included. *All estimates are adjusted, as described in the methods sections.* |
| | | (*b*) Report category boundaries when continuous variables were categorized. *Categories for age-gender strata are described on page 3 of the appendix.* |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period. *Rate ratios are also expressed in terms of impact on absolute numbers in tables 1 to 3 in the main paper and tables A1 to A12 in the appendix.* |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses *The sensitivity analysis is reported on page 6 of the appendix.* |
| **Discussion** | | |
| Key results | 18 | Summarise key results with reference to study objectives *Included* |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias *Included* |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence *Included* |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results *Included* |
| **Other information** | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based *Included* |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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# Impact of the Southwark and Lambeth Integrated Care Older People's Programme on hospital utilisation and costs: controlled time series and cost consequence analysis.



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| | |

# Impact of the Southwark and Lambeth Integrated Care Older People's Programme on hospital utilisation and costs: controlled time series and cost consequence analysis.

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**Objectives**. To estimate the impact on hospital utilisation and costs of a multi-faceted primary care intervention for older people identified as being at risk of avoidable hospitalisation.

**Design**. Observational study: controlled time series analysis; estimation of costs and cost-consequences of the Programme. GP practice level data were analysed from 2009 to 2016 (intervention operated from 2012-2016). Mixed effect Poisson regression models of hospital utilisation included comparisons with control practices and background trends in addition to within-practice comparisons. Cost estimation used standard tariff values.

**Setting**: 94 practices in Southwark and Lambeth, 263 control practices from other parts of England.

**Main outcome measures**: Hospital utilisation: emergency department attendance, emergency admissions, emergency admissions for ambulatory sensitive conditions, outpatient attendance, elective admission, length of stay.

**Results**: By the fourth year of the Programme there were reductions in A&E attendance (rate ratio 0.944, 95%CI 0.913-0.976), outpatient attendances (rate ratio 0.938 95%CI 0.902-0.975) and elective admissions (rate ratio 0.921 95%CI 0.908-0.935) but there was no evidence of reduced emergency admissions. The costs of the Programme were £149 per resident aged 65 and over but savings in hospital costs were only £86 per resident aged 65 and over, equivalent to a net increase in health service expenditure of £64 per resident, though the Programme was nearly cost-neutral if set-up costs were excluded. Holistic Assessments carried out by GPs and consequent Integrated Care Management plans were associated with increases in elective activity and costs; £126 increase in outpatient attendance and £936 in elective admission costs per Holistic Assessment carried out, and £576 increase in outpatient and £5,858 in elective admission costs per patient receiving Integrated Care Management.

**Conclusions**: The Older People's Programme was not cost-saving. Some aspects of the Programme were associated with increased costs of elective care, possibly through the identification of unmet need.

**Strengths and limitations of this study**

- The analysis covered a seven-year period; three years prior to and the four years following the start of the Programme including a set of matched controls from other parts of England.
- We examined within-practice changes using random effects models. We analysed rates of hospital utilisation across different age and gender groups, to allow for potential changes in the age profile of the population over the course of the study period. Models also adjusted for individual practice characteristics and the effect of the time of year (seasonality).
- For two specific components of the intervention (Holistic Assessments and Integrated Care Management) we were able to look for a 'dose-effect' to see whether the delivery of these elements appeared to have independent effects on hospital utilisation.
- Sensitivity analyses, excluding small numbers of practices with unusually high rates of admission or mean length of stay, did not alter our conclusion.
- The analysis focused on measures of secondary care use, however the intervention might have had an effect that went beyond these outcomes.

## Introduction

It is widely recognised that care of elderly people falls short of the ideal. Reasons for this include failure to identify developing medical problems and failure to provide well-coordinated care for people with multiple complex problems, both of which may lead to avoidable emergency admissions.[1,2] A wide range of initiatives have been developed in recent years but most include, in some form, identifying patients in need of more intensive or coordinated management and then intervening with proactive packages of care designed to maximise patients' abilities to self-manage their conditions and anticipate preventable deteriorations in health. Risk profiling and intensive case management form common parts of these approaches.[3,4,5,6,7]

The conceptual basis behind case management interventions lies in the Chronic Care Model, which includes using clinical information systems to plan patient care and redesigning the delivery of care to meet the needs of patients with chronic illness.[8] Payers have focused on these elements of the model to identify patients with high healthcare costs, hoping that better targeted and coordinated care will improve care and reduce costs, though often with a focus on costs as the primary outcome. Uncontrolled studies of healthcare utilisation in this group often show reduction in utilisation, which may simply result from regression to the mean[9] and systematic reviews of rigorous evaluations of case management and interventions to integrate or coordinate care have, on the whole, shown much smaller effects[6,10,11]. One problem is whether case management interventions should target the highest risk group who are likely to show the greatest impact on individuals but unlikely to show much impact on healthcare costs overall.[9] The Southwark and Lambeth Integrated Care (SLIC) Older People's Programme ('the Programme') reported in this paper took a population wide approach. The Programme originally intended to carry out holistic assessments in general practice with half of all residents aged 65 and over in the two south London boroughs, combined with a range of primary and secondary care interventions and targeted case management for those identified as at risk.

The Programme was set up in 2012 to maximise the health and independence of older people and minimise avoidable hospital utilisation.[12] SLIC brought together general practitioners (GPs), hospitals and local authorities to redesign services and provide better integrated care for people aged 65 and over. The Programme consisted of many different projects, which addressed a range of aspects of health and social care, summarised in the box. Alongside the projects listed, the Programme aimed to support the development of the wider system enablers of change such as IT infrastructure.

**Box. Summary of the main elements of the SLIC Older People's Programme**

| |
|---|
| *Better proactive identification of need and interventions to avoid crisis* |
| • Holistic assessments (HAs); a proactive and holistic assessment of need, for older people, undertaken by GP practices.<br>• Integrated care management (ICM) plans for older people identified as 'at risk' in holistic assessments; additional named support for care co-ordination/navigation or wider care planning<br>• Community based multi-disciplinary team meetings (CMDT); these include hospital, community and social care staff who support care managers and GPs with challenging care management or system blockages.<br>• Redesigned clinical pathways including for falls, infections, nutrition and dementia |
| *An alternative acute response* |
| • Consultant 'hotline' and 'hot clinic'; direct access to specialist hospital phone line and rapid access clinics for community staff and GPs to support immediate action planning and admission avoidance.<br>• Enhanced Rapid Response (ERR); community based therapy, nursing and social care to support people to stay in their home and prevent an admission to hospital or to support them to be discharged from hospital earlier in their stay.<br>• @home; multidisciplinary team providing acute clinical care at home which otherwise would be carried out in hospital. |
| *Maximising independence before long-term care is finalised* |
| • Simplified discharge processes; designing options for a unified point of access for community and social care services at the point of discharge and new models to improve the discharge process for patients returning home or to a care home. |

A key element of the Programme was the introduction of a screening tool, Holistic Assessments (HAs), to proactively identify health and social care needs of people aged 65 and over within General Practice in the two boroughs and then put care plans in place to address those needs that might otherwise have led to avoidable secondary care use. Each HA included assessment of the patient's physical health, mental health and social care needs, as well as wider social aspects of daily living (e.g. benefits and housing). Patients identified as requiring additional support were allocated for Integrated Care Management (ICM), conducted by a dedicated member of staff from a local care provider. Care managers varied from patient to patient. For example, a patient with complex medical needs may be care managed by their named GP while someone requiring more non-medical support and service co-ordination could be care managed by another trained professional within the practice team. Where patients presented with complex problems or where systems blockages were present, cases could be presented and discussed at a local Community Multi-Disciplinary Team (CMDT).

The intention was for GPs to undertake an HA with half of all their patients aged 65 and over. However, from the outset the Programme experienced difficulties in delivering the anticipated activity targets for HAs, ICM and CMDT. Low levels of activity were attributed to a number of reasons; for example, some primary care staff felt interventions were imposed on them and that they lacked time to engage with the Programme.[13] In 2014, recovery plans were put in place, the HAs were reviewed and targets revised. This resulted in the eligible population for HAs being changed to all people aged 80 or over and people aged over 65 who were either housebound or had not been seen by a GP for 15 months. In 2015, this bundle of projects was expanded to include Care Navigation and Locality Geriatricians.

This evaluation was commissioned to run in parallel with the Programme from August 2012 until the end of the Programme in March 2016, with the principle aim of examining changes in hospital utilisation by people aged 65 and over registered with GPs in Southwark and Lambeth following implementation of the Programme. In most respects it was not possible to single out which elements of the Programme were more or less successful in achieving the wide range of aims originally set out by the SLIC partners. However, we were able to estimate the overall effect of the Programme on hospital admissions and length of stay and, because of the particular way the Programme developed, we were able to isolate the effects of HAs and ICM plans for those identified as 'at risk'.

**Method**

Using Hospital Episode Statistics (HES) [14] provided by NHS Digital, which contains details of all admissions, outpatient appointments and A&E attendance at NHS hospitals in England, we considered five outcome measures of hospital utilisation for people aged 65 and over registered at a GP practice in Southwark and Lambeth:

1. accident and emergency (A&E) attendance;
2. emergency hospital admissions;
3. emergency hospital admissions for patients with admissions for 'ambulatory care sensitive' (ACS) conditions recorded as one of the diagnoses on discharge[15]. ACS conditions are those for which, in principle, crises leading to emergency admissions that might be prevented by improved care in the community.
4. outpatient attendance;
5. elective hospital admissions

A series of analyses were performed using a Poisson regression based approach that allowed for the longitudinal and clustered nature of the data. Data were analysed for the three years prior to and the four years following the start of the Programme (second quarter of 2009 to first quarter of 2016) in 5-year age-band by gender strata. By analysing rates of hospital utilisation across different age and gender groups, we allow for potential changes in the age profile of the population over the course of the study period. In addition to age and gender, models also adjusted individual practice characteristics and for the effect of the time of year (seasonality). Further details of the methods and full regression results are shown in the appendix. We carried out sensitivity analyses excluding small numbers of practices with unusually high rates of admission or mean length of stay, but none of these made a material difference to our conclusions and they are not reported here. In addition to these outcomes, we also analysed length of stay and found no effect of any of the interventions (full results of the length of stay analysis are in appendix tables A1 and A2).

In our first analysis we compared trends in these practices with those in a matched group of control practices from other parts of England using a 'genetic' matching algorithm.[16] Originally control practices were matched with a ratio of five controls for every intervention practice with replacement meaning that control practices could appear more than once in the comparison dataset. However, due to the extended period of analysis we found a significant number of practices had closed meaning it would be impossible to maintain exact matching. As a consequence, we felt the advantage of including duplicate records for some practices was minimal and only a single copy of data from each practice was used. Practices were matched on basis of list size, the proportion of patients registered with the practice over the age of 65, the proportion of patients registered with the practice over the age of 80, the proportion of male patients, the mean years since qualification of GPs, the number of patients per full time equivalent GP (a measure of workload), the proportion of full time equivalent GPs made up by male GPs, practice deprivation score and the proportion of the practice population describing themselves as white. In addition, control practices were matched on baseline admissions/attendance and the rate of change of those admissions/attendance at baseline, in this case not including A&E attendance. Further details of the matching are given in the appendix.

A second set of analyses took account of the variation in the level of activity that occurred between practices in Southwark and Lambeth for two key elements of the Programme –HAs and ICM. Since some practices implemented these more rapidly and more comprehensively than others, we were able to look for a 'dose-effect' to see whether the delivery of these two specific elements of the Programme appeared to have independent effects on hospital utilisation. We used the percentage of patients aged 65 and over who had received one of the interventions at each of 13 three-month post-intervention time points as a measure of the 'dose' of intervention in that practice at that time (using the cumulative total percentage at each time point). For these analyses we conducted two separate regressions: one estimating the effect of increasing HAs and ICM in comparison to our control group of practices and the second restricting the analysis of increasing HAs and ICM to practices in Southwark and Lambeth. The restricted analysis allows for practices in Lambeth and Southwark being 'special' in some way, for example, particular ethnic profiles, which were different from other parts of the country. We report the latter set of results in the main paper as more reliably estimating differences in primary care activity between practices that have performed more HAs/ICM and those practices performing fewer or none, while the comparison with control practices may also reflect a more general effect of the Programme (e.g. changes to budgets, changes in other services including secondary care provision). For completeness, we present both sets of results in the appendix, with the models described in more detail in Appendix Box A1

For the economic analysis, we drew data on the costs of the SLIC Programme from a Kings College London report[17]. This estimated the costs of the whole Programme over the period at £7.4 million of which £2.9 million were infrastructure or 'enabling' costs associated with the initial establishment of the Programme. Averaging these costs across all residents age 65 and over in Southwark and Lambeth gives SLIC implementation costs per older person of £149 across the life of the Programme, or £91 excluding infrastructure/enabling costs. Hospital utilisation costs were taken from the NHS Improvement Tariff Payment System[18] and the PSSRU cost book[19]. These give average, upper and lower bounds for NHS payments for A&E attendance, emergency and elective admissions and outpatient attendance (see appendix, table A3). In the paper we report the results for estimated average costs incurred, with sensitivity analyses using the upper and lower bounds for both cost and potential impact on hospital utilisation reported in the appendix (table A4). We only estimated costs where there were statistically significant effects on the outcomes and we did not carry out this analysis for ACS conditions to avoid double counting.

We used Stata version 15 for data management and all models were run in SAS version 9.4.

STROBE and CHEERS checklists are included as supplementary files.

Patient and Public involvement

The analyses of secondary data carried out in this study were specified in the final protocol agreed with the funder. SLIC had its own patient representative group and a member of this group was present at meetings of the SLIC Evaluation Steering Group which reviewed interim findings. There was no other direct patient or public involvement in developing or reporting on the analyses reported in this paper.

## Results

We analysed data from 357 practices, including 94 practices in Southwark and Lambeth and 263 matched control practices. For reasons described above, some control practices were selected more than once in the matching procedure: of the matched practices, 164 (62 per cent) are practices that were selected only once. Sixty one (23 per cent) practices were selected twice and the remaining 38 (15 per cent) of control practices are made up of practices that appear three or more times.

Quality of Matching

We examined the extent to which the intervention and control practices were matched for baseline characteristics, the results of which are shown graphically in figures A1 to A17 in the appendix. The variables showing substantial departures from the national profile are the percentage of patients who are over 65 (figure A10), over 85 (figure A11), the practice deprivation score (figure A13) and white (figure A14). In particular we see that intervention practices tend to have fewer old patients compared to England and are on average located in more deprived areas (i.e. their IMD score is higher). In general, the matching has done a reasonable job of reproducing the distribution of matching variables in the intervention practices, even for those variables where substantial departures are seen from the national distribution. However, some small, and statistically significant, deviations remain. As described above, we further adjusted for practice characteristics in the analysis to isolate so far as possible the effect of the intervention.

Overall impact of the SLIC Programme on hospital utilisation

Table 1 shows the overall effect of the Programme on the five hospital utilisation outcomes by the end of the Programme in 2016. A more detailed year-by-year breakdown of the results is shown in the appendix (tables A5 to A14).

| Outcome | Rate ratio* (95%CI) | p-value | Observed rate for SLIC | Expected rate in the |
|---|---|---|---|---|

| | | | practices per 1000 patients per year | absence of SLIC intervention per 1000 patients per year |
|---|---|---|---|---|
| A&E attendance | 0.944 (0.913-0.976) | 0.001 | 144 | 153 |
| Emergency admissions | 1.011 (0.971-1.052) | 0.600 | NS** | NS |
| Emergency admissions for ACSCs ƚ | 1.073 (1.004-1.147) | 0.037 | 20 | 19 |
| Elective admissions | 0.938 (0.902-0.975) | 0.001 | 153 | 164 |
| Outpatient attendance | 0.921 (0.908-0.935) | 0.001 | 1220 | 1324 |

* Rate ratios for model 1 represent the relative change in the rate of admission compared to what would have been expected in the absence of SLIC activity. A rate ratio of 1 indicates no change, while a rate ratio greater than 1 represents an increase, and a rate ratio less than 1 represents a decrease, in admissions.
** No significant change
ƚ Ambulatory Care Sensitive Conditions

*Table 1 Hospital utilisation: comparison with control practices by year 4 of the SLIC Programme*

The Programme was associated with a reduction in A&E attendance by patients age 65 and over compared to that expected based on control practices and background trends. This reduction was only evident by the end of the Programme: more detailed year-by-year results (appendix, table A5) show a small initial rise in attendance followed by no change in the middle of the programme and a reduction by the fourth year. Compared to that expected based on control practices and background trends there was no evidence of a reduction in emergency admissions (a key aim of the Programme) in any of the four years, but a small rise in emergency admissions for ACS conditions, a rise that was evident in all four years of the Programme (appendix table A9). There were significant reductions in attendance at outpatients and in elective admissions, neither of which were stated aims of the Programme.

Over the four years of the Programme, there was a net reduction in hospital costs of £86 per Southwark and Lambeth resident 65 or over. Against an overall cost of implementing the SLIC Programme of £149, this represents a net increase in cost to the NHS of £64 per resident. If the infrastructure/enabling costs are removed (as these might not be ongoing once the Programme was established) then the net saving in hospital costs (£86) is very close to the costs of the Programme (£91) and sensitivity analyses (table A14) using lower bounds for costs and effect on hospitalisation shows the potential for the Programme to be cost-saving.

Impact of Holistic Assessments and Integrated Care Management on hospital utilisation

At the end of the evaluation in March 2016, 26.9% of the population aged 65 and over had received a HAs, ranging from 0% to 94.1% of the population aged 65 and over in individual general practices. 3.5% of the population aged 65 and over had been referred for ICM, ranging from 0% to 18.3% of the population aged 65 and over in individual general practices.

Table 2 shows the average change in the rate of hospital utilisation for the six outcomes for a 1% increase in the proportion of the population aged 65 and over receiving HAs. The models account for individual practice pre-intervention trends, seasonality and the full range of individual practice characteristics. Table 3 shows similar analyses, this time with ICM as the outcome. In each case we report the additional secondary care costs incurred association with the increased primary care activities.

| Outcome | Rate ratio* (95%CI) | p-value | Expected change per 10,000 Holistic Assessments | Additional hospital costs incurred per Holistic Assessment |
|---|---|---|---|---|
| A&E attendance | 1.000 (0.999-1.001) | 0.760 | NS** | £0 |
| Emergency admissions | 1.001 (1.000-1.002) | 0.201 | NS | £0 |
| Emergency admissions for ACSCs ǂ | 1.001 (0.998-1.003) | 0.516 | NS | £0 |
| Elective admissions | 1.004 (1.003-1.005) | <0.001 | 2399 | £936 |
| Outpatient attendance | 1.002 (1.001-1.002) | <0.001 | 9149 | £126 |

* Rate ratios for model 1 represent the relative change in the rate of admission compared to what would have been expected in the absence of SLIC activity. A rate ratio of 1 indicates no change, while a rate ratio greater than 1 represents an increase, and a rate ratio less than 1 represents a decrease, in admissions.
** No significant change
ǂ Ambulatory Care Sensitive Conditions

*Table 2. Effect of Holistic Assessments and additional hospital costs*

| Outcome | Rate ratio* (95%CI) | p-value | Expected change per 1000 Integrated Care Management cases | Additional hospital costs incurred per patient care managed |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| A&E attendance | 1.000 (0.995-1.006) | 0.911 | NS** | £0 |
| Emergency admissions | 1.005 (0.998-1.011) | 0.190 | NS | £0 |
| Emergency admissions for ACSCs ǂ | 1.005 (0.992-1.017) | 0.476 | NS | £0 |
| Elective admissions | 1.024 (1.018-1.030) | <0.001 | 1501 | £5,858 |
| Outpatient attendance | 1.008 (1.006-1.010) | <0.001 | 4172 | £576 |

* Rate ratios for model 1 represent the relative change in the rate of admission compared to what would have been expected in the absence of SLIC activity. A rate ratio of 1 indicates no change, while a rate ratio greater than 1 represents an increase, and a rate ratio less than 1 represents a decrease, in admissions.

** No significant change

ǂ Ambulatory Care Sensitive Conditions

*Table 3. Effect of Integrated Care Management and additional hospital costs*

These results show no changes in relation to any of the outcomes with the exception of outpatient attendance and elective admissions for which there was a substantial, and unanticipated, increase in hospital utilisation and consequently in secondary care costs associated with the delivery of HAs and ICM.

**Discussion**

SLIC's Older People Programme was one of a number of NHS initiatives designed to improve care for older people but had an important additional objective of reducing costs. The rationale for the commonly held belief that better integrated care will reduce costs is that poorly coordinated care may lead to unnecessary healthcare expenditures, for example through avoidable emergency admissions to hospital.

The principal finding of this evaluation was that compared to expected trends, based on data from matched control practices and background trends, NHS costs increased rather than decreased over the course of the Programme, although it might have been cost neutral if set-up and infrastructure costs had been excluded. A key aim of the Programme to reduce emergency admissions was not achieved, though there was some evidence of reduced A&E attendance towards the end of the Programme. For two key elements of the Programme – HAs and ICM for patients identified as being at higher risk - there was clear evidence that despite an overall reduction in volume of elective care compared to what would have been expected the two interventions increased both outpatient attendances and elective admissions and, as a result, led to significant increases in NHS costs. Although we were not able to determine the nature of the conditions giving rise to this increased secondary care activity, based on the observed increase in elective admissions and outpatient attendance it seems reasonable to speculate that this was due to the identification of unmet needs as a result of these enhanced primary care activities that were central to the SLIC Programme. By accounting for within practice changes, our analysis implies that if the number of HAs and ICM conducted within a practice was being driven by patient need then the number of planned admissions was accelerating in practices with the greatest need. If this is true it is an important message; programmes aimed at integration may not always be cost reducing. In particular, it would be of value to understand whether the increased elective care was to receive interventions that are likely to have a major effect on quality of life or whether these were likely to be for interventions of lower value.

There are a number of limitations to the study. This type of observational analysis is always potentially biased by unknown or unmeasured confounders. While it is standard to allow for confounders by using external controls, many areas of England were adopting some sort of initiative to better co-ordinate care. We deliberately avoided some areas with well-known integrated care schemes when selecting controls (e.g. North West London) but problems inevitably remain in identifying matched controls. We addressed this by looking at within-practice changes using random effects models, using a broadly similar set of practices and further adjusting for the practice characteristics, which were included in the matching process. Using this approach, we expect our models to be robust to any systematic differences between control practices and SLIC practices with the exception of the Programme that was the focus of the evaluation. Further, our dose-response, based on the intensity of HAs and ICM, restricted the analysis to practices within Southwark and Lambeth where the level of HA and ICM activity was known. This analysis effectively treats all Southwark and Lambeth practices as controls for each other and overcomes some of the limitations associated with identifying controls.

In line with the specified aims of the Programme, the analysis focused on measures of secondary care use. However, the intervention might have had an effect that went beyond these outcomes such as improved patient outcomes or experience of care. Future studies should seek to look at whether interventions that aimed to improve co-ordination of care resulted in gains beyond direct costs of hospital use and whether this differed for patients with different health status.

A further weakness is that, with the exception of HAs and ICM plans, we were unable to relate the changes we found to the wide range of initiatives undertaken by SLIC, some of which developed more slowly than was originally intended[13]. The observed difference in impact on elective care between the overall effect of the Programme and the dose-response analysis suggest that projects other than HAs and ICM may be responsible for the overall reductions in elective care observed. Therefore in order to fully interpret the findings, it would be important to understand which of the original plans (e.g. as shown in Box) were actually implemented and to what time-scale and how comprehensively they were implemented. Full information on this was not available to us and would be needed to draw adequate conclusions about whether individual facets of the intervention 'worked' or did not.

Our findings are consistent with several previous studies. For example, a systematic review of interventions to improve coordination in primary care found that around half of studies demonstrated a positive outcome for either health or patient experience, but less than a fifth found any reduction in health service costs[20]. Some studies have found that interventions of a similar type (risk profiling and case management) increase costs initially but that cost savings may accrue after a period of time[21], and we found evidence that reductions in some secondary care activities appeared towards the end of the four-year Programme. A more recent systematic review of case management of at-risk patients in primary care found no evidence that these interventions produced a reduction in either health service costs or utilisation, though the authors reported 'very small' but significant improvements in self-rated health associated with the introduction of case management[6]. It may be that some of the negative evaluations of previous case management programmes result from insufficient time for the evaluations to bed in. These may take more time than payers anticipate, especially where changes to working practices and culture are required[22]

The principal implication of these findings for clinicians, NHS managers and policymakers is that interventions, which aim to improve coordination of care, especially if they use some form of population case finding, should focus on improving care rather than reducing costs. Such programmes may identify unmet need and hence lead to potentially appropriate increased use of specialist care. Future studies should focus on improvements in quality of care and not treat the costs of care as being the main outcome of importance.

## Checklist

STROBE and CHEERS checklists are included as supplementary files.

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## Copyright statement



## Contributorship statement

All authors (JE, GA, JF, EP, SM, MY, MR, AM) contributed to the conception or design of the work, the acquisition, analysis, or interpretation of the data. GA, JE and SM led on the statistical analysis. AM and JF led on the economic analysis. MR is the guarantor of the study. All authors (JE, GA, JF, EP, SM, MY, MR, AM) were involved in drafting and commenting on the paper and have approved the final version.

## Ethical approval

Ethical approval was not required for the study as it used standard Hospital Episode Statistics extracts from NHS Digital, fully anonymised and with no sensitive fields

## Competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work apart from the research grant from Guy's and St Thomas's charity, no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

## Data sharing

No additional data are available.

## Transparency declaration.

Professor Roland affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted.

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# Impact of the Southwark and Lambeth Integrated Care Older People's Programme on hospital utilisation and costs: controlled time series and cost consequence analysis: Appendix

## Further details of statistical methods

This part of the appendix sets out the technical details of our statistical analysis. We consider four measures of secondary care use: A&E attendances, emergency admissions, outpatient attendances and elective admissions. The same methodology is applied to all four outcome measures. For each outcome we consider overall changes in the rates of admission within Southwark and Lambeth since the introduction of the Older People's Programme relative to what would have been expected based on what happened in areas of the country not implementing such a Programme. The counterfactual scenario was not explicitly calculated but implicitly built into the regression models and was based on practice specific pre-intervention levels and trends, changes seen in control practices over time as well as seasonality and a range of practice characteristics. All our analyses were completed using longitudinal Poisson regression modelling of practice admission/attendance rates.

### Matching

The analysis makes use of a set of matched practices. Practices were matched using the so called 'genetic' matching algorithm[1] on baseline admissions/attendances and the rate of change of those admissions/attendances at baseline (with the exception of A&E attendances). The matching also included total list size, the proportion of patients registered with the practice over the age of 65, the proportion of patients registered with the practice over the age of 80, the proportion of patients registered with the practice that were male, the mean years since qualification of GPs, the number of patients per full time equivalent GP (a measure of workload) and the proportion of full time equivalents made up by male GPs, practice deprivation score and the proportion of the practice population describe themselves as white.

The matching was done to obtain five control practices per intervention practice. However, this was done with replacement meaning that one control practice could appear more than once in the comparison set. A total of 263 control practices were identified for the 94 intervention practices. Our original plan was to perform two sets of analyses. The first would include multiple copies of the data for those practices appearing in the matching set more than once. The purpose for doing this was to make the comparison set overall as close to the set of intervention practices as possible and reduce bias. The second set of analyses would only include each of the matched practices once. The reason for this was to avoid any exaggeration of statistical significance due to the artificially enhanced sample size. Unfortunately a number of practices in our analysis data set closed during the period of study and so maintaining an ideally matched overall sample throughout the period was not possible. For this reason we have only conducted the analysis including single copies of control practices. Because we used mixed effects regressions our findings can be interpreted as withinpractice changes and so between-practice differences which remain unchanged over time should not confound our observed associations. Furthermore, we adjust for all factors included in the matching process to improve robustness to such confounding.

Data processing

Data on hospital utilisation are taken from Hospital Episode Statistics. Here we make use of three separate datasets: admitted patient care, accident and emergency, and outpatients. Whilst the outpatients and accident and emergency datasets require little preliminary processing, the admitted patient care data does. The admitted patient care data is delimited at the level of the consultant led episode. Given a patient may receive care from more than one consultant's team during their time spent in hospital, it is important to link these episodes of care together to determine the actual number of admissions and the overall length of stay. We use the algorithm developed by the Centre for Health Economics, University of York, to define Continuous Inpatient Spells (CIPS) which also recognise that patients may be transferred between hospitals in anyone admission. Once the CIPS are constructed they are flagged according to whether the admission was elective or an emergency.

Once data pre-processing is complete, admissions or attendances of each type are aggregated for each quarter from April 2009 in groups defined by general practice of patient, age of patient (in five year bands from 65 upwards, up to 85 years old and one group for 85 years and older) and gender of patient. This gives 10 strata per practice at each time point. Data are restricted to those 65 years of age and older and to April 2009 onwards.

In order to model the rates of admissions we need to know the denominator populations to which these admissions refer. These are calculated from the number of patients registered with the practice in the appropriate age by gender strata. The data on practice population are recorded in April each year. These denominators are then applied to each quarter in the calendar year. We excluded data from practices in years in which their practice code did not appear in the denominator data, even when attendances or admissions were attributed to patients at the practice. Further, we excluded the data from practices in the year preceding that where the practice did not appear, in order to exclude practices where mergers or closures may have occurred during the year of analysis. Although such exclusions introduced missing data the model framework used (a longitudinal mixed effects model) is robust to missing data over time under the assumption that the data are missing at random conditional on the covariates in the model.[2]

Statistical analysis

We made use of a series of five models for each of the outcomes of interest to probe the effect of the intervention. The basic structure of each model is the same, differing only in the way in which we operationalise the intervention in the models. We first describe the general model in the absence of the intervention and then describe how the intervention is captured.

*General model*

The models used are mixed effect Poisson models, where the outcome is the number of admissions or attendances in each practice by age group and gender strata. In order to model rates rather than counts, an offset equal to the population denominator for that stratum (see Data section above) is applied in the model. Being a longitudinal model, there are multiple observations for each practice by age group and gender stratum (i.e. one for each quarter of data used). As such we consider the data to be clustered by practice and this is captured using a random intercept.

The models contain strata level categorical fixed effects for age group and gender. They also contain a number of practice level continuous fixed effects describing the practice. These are the total list size, the proportion of patients registered with the practice 65 and over, the proportion of patients registered with the practice aged 80 and over, the proportion of patients registered with the practice that were male, the practice deprivation score, the proportion of the practice population describe themselves as white, the number of GPs at the practice (excluding registrars), the number of full time equivalent GPs, the mean years since qualification of GPs, and the proportion of full time equivalents made up by male GPs. We also include an indicator for SLIC practices in case there remain any systematic differences between them and the control practices.

Background change in the model is captured using four fixed effects and two random effects. Firstly a categorical indicator variable is used for quarter of the year to capture seasonality. This protects against the confounding effect of interventions starting in a particular season and erroneously attributing the seasonal change to the intervention. A quarterly time variable has been created which is the number of quarters from January 2000, which was included as both a squared and cubic terms. Including these three variables as continuous fixed effects allows for the background trend over time to be increasing or decreasing and for this trend to be non-linear. Further, the time variable is included as random effect to allowing the modelled trends over time in admissions to be differential by practice.

*Operationalising the intervention within the general regression model*

Five models were constructed to model the effect of the various interventions on the range of hospital utilisation outcomes.

### Model 1

In this model a categorical variable is included taking a value of 0 for all observations prior to the start of SLIC and for control practices at all time points. For SLIC practices it takes the value of the number of years since the start of the intervention, i.e. 1 in 2012/13, 2 in 2013/14 etc. The resulting rate ratios show on average the relative rate of admission in intervention practices compared to what would have been expected had the effect of the intervention been absent. This rate ratio represents the average difference over a financial year. The model treats all GP practices within the SLIC catchment area as receiving the intervention i.e. includes both practices that are and are not performing HAs/integrated care management.

### Model 2

Recognising that not all practices are performing the intervention at the same level, we decided to perform a dose-response analysis. In order to do that we calculated for each practice at each quarter the cumulative number of HAs that had been performed. This was then divided by the number of over 65 year olds registered at that practice. Whilst in theory patients may have received more than one HA, we interpret this number as the proportion of over 65 year olds who have received an HA. This variable is by definition zero for non-SLIC practice and pre-intervention. Including this variable in our model captures this dose-response effect. The resulting rate ratio is the average change in the rate of admissions or attendances for a 1% increase in the proportion of the population over 65 receiving HA.

### Model 3

As above but restricting the model only to SLIC practices. By doing this the SLIC practices act as their own control, comparing SLIC practices with high volumes of intervention with those with low volumes. Background trends in this model are informed by SLIC practices only.

### Model 4 and 5

Models 4 and 5 repeat 2 and 3 but replacing HAs with integrated care management.

A summary of the models and their interpretation is show in box A1

**Box A1. Summary of the five models assessing changes in hospital utilisation.**

**Changes in rates of admissions over time**

Model 1: shows the average practice change in the rate of hospital use on a year-by-year basis relative to what would have been expected with not being part of the SLIC Programme. The model includes both practices that were and were not performing HAs/integrated care management. The results are presented for four financial years' (April to March) data, starting in April 2012 to March 2016.

The resulting rate ratios can be interpreted as the average difference between practices (the relative rate of admission in intervention practices, compared to control practices). A rate ratio of 1 indicates no change, while a rate ratio greater than 1 represents an increase in admissions in the intervention compared to what was expected and a rate ratio less than 1 represents a decrease in admissions in the intervention compared to what was expected.

**Effect of increasing HAs and integrated care management (compared to control practices)**

Model 2: shows the average change in the rate of hospital utilisation for the six outcomes for a 1% increase in the proportion of the population aged 65 and over receiving HA. As above, this model accounts for background changes informed by national trends in our control group of practices, individual practice preintervention trends, seasonality and individual practice characteristics. In contrast to model 1, here we treat practices not performing HAs as having zero "dose" of intervention, as with the control group of practices.

Model 4: shows the average change in the rate of hospital utilisation for the six outcomes for a 1% increase in the proportion of the population aged 65 and over receiving integrated care management. As above this model accounts for background changes informed by national trends in our control group of practices, individual practice pre-intervention trends, seasonality and individual practice characteristics. In contrast to model 1, here we treat SLIC practices not undertaking integrated care management as having zero 'dose' of intervention, along with the control group of practices.

**Effect of increasing HAs and integrated care management (analysis restricted to SLIC practices)**

Model 3: repeats analysis of model 2 but is restricted to SLIC practices. It shows the average change in the rate of hospital utilisation for the six outcomes for a 1% increase in the proportion of the population aged 65 and over receiving an HA. Background trends in this model are informed by SLIC practices only.

Model 5: the analysis repeats that of model 4 but is restricted to SLIC practices. It shows the average change the rate of hospital utilisation for the six outcomes for a 1% increase in the proportion of the population aged 65 and over receiving integrated care management. Background trends in this model are informed by SLIC practices only.

The resulting rate ratios for models 2 to 5 can be interpreted as the average difference between two practices, where one is performing HAs/integrated care management on 1% more of its patients aged 65 and over than the other. A rate ratio of 1 indicates no change, while a rate ratio greater than 1 represents an increase, and a rate ratio less than 1 represents a decrease, for example, in admissions.

### *Data structure, sample size and sensitivity analysis*

All of the analyses were conducted at the GP practice-level. Outcome data used for the analyses come from Hospital Episode Statistics (HES) – a centrally held data warehouse containing details of all admissions, outpatient appointments and A&E attendances at NHS hospitals in England. Our dataset consists of 357 practices, including 94 practices in Southwark and Lambeth, and covers the time period from the three years prior to, and four years following, the start of the Programme (2nd quarter of 2009 to 1st quarter of 2016). For each GP practice we know the number of admissions and attendances in each five-year age band (5 age groups) for each gender and for each quarter over the seven years (28 quarters). We refer to each of these as a 'stratum', for example, the number of admissions or attendances for women in the age group 65 to 69 years old during the 1st quarter of

2015 in a specific GP practice. In total the data set consisted of 98,081 strata for hospital admissions/attendance, corresponding to a population of between 194,337 and 215,447 at any one time period (the actual population served changed over time). In analyses of admissions and A&E attendance which were restricted to SLIC practices the dataset included 25,702 strata corresponding to populations of between 50,356 and 53,869 in any one time period. When considering inpatient length of stay 87,338 strata were included in the model corresponding to between 35,410 and 45,816 admissions in any one quarter. Inpatient length of stay models restricted to SLIC practices included populations of between 10,542 and 12,596 in any one time period.

Initial inspection of the raw data showed that for some practices there were times where the rates of admission or attendances were very high in one or more of the strata (as above, these are fiveyear age bands subdivided by gender for each quarter in each of the three years prior to and four years following the start of the Programme). To examine the influence of these high rates we carried out sensitivity analyses excluding data where very high admission/attendance rates or mean lengths of stay were seen (excluding individual strata with more than one admission per person per quarter for A&E attendance and inpatient emergency admissions, more than three admissions per person per quarter for inpatient elective admissions or more than four admissions per person per quarter for outpatient appointments). In the inpatient length of stay analysis we excluded mean lengths of stay longer than 1 year. These sensitivity analyses excluded up to a maximum of 108 patients at risk for A&E admissions, 926 for outpatient appointments, 77 for elective admission and 21 for emergency admissions (these are maximum numbers per quarter, the number of exclusions varies by quarter). For inpatient length of stay a maximum of 160 admissions were excluded in a given quarter. None of the sensitivity analyses made a material difference to our conclusions and the detailed results are therefore not included in the report, but are available on request from the authors.

Further details of the economic analysis

In the appendix we also expand on the results shown in the main paper which refer to average NHS costs. In actuality, these vary across the country and routine NHS statistics report lowest and highest costs as well as the average value. In the first table here (table A3), we show the bounds of these tariff values. In the second table (A4) we additionally show as a sensitivity analysis the effect of using upper and lower bounds of costs and also upper, average and lower bounds of activity based on the confidence intervals reported in the statistical analysis.

## **Further results of the analyses: Tables**

The main results are summarised in tables 1, 2 and 3 in the main paper. Here we reproduce more detailed outputs which contain analysis for each year in model 1 and full outputs from models 2 to 5. Model outputs are provided for each of the five outcome measures.

In the following tables (A1, A2 for length of stay and A5 to A14 for other outcomes), rate ratios for model 1 represent the relative change in the rate of admission or length of stay compared to what would have been expected in the absence of SLIC activity. In models 2 to 5 the rate ratios represent the average relative difference between two practices, where one is performing HAs or integrated care management on 1% more of its patients aged 65 and over than the other. A rate ratio of 1 indicates no change, while a rate ratio greater than 1 represents an increase, and a rate ratio less than 1 represents a decrease, in admissions. Observed attendance rate refers to the observed attendance rate in patients aged 65 and over across all SLIC practices included in the analysis. The expected rate has been calculated according to the model results and is equal to the observed rate/rate ratio. For Holistic Assessments (HAs) and Integrated Care Management (ICM), the expected change in attendances has been calculated from the model rate ratio for 18.9% of the 65 and over population receiving HAs and for 1.9% of the 65 and over population receiving integrated care management.

*Table A1. Length of stay for all inpatient admissions: Comparison with control practices*

| Year | Rate ratio for length of stay[a] (95% CI)[b] | p-value[c] | Observed mean length of stay for SLIC practices[d] (in days) | Expected mean length of stay in the absence of SLIC intervention[d] (in days) |
|---|---|---|---|---|
| 2012/13 | 1.073 (1.014-1.134) | 0.014 | 28 | 26 |
| 2013/14 | 1.009 (0.942-1.081) | 0.797 | No significant change | No significant change |
| 2014/15 | 1.004 (0.932-1.083) | 0.907 | No significant change | No significant change |
| 2015/16 | 1.011 (0.937-1.090) | 0.776 | NS | No significant change |

*Table A2. Length of stay for all inpatient admissions: Effect of HAs and integrated care management*

| Rate ratio for length of stay[a] (95% CI)[b] | p-value[c] | Expected change in length of stay per 10,000 HAs or per 1,000 ICMs |
|---|---|---|
| *Model 2 – Effect of HAs (cumulative total over four years compared to control practices)* | | |
| 0.999 (0.997-1.001) | 0.467 | No significant change |
| *Model 3 – Effect of HAs (cumulative total over four years – SLIC practices only)* | | |
| 1.000 (0.997-1.002) | 0.754 | No significant change |
| *Model 4 – Effect of Integrated care management (cumulative total over four years compared to control practices)* | | |
| 0.995 (0.983-1.007) | 0.420 | No significant change |
| *Model 5 – Effect of Integrated care management (cumulative total over four years – SLIC practices only)* | | |
| 0.996 (0.981-1.012) | 0.657 | No significant change |

*Table A3. Economic analysis: Low, Average and High standard NHS Tariff Value Range (2017/18)*

| | Lowest | Average | Highest |
|---|---|---|---|
| A&E Attendances | £91 | £184 | £322 |
| Emergency Admissions | £628 | * | £2,953 |
| Elective Admissions | £2,517 | £3,903 | £4,162 |
| Out-patients | £138 | £138 | £138 |

*not available

*Table A4. Economic analysis: Net cost in comparison to control practices of the Older People's Programme per Southwark and Lambeth resident ≥65: sensitivity analysis using low, average and high*

*NHS tariffs and lower, average and upper bounds of estimated impact on hospital utilisation*

| | Lower bound of activity | | | Mean bound of activity | | | Upper bound of activity | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lowest tariff | Average tariff | Highest tariff** | Lowest tariff | Average tariff | Highest tariff | Lowest tariff | Average tariff | Highest tariff |
| Total SLIC cost | £149 | £149 -£103 - | £149 | £149 | **£149** | £149 | £149 | £149 | £149 |
| Total offset | £99 | | -£154 | -£70 | **-£86** | -£106 | -£45 | -£15 | -£45 |
| Net Total SLIC cost | £47 | £50 | £4 | £79 | **£64** | £43 | £105 | £134 | £105 |
| Total SLIC cost (net infrastructure costs) | £91 | £91 | £91 | £91 | **£91** | £91 | £91 | £91 | £91 |
| Net Total SLIC cost | -£12 | -£8 | -£63 | £21 | £5 | -£15 | £46 | £76 | £46 |

*The figures in bold are those presented and discussed in the main paper. ** For A&E attendance the figure of £2953 was used for both upper and average tariff.

*Table A5. A&E attendance: Comparison with control practices*

| Year | Rate Ratio[a] (95% CI)[b] | p-value[c] | Observed rate for SLIC practices (A&E attendances per 1000 patients per year) | Expected rate in the absence of intervention (A&E attendances per 1000 patients per year) |
|---|---|---|---|---|
| 2012/13 | 1.020 (1.002-1.038) | 0.032 | 144 | 141 |
| 2013/14 | 1.001 (0.978-1.025) | 0.931 | No significant change | No significant change |
| 2014/15 | 0.973 (0.946-1.002) | 0.068 | No significant change | No significant change |
| 2015/16 | 0.944 (0.913-0.976) | 0.001 | 144 | 153 |

*Table A6. A&E attendance: Effect of HAs and integrated care management*

| Rate Ratio[a] (95% CI)[b] | p-value[c] | Expected change in number of A&E attendances per 10,000 HAs[e] or per 1,000 ICMs[f] |
|---|---|---|
| *Model 2 – Effect of HAs (cumulative total over four years compared to control practices)* | | |
| 1.000 (0.999-1.000) | 0.306 | No significant change |
| *Model 3 – Effect of HAs (cumulative total over four years – SLIC practices only)* | | |
| 1.000 (0.999-1.001) | 0.760 | No significant change |
| *Model 4 – Effect of integrated care management (ICMs, cumulative total over four years compared to control practices)* | | |
| 1.004 (0.999-1.008) | 0.114 | No significant change |
| *Model 5 – Effect of integrated care management (cumulative total over four years – SLIC practices only)* | | |

| | | |
|---|---|---|
| 1.000 (0.995-1.006) | 0.911 | No significant change |

*Table A7. Emergency admissions: Comparison with control practices*

| Year | Rate Ratio[a] (95% CI)[b] | p-value[c] | Observed rate for SLIC practices[d] (emergency admissions per 1000 patients per year) | Expected rate in the absence of intervention[d] (emergency admissions per 1000 patients per year) |
|---|---|---|---|---|
| 2012/13 | 1.043 (1.019-1.067) | <0.001 | 77 | 74 |
| 2013/14 | 1.031 (1.001-1.062) | 0.043 | 77 | 75 |
| 2014/15 | 1.019 (0.983-1.056) | 0.301 | No significant change | No significant change |
| 2015/16 | 1.011 (0.971-1.052) | 0.600 | No significant change | No significant change |

*Table A8. Emergency admissions: Effect of HAs and integrated care management*

| Rate Ratio[a] (95% CI)[b] | p-value[c] | Expected change in number of emergency admissions per 10,000 HAs[e] or per 1,000 ICMs[f] |
|---|---|---|
| *Model 2 – Effect of HAs (cumulative total over four years compared to control practices)* | | |
| 1.000 (0.999-1.001) | 0.497 | No significant change |
| *Model 3 – Effect of HAs (cumulative total over four years – SLIC practices only)* | | |
| 1.001 (1.000-1.002) | 0.201 | No significant change |
| *Model 4 – Effect of Integrated care management (ICM, cumulative total over four years compared to control practices)* | | |
| 1.004 (0.998-1.009) | 0.177 | No significant change |
| *Model 5 – Effect of Integrated care management (ICM, cumulative total over four years – SLIC practices only)* | | |
| 1.005 (0.998-1.011) | 0.190 | No significant change |

*Table A9. Emergency admissions for ambulatory care sensitive conditions: Comparison with control practices*

| Year | Rate Ratio (95% CI)* | p-value | Observed rate for SLIC practices[d] (ACSC admissions per 1000 patients per year) | Expected rate in the absence of intervention[d] (ACSC admissions per 1000 patients per year) |
|---|---|---|---|---|
| 2012/13 | 1.072 (1.026-1.120) | 0.002 | 21 | 19 |
| 2013/14 | 1.118 (1.056-1.184) | <0.001 | 21 | 19 |
| 2014/15 | 1.149 (1.076-1.228) | <0.001 | 22 | 19 |
| 2015/16 | 1.073 (1.004-1.147) | 0.037 | 20 | 19 |

*Table A10. Emergency admissions for ambulatory care sensitive conditions: Effect of HAs and integrated care management*

| Rate Ratio (95% CI)* | p-value | Expected change in number of ACSC admissions per 10,000 HAs[e] or per 1,000 ICMs[f] |
|---|---|---|

| | | |
|---|---|---|
| *Model 2 – Effect of HAs (cumulative total over four years compared to control practices)* | | |
| 1.001 (1.000-1.003) | 0.073 | No significant change |
| *Model 3 – Effect of HAs (cumulative total over four years – SLIC practices only)* | | |
| 1.001 (0.998-1.003) | 0.516 | No significant change |
| *Model 4 – Effect of Integrated care management (ICM, cumulative total over four years compared to control practices)* | | |
| 1.008 (0.998-1.017) | 0.127 | No significant change |
| *Model 5 – Effect of Integrated care management (ICM cumulative total over four years – SLIC practices only)* | | |
| 1.005 (0.992-1.017) | 0.476 | No significant change |

*Table A11. Outpatient attendance: Comparison with control practices*

| Year | Rate Ratio[a] (95% CI)[b] | p-value[c] | Observed rate for SLIC practices[d] (outpatient attendances per 1000 patients aged 65 and over per year) | Expected rate in the absence of intervention[d] (outpatient attendances per 1000 patients aged 65 and over per year) |
|---|---|---|---|---|
| 2012/13 | 0.961 (0.954-0.968) | <0.001 | 1093 | 1137 |
| 2013/14 | 1.004 (0.995-1.014) | 0.375 | NS | NS |
| 2014/15 | 0.973 (0.961-0.985) | <0.001 | 1213 | 1247 |
| 2015/16 | 0.921 (0.908-0.935) | <0.001 | 1220 | 1324 |

*Table A12. Outpatient attendance: Effect of HAs and integrated care management*

| Rate Ratio[a] (95% CI)[b] | p-value[c] | Expected change in number of outpatient attendances per 10,000 HAs[e] or per 1,000 ICMs[f] |
|---|---|---|
| *Model 2 – Effect of HAs (cumulative total over four years compared to control practices)* | | |
| 1.000 (1.000-1.000) | 0.557 | No significant change |
| *Model 3 – Effect of HAs (cumulative total over four years – SLIC practices only)* | | |
| 1.002 (1.001-1.002) | <0.001 | 9149 |
| *Model 4 – Effect of Integrated care management (ICM, cumulative total over four years compared to control practices)* | | |
| 1.003 (1.001-1.005) | <0.001 | 1491 |
| *Model 5 – Effect of Integrated care management (ICM, cumulative total over four years – SLIC practices only)* | | |
| 1.008 (1.006-1.010) | <0.001 | 4172 |

*Table A13. Elective admissions: Comparison with control practices*

| Year | | Rate Ratio[a] (95% CI)[b] | pvalue[c] | Observed rate for SLIC practices[d] (elective admissions per 1000 patients aged 65 and over per year) | Expected rate in the absence of intervention[d] (elective admissions per 1000 patients aged 65 and over per year) |
|---|---|---|---|---|---|
| 2012/13 | | 1.001 (0.982-1.020) | 0.945 | No significant change | No significant change |

| | | | | | |
|---|---|---|---|---|---|
| 2013/14 | | 0.990 (0.965-1.016) | 0.454 | No significant change | No significant change |
| 2014/15 | | 0.955 (0.924-0.987) | 0.005 | 156 | 164 |
| 2015/16 | | 0.938 (0.902-0.975) | 0.001 | 153 | 164 |

*Table A14. Elective admissions: Effect of HAs and integrated care management*

| Rate Ratio[a] (95% CI)[b] | p-value[c] | Expected change in number of elective admissions per 10,000 HAs[e] or per 1,000 CMs[f] |
|---|---|---|
| *Model 2 – Effect of HAs (cumulative total over four years compared to control practices)* | | |
| 1.001 (1.000-1.001) | 0.165 | No significant change |
| *Model 3 – Effect of HAs (cumulative total over four years – SLIC practices only)* | | |
| 1.004 (1.003-1.005) | <0.0001 | 2399 |
| *Model 4 – Effect of Integrated care management (cumulative total over four years compared to control practices)* | | |
| 1.012 (1.007-1.016) | <0.001 | 735 |
| *Model 5 – Effect of Integrated care management (cumulative total over four years – SLIC practices only)* | | |
| 1.024 (1.018-1.030) | <0.0001 | 1501 |

## Further results of the analysis: Figures

The following figures show differences between control and intervention practices at baseline.

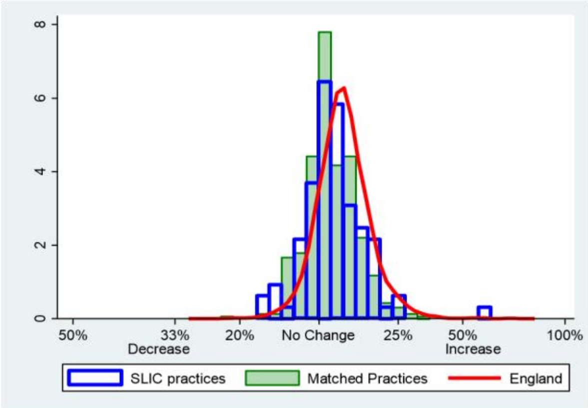


*Figure 1. Age adjusted emergency admission rate for over 65 year olds, 2010/11*

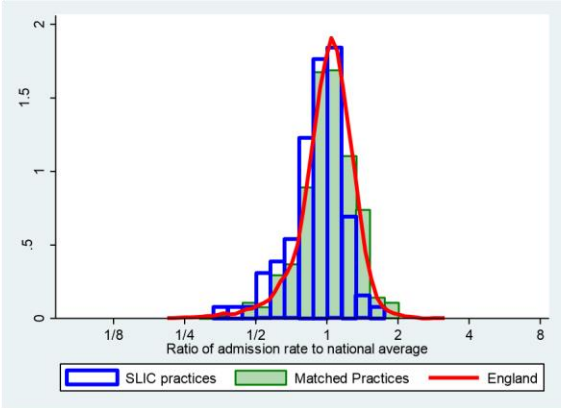


*Figure 2. Age adjusted elective admission rate for over 65 year olds, 2010/11*

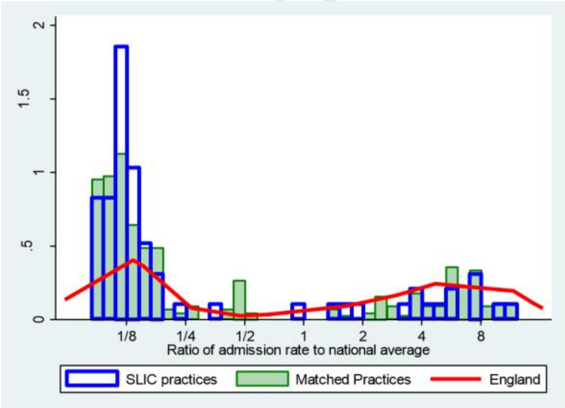


*Figure 3. Age adjusted emergency admission rate: ACSC admissions for over 65 year olds, 2010/11*

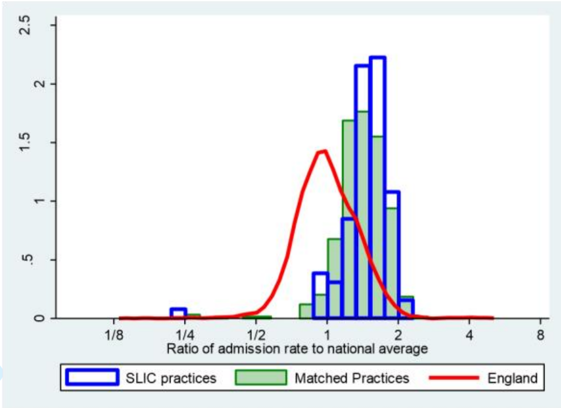


*Figure 4. Age adjusted outpatient attendance rate for over 65 year olds, 2010/11*

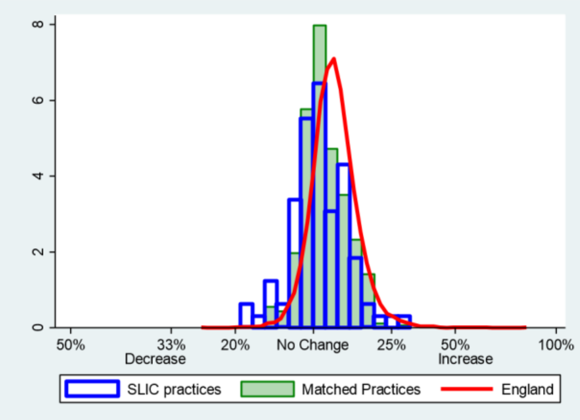


Figure 5. Age adjusted annual relative change in emergency admission rate for over 65 year olds

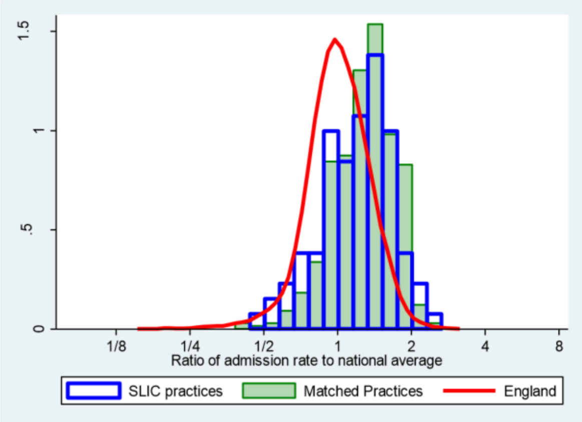


Figure 6 Age adjusted annual relative change in elective admission rate for over *65 year olds*

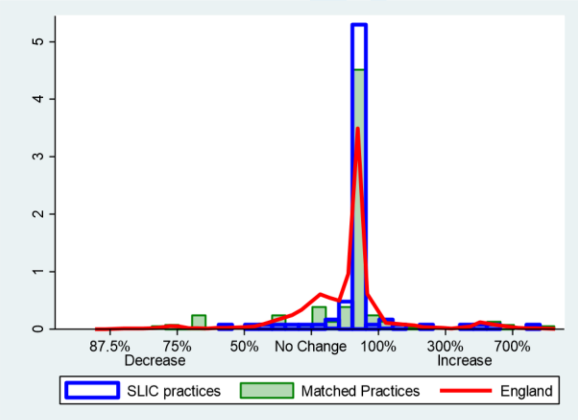


*Figure 7. Age adjusted annual relative change in emergency admission rate and ACS conditions admissions for over 65 year olds*

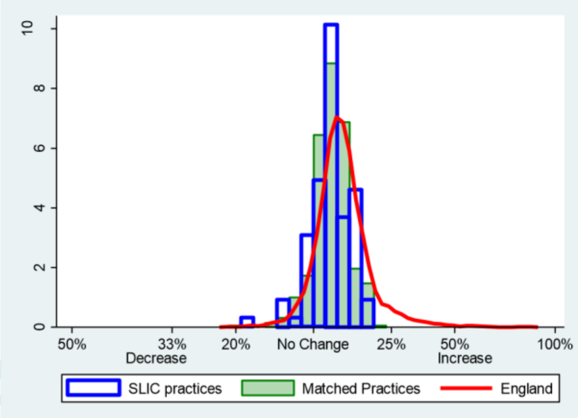


*Figure 8. Age adjusted annual relative change in outpatient attendance rate for over 65 year olds*

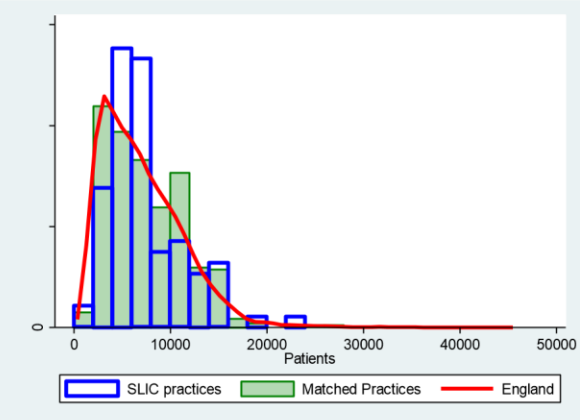


*Figure 9. Practice list size*

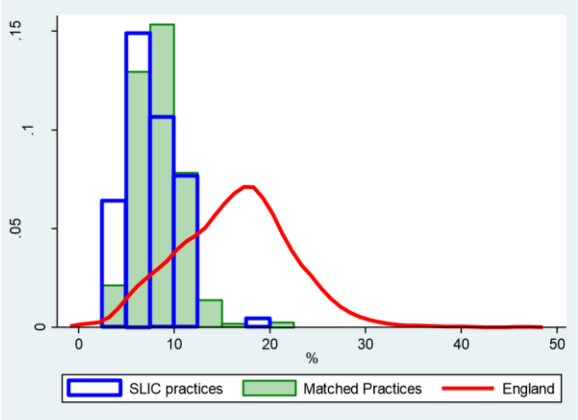


Figure 10. Percentage of practice population over the age of 65

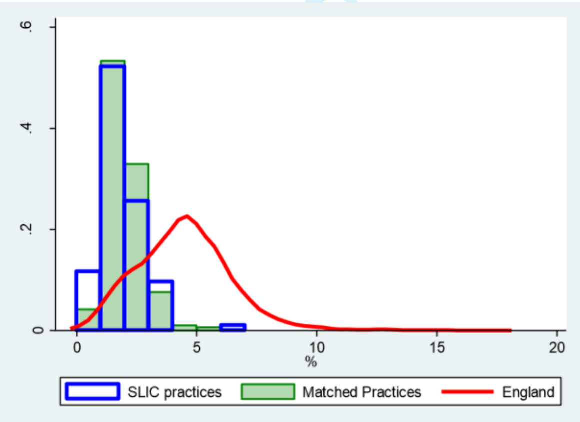


Figure 11 Percentage of practice population *over the age of 80*

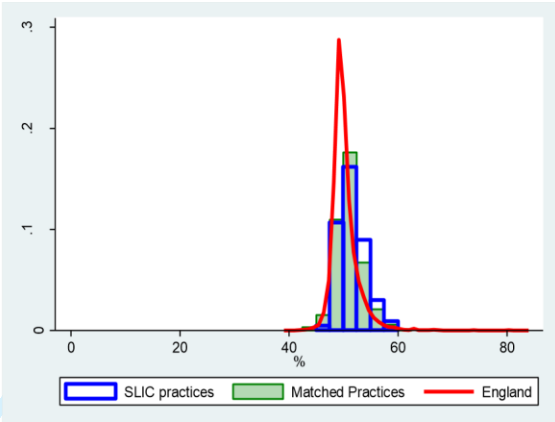


*Figure 12. Percentage of practice population who are male*

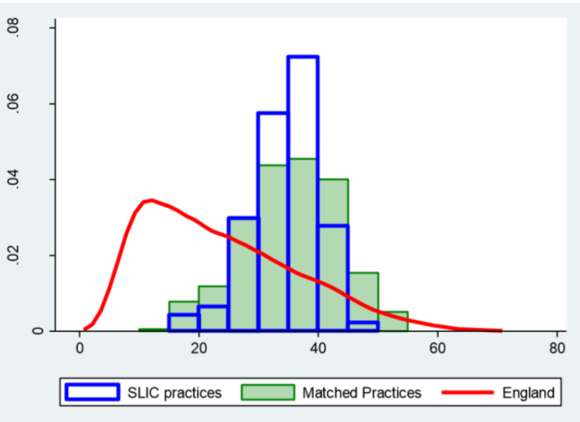


*Figure 13. Practice deprivation score*

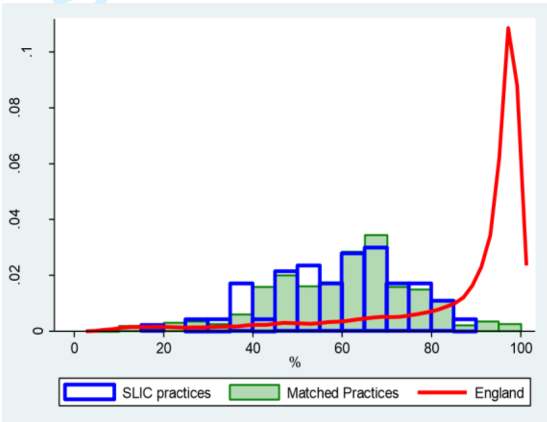


*Figure 14. Percentage of practice population who describe themselves as white*

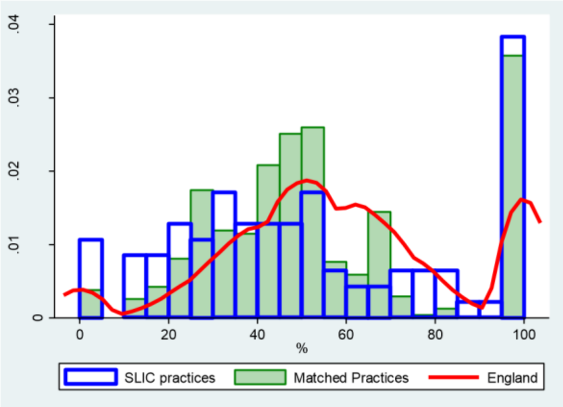


*Figure 15. Percentage of full-time equivalents made up of male GPs*

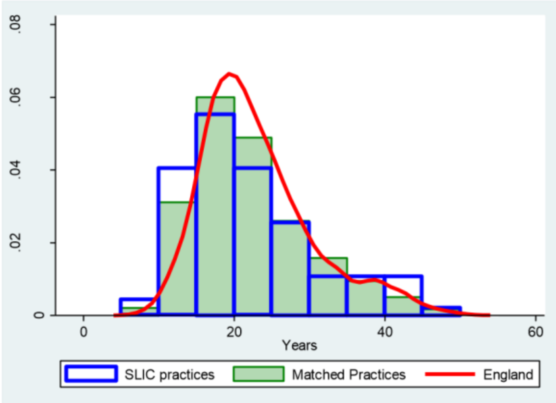


*Figure 16. Mean years since qualification of GPs*

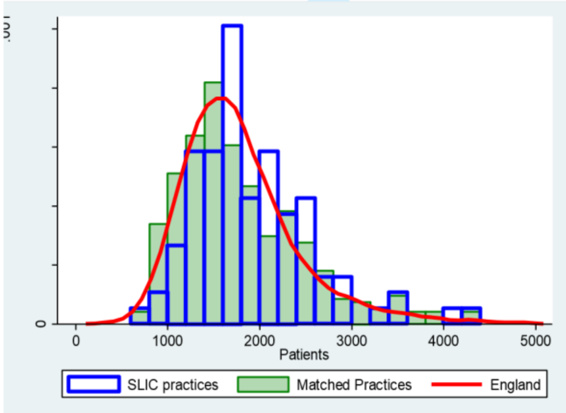


*Figure 17. Patients per full-time equivalent*


1 Sekhon JS. Multivariate and propensity score matching software with automated balance optimization: the matching package for R. 2011. Journal of Statistical Software 2011; 42. doi 10.18637/jss.v042.i07

2 Gibbons RD, Hedeker D, DuToit S. Advances in analysis of longitudinal data. Annu Rev Clin Psychol. 2010; 6: 79–107.

STROBE Statement Case finding and intensive care management of elderly people in primary care may increase secondary care costs: cost-consequences analysis of the South London Integrated Care Pilot.

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract: *Title and abstract include 'controlled time series' and 'cost-consequences analysis'* |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found: *Abstract includes these* |
| **Introduction** | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported. *Introduction (pages 3 and 4) includes these.* |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses. *Objectives and prespecified hypotheses are set out in the method section on page 4. Page 5 explains the rationale for carrying our additional analyses on holistic assessments and integrated case management that were not part of the original protocol.* |
| **Methods** | | |
| Study design | 4 | Present key elements of study design early in the paper. *These are set out in pages 4 and 5 of the paper.* |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection *These are set out in pages 4 and 5 of the paper.* |
| Participants | 6 | *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls. *These are set out in pages 4 and 5 of the paper, with further details on page 2 of the appendix* |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable *Details are given on pages 4 and 5 of the main paper. Further details of assessment methods are described on pages 2-6 of the appendix* |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. *Data sources are set out on page 4 of the main paper. Further details of assessment methods are described on pages 2-6 of the appendix* |
| Bias | 9 | Describe any efforts to address potential sources of bias. *Details of matching and efforts to reduce bias are described on page 2 of the appendix* |
| Study size | 10 | Explain how the study size was arrived at: *This is described on page 5 and 6 of the appendix – the analysis included data for the whole relevant population of the two London boroughs.* |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why *Details are given on pages 4 and 5 of the main paper. Further details are included on pages 2-6 of the appendix* |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding *See response to Q 11* |

| | | |
|---|---|---|
| | | (*b*) Describe any methods used to examine subgroups and interactions *See response to Q 11* |
| | | (*c*) Explain how missing data were addressed *See response to Q 11* |
| | | (d)*Case-control study*—If applicable, explain how matching of cases and controls was addressed |
| | | (*e*) Describe any sensitivity analyses *A sensitivity analysis for practices where there were times where the rates of admission or attendances were very high for one or more of the age-gender strata is described on page 6 of the appendix* |
| **Results** | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. *The number of subjects is described on pages 5/6 of the appendix.* |
| | | (b) Give reasons for non-participation at each stage *N/A* |
| | | (c) Consider use of a flow diagram *Not included* |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders *These are not included as such. For the cases, the population included the whole relevant population of two London boroughs, with matching criteria for controls as described above.* |
| | | (b) Indicate number of participants with missing data for each variable of interest N/A |
| Outcome data | 15* | |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure *These are reported on pages 5/6 of the appendix.* |
| | | |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included. *All estimates are adjusted, as described in the methods sections.* |
| | | (*b*) Report category boundaries when continuous variables were categorized. *Categories for age-gender strata are described on page 3 of the appendix.* |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period. *Rate ratios are also expressed in terms of impact on absolute numbers in tables 1 to 3 in the main paper and tables A1 to A12 in the appendix.* |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses *The sensitivity analysis is reported on page 6 of the appendix.* |
| **Discussion** | | |
| Key results | 18 | Summarise key results with reference to study objectives *Included* |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias *Included* |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence *Included* |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results *Included* |
| **Other information** | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based *Included* |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

**CHEERS checklist—** ***note that the identification of locations within the paper refers to the revised version of the paper with tracked changes.***

| Section/item | Item No | Recommendation | Reported on page no/ para no |
|---|---|---|---|
| **Title and abstract** | | | |
| Title | 1 | Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared. | Page 1, line 2 |
| Abstract | 2 | Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions. | page 2 |
| **Introduction** | | | |
| Background and objectives | 3 | Provide an explicit statement of the broader context for the study. | page 4 |
| | | Present the study question and its relevance for health policy or practice decisions. | Page 5 (end) and page 6 (first two paras) |
| **Methods** | | | |
| Target population and subgroups | 4 | Describe characteristics of the base case population and subgroups analysed, including why they were chosen. | Page 7 (para 2) |
| Setting and location | 5 | State relevant aspects of the system(s) in which the decision(s) need(s) to be made. | Page 4 (last para) and box on page 4-5. |
| Study perspective | 6 | Describe the perspective of the study and relate this to the costs being evaluated. | Page 6, paras 2-3 |
| Comparators | 7 | Describe the interventions or strategies being compared and state why they were chosen. | Page 4 (last para) and box on page 4-5 |
| Time horizon | 8 | State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate. | Page 7 para 1: three years before and four years after the start of the programme. |
| Discount rate | 9 | Report the choice of discount rate(s) used for costs and outcomes and say why appropriate. | Not applicable |
| Choice of health outcomes | 10 | Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed. | Page 6 (last para) |
| Measurement of effectiveness | 11a | *Single study-based estimates:* Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data. | Page 7 and first two paras on page 8. Note that clinical effectiveness was not part of this study. |
| | 11b | *Synthesis-based estimates*: Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data. | Not applicable |
| Measurement and valuation of preference based outcomes | 12 | If applicable, describe the population and methods used to elicit preferences for outcomes. | Not applicable |
| Estimating resources and costs | 13a | *Single study-based economic evaluation :*Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs. | Page 8 para 2 |
| | 13b | *Model-based economic evaluation:* Describe | Not applicable |

| | | | |
|---|---|---|---|
| | | approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs. | |
| Currency, price date, and conversion | 14 | Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate. | Page 8, para 2. Appendix A13 |
| Choice of model | 15 | Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended. | Not applicable |
| Assumptions | 16 | Describe all structural or other assumptions underpinning the decision-analytical model. | Not applicable |
| Analytical methods | 17 | Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty. | Page 7 paras 1-3 and page 8 paras 1-2 |
| **Results** | | | |
| Study parameters | 18 | Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended. | Not reported |
| Incremental costs and outcomes | 19 | For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios. | Page 12-13 table 1, page 14 tables 2-3, Appendix table A4 |
| Characterising uncertainty | 20a | *Single study-based economic evaluation:* Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective). | Discussion of potential effects of imprecise matching of controls on page 15 (last para) and page 16 (paras 1-2) |
| | 20b | *Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions. | Not applicable |
| Characterising heterogeneity | 21 | If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information. | Not reported |
| **Discussion** | | | |
| Study findings, limitations, generalisability, and current knowledge | 22 | Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge. | Page 15 paras 3-4 and page 16 paras 1-5. |
| | | | |
| **Page Other** | | | |
| Source of funding | 23 | Describe how the study was funded and the role of | Page 18 last para |

| | | | |
|---|---|---|---|
| | | the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support. | |
| Conflicts of interest | 24 | Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations. | Page 18 para 6 |

For consistency, the CHEERS statement checklist format is based on the format of the CONSORT statement checklist