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Analysis of virtual wards: a multidisciplinary form of case management that integrates social and health care

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Aims and Objectives

The primary aim of this study is to assess the extent to which integrating health and social care services by means of 'Virtual Wards'(VW) leads to changes in the use of emergency hospital care and social care. The work will profile the 'costs' of setting up and running VWs and compare this to any change in utilisation. Virtual Wards offer multidisciplinary case management to patients at highest predicted risk of unplanned hospital admission, based on the forecasts of a predictive risk model (Lewis 2005; Ham 2009). They integrate health and social care services at the organizational ("*meso*") and patient ("*micro*") levels (Rosen & Ham 2008). Using the staffing, systems and daily routines of a hospital ward—with a social worker as a key member of the team—they deliver highly coordinated preventive care at home to people at high predicted risk.

The objectives of this study are to:

- Calculate the impact of Virtual Wards on reducing rates of emergency hospital admission and their impact on intensive social care.

- Establish the costs and savings of Virtual Wards from the perspectives of society, the NHS and Local Government.

- Develop an index for determining the optimal case load for case management that accounts for the case-load versus quality of care trade-off (which depends centrally on the case-mix of patients).

- Develop an interactive cost model where users input local variables and the model advises the user as to the optimal configuration of Virtual Wards locally, taking into account case-mix.

Background

Stronger co-ordination and collaboration between the primary, community and social care sectors is regarded as essential for the provision of high quality, safe and efficient services to people living with complex, long-term health and social care needs (Leutz, 1999; Glendinning, 2002; Rosen & Ham, 2008; Ramsay & Fulop, 2008; Tollen, 2008). The drive for improved integration is given additional impetus by the twin pressures of (a) rising chronic disease prevalence and (b) impending reductions in real terms funding of the NHS in England.

Previous studies have identified a range of 'essential ingredients' for the delivery of high quality integrated care (e.g Kodner, 2006; Ramsay and Fulop, 2008). Rosen and Ham (2008) classify these as "*macro*" (policy, financial and regulatory environment), "*meso*" (organisational and clinical structures and processes), and "*micro*" (patient interactions with different individuals and teams) levels of integration. This study will use the example of Virtual Wards (Lewis 2005; Ham 2009), which is an innovative form of multidisciplinary case

management that integrates primary, community and social care at the *meso* and *micro* levels, to explore the cost-effectiveness of this integrated intervention in reducing emergency hospital admissions for patients at high predicted risk, and the impact on social care services.

The Chronic Care Model (Wagner 1998) summarizes the prerequisites for improving care in health systems at the community, organization, practice and patient levels. Most chronic care interventions tend to work on a hub-spoke model of care where a central case manager, such as a community matron or a guided care nurse (Bolt et al., 2008), acts as the patient's point of contact with all members of the team—drawing on specialities as required and communicating with each. For example the NHS Improvement Plan (Department of Health, 2004) describes the role of the community matron as being,

> *"…one person who acts as both provider and procurer of care and takes responsibility for ensuring all health and social care needs are met."*

Multidisciplinary Case Management

The evidence suggests that hospital avoidance interventions are most successful with the highest-risk patients (Krause 2005, Peikes 2009). However a feature of high-risk patients is that they are typically older, with multiple chronic conditions often coupled with psychological and social problems (Billings et al 2006; Wennberg et al. 2006). Because of these interacting, complex needs, a flexible team-based approach in a community setting, such as Virtual Wards, may be preferable to a hub-spoke model for preventing emergency hospitalisation (Caplan et al, 2004).

Other theoretical advantages of a team-based approach to case management include the ability to cover for sickness leave and annual leave; to provide 7-day a week cover; increased opportunities for problem-sharing and problem-solving; and the discipline of preparing for a "ward round" in a similar way that junior doctors prepare for a consultant ward round. Moreover, in a hub-spoke model the *esprit de corps* experienced in a hospital team is missing, such that community based nurses often feel isolated and unsupported—typically reporting lower job satisfaction (Redfern et al., 1999).

The Virtual Wards in Croydon, Devon and Wandsworth are the focus for this study and will be used as an example of an innovation in integrated care targeted according to a risk prediction tool. There is a strong appetite at all three PCTs and all three councils for an evaluation of the type proposed here. Introduced originally by Croydon PCT and Croydon Council in 2006, the Virtual Wards project won an unprecedented four Health Service Journal awards: Primary Care Innovation; Clinical Service Redesign; Patient-Centred Care and Information-Based Decision Making (Edwards 2006). The following year the project was the overall winner of the Guardian Newspaper's 2007 Public Service Awards (Guardian 2007).

> *"The judges felt that Croydon's Virtual Wards scheme stood out, even in a field of quite remarkable examples of public service excellence, as a real breakthrough that holds out the prospect of positive and lasting change in health and social care."*

There are currently ten Virtual Wards open in Croydon, with the capacity to care for 1,000 high-risk patients, four Virtual Wards in Wandsworth, which opened in April 2009 and one Virtual Ward in Devon, which opened in October 2008. Table 1 compares the Virtual Wards in the three sites.

Table 1: Comparison of the Virtual Wards in Croydon, Devon and Wandsworth

	Population	**Model**
Croydon	Varied (inner-city and suburban; high and low income)	Nurse-led
Devon	Market town and rural	Practice-led
Wandsworth	Inner-city; high and low income.	VWGP led (salaried, dedicated Virtual Ward GP)

The concept is being adopted across the UK and internationally. However there is as yet no robust evidence of their efficacy or cost-effectiveness.

Predictive Modelling

Virtual Wards patients are selected according to the output of a predictive model (Cummings et al., 1997). Predictive models use relationships in electronic administrative data to assign a risk score to an individual that reflects his or her risk of emergency admission to hospital in the subsequent 12-month period (Cousins et al 2002).

Emergency hospitalisation rates are highly skewed across the population, such that a small number of people typically account for a very large proportion of service use. For example, 5% of patients in England account for 49% of inpatient bed days. In theory, the NHS could make substantial net savings if they could reduce emergency hospitalizations by offering targeted preventive care to at-risk individuals. However, for hospital-avoidance programmes to be successful, they must take account of a phenomenon called 'regression to the mean'. Those patients who are currently experiencing repeated hospital admissions will in general have markedly fewer hospital admissions in future even without intervention. So, if patients are selected for preventive care on the basis of current risk, then although the programme might appear to be successful in reducing the number of admissions, in fact most of this reduction would have occurred anyway, and the true impact in these circumstances would be only marginal.

If instead, patients could be identified before they became high-risk, then a much greater impact would theoretically be possible. It is for this reason that in 2004, the Department of Health commissioned two predictive models for the English National Health Service, called the Patients at Risk of Re-hospitalization model (PARR) and the Combined Predictive Model. Predictive models overcome the problem of regression to the mean by identifying those patients who will be at risk in the 12 months after prediction rather than those who are currently at high risk.

Integration

High-risk patients typically have several interacting illnesses. Within a population, they are amongst those who need integrated care the most because they require *"a mix of services delivered sequentially or simultaneously by multiple providers and receive both cure and care in home, community and institutional settings"* (Kodner & Spreeuwenberg, 2002)

Using the framework described by Kodner & Spreeuwenberg (2002), Virtual Wards achieve integration in the following domains:

Domain	Details
Funding	Jointly funded by PCT and Local Authority.
Administrative	Joint Strategic Needs Assessment and joint regulation (Care Quality Commission)
Organizational	VW staff drawn from primary care, community care, social care and Third Sector. VW staff hold honorary contracts with local acute hospitals.
Service Delivery	Virtual Wards deliver joined-up services by means of: Joint audit meetings Centralised information, referral (from predictive model) and intake Multidisciplinary case management On-call coverage Integrated information systems
Clinical	Regular multidisciplinary "ward rounds"

Table 1 Operational Domains of Integrated Care

From an administrative ("top-down") perspective, Virtual Wards ensure that members of a multidisciplinary team meet regularly and share responsibilities for complex patients. From a patient ("bottom-up") perspective, the ward clerk for the Virtual Ward acts as the single point of contact through which patients and their carers can contact the entire health and social care team.

Integration within Virtual Wards occurs at the following levels (Gröne & Garcia-Barbero, 2002):

Level	Details
Health Information	Staff share a single electronic record
Vision of the System	Common aim of preventing unplanned hospital admissions and admission to care homes
Use of Resources	Separate funding streams for health and social care
Decision Making	Multidisciplinary "ward rounds" in which team-based decisions are reached
Nature of partnership	Memorandum of Understanding (signed by PCT, Council and GP practices) acts as a joint "mission statement"

Table 2 Levels of integration

An important issue for projects such as Virtual Wards is the balance of investment between the health and social care sectors, and the savings that may accrue to each. For example, it is possible that an investment in improved preventive healthcare may achieve savings in social care expenditure through increased independence. Alternatively, if rates of emergency hospital admission and length of hospital stay are reduced, then this may increase social care costs. The incentives for social care to engage in this type of integrated, preventive work are therefore complex. Historically our understanding of these trade-offs have been poor and yet the potential return on investment is very high for both sectors.

Discharging patients from the virtual ward

It is often asked how long patients should remain on a virtual ward. Whereas the original guidance from the Department of Health was that patients should receive lifelong case management (Department of Health 2007), the commissioners of virtual wards in some areas have decided that a maximum 'length of stay' should be applied. This is intended to increase efficiency by ensuring a continuous throughput of patients. Elsewhere, the length of stay on a virtual ward is more flexible - often guided by clinical opinion and/or changes in predicted risk score.
Given the current debate on this question (both in sites that are currently operating a virtual and many others that are considering commissioning or providing a virtual ward), the NIHR Management Fellow attached to this research project seeks ethical permission to address this question as part of her fellowship.

The criteria for admission to the virtual ward using predictive modelling tools is explained above. This process enables service providers to offer virtual ward services to those individuals who are identified as being at risk of emergency hospital admission. So whereas the pathway for admission on to a virtual ward is well understood, there is less clarity about the optimum length of stay on a virtual ward. This is in contrast to the situation for inpatients on an acute hospital ward. The increasing interest in improving the efficiency and productivity of virtual wards has led to a wide range of initiatives to reduce length of stay on a virtual ward by developing discharge criteria.
Clearly, if all the patients admitted remained in the care of a virtual ward then there would be a reduction in the turnover of people who could benefit from this care delivery model. However, it might also mean that the virtual ward staff were not be using their advanced practice skills on the patients who require them most. Therefore in this situation the virtual ward might have a reduced capacity (essentially due to form of "bed blocking" to use hospital parlance).

We are therefore proposing undertaking a descriptive analysis of the advantages and disadvantages of different approaches to determining the length of stay on the ward. We will focus specifically on five options :
- A set time period (e.g. 12 weeks).
- A flexible period that is decided on clinical need
- An indefinite stay
- A reduction in predictive risk score
- Other criteria

We will assess which of these strategies are used in current practice of discharging patients from virtual wards in the same three sites as the main virtual ward evaluation

(Croydon, Devon and Wandsworth). In addition we will consider more widely the perceived benefits and disbenefits of each approach drawing on the experiences in the sites and the wider literature.

Cost Savings

It has long been hoped that integrated care should deliver cost savings (Leutz, 1999) and it is known that large sums could be invested "upstream" in preventive care for the most costly patients and still yield substantial net savings from averted "downstream" expenditure (Billings, 2007). However as yet there is no robust evidence of the efficacy or cost-effectiveness of interventions offered on the basis of predictive risk models in England (Ham, 2009).

Assessments of complex interventions such as Virtual Wards are fraught with difficulties. In particular:

- If participants were selected because they were at high current risk then regression to the mean would result in pronounced reductions in future utilisation – whether the intervention was effective or not.
- As a complex intervention, the specific processes that are carried out involve many different actors.
- Large sample sizes and/or long duration evaluations may be needed.

Case Load

There is little evidence to date on the optimal configuration of community-based hospital avoidance initiatives. Department of Health guidance recommends that community matrons should have a caseload of 50-80 patients. However, as Sargent, Boaden and Roland (2008) note, there is limited evidence about whether this is the optimal number in terms of quality and effectiveness. They analysed the case-loads of 46 case managers and concluded that higher case loads were associated with more reactive care and increased hospital admissions. Their findings suggest that any intervention designed to reduce hospital interventions can be rendered ineffective if the case loads are too large.

However, whilst in general smaller case-loads would be expected to increase the quality of service, this increased quality might not be cost-effective. The case-load versus quality trade-off depends centrally on the case-mix of patients, suggesting that an index for case-load targets needs to be developed (Williams and Cooper, 2007). This research, in which we will build an economic model of Virtual Wards, will help commissioners determine the most cost-effective configuration of preventive, community-based services for their populations. To our knowledge there has been no previous work done on building an economic model of Virtual Wards or any similar case management service.

Need

Health Need

People cared for on Virtual Wards typically have highly complex health needs. Virtual Wards promote the integration of health and social care services with the

specific aims of preventing unplanned hospital admission (a marker of avoidable morbidity) and the instigation of intensive social care (marking a loss of independence).

Expressed Need

As noted by Ham (2009), the NHS has invested in predictive models such as PARR but there has been little analysis as to the impact of a combination of predictive risk models plus targeted intervention on patient outcomes. A recent systematic review of hospital avoidance programmes for high-risk patients (Peikes 2009) called for further research into how to adapt care coordination to improve patient outcomes. Willams and Cooper (2007) call for a tool to calculate the optimal case-load for case managers.

Sustained Interest and Intent

Already a key priority for the NHS, the importance of integrating health and social care is expected to increase further in coming years as the population ages and more people live with complex illness (Department of Health, 2009).

Capacity to Generate New Knowledge

This study will generate new evidence on the efficacy and cost-effectiveness of integration at the *micro* and *meso* levels for high-risk people, and specifically will produce guidance on the optimal configuration of Virtual Wards. It will also demonstrate how routine data may be used to measure the impact of integration on hospital and care home admissions, to optimize integrated resources locally, and to calculate optimal case loads for case management taking into account case mix.

Organizational Focus Consistent with SDO Mission

This research will generate research evidence on a novel mechanism of organizing the delivery of preventive health and social care for people at different levels of predicted risk.

Actionable Findings and Prospects for Change

Although the use of predictive models is now a *World Class Commissioning* competency (sub-competency 6.1), there is currently a lack of evidence to guide the NHS management community on the best interventions for high-risk people. Our interactive cost model will advise commissioners as to the optimal configuration of Virtual Wards locally—offering practical information to support integration.

Building on Existing Work

This project is complementary to, and builds on a suite of other work conducted by this team for the Department of Health, all aimed at improving the cost effectiveness

of chronic disease management through improved use of routine data. This includes the development of risk stratification models for the NHS (PARR/Combined model), and using these models to evaluate the impact of DH-funded pilots: Partnerships for Older People Pilots (POPPs), the Integrated Care Pilots (ICP) and the Whole System Demonstrators (WSD).

Methods

Target organization

Primary targets: Croydon, Devon and Wandsworth PCTs and their respective councils. Additionally the GP practices and Practice Based Commissioning Groups in the three Sites; the local acute hospitals (Mayday, St. George's, Queen Mary's Roehampton and Kingston, North Devon Healthcare Trust) and mental health Trusts (South London & Maudsley, South West London & St. George's and Devon Partnership Trust); London Ambulance Trust and South West Ambulance Service Trust; GP out-of-hours providers (*Croydoc, Harmoni* and Devon Doctors Ltd.) plus a large range of Third Sector organizations.

Staff groups/professions

Commissioners; clinicians on the multidisciplinary Virtual Ward teams including nurses, social workers, pharmacists etc (plus VWGPs in Wandsworth only); finance and senior managerial staff.

Patient care group/disease area to be studied

Adults and older people at highest predicted risk of unplanned hospital admission (who typically have multiple, interacting long term conditions—often coupled with sensory impairment, mental illness or substance-abuse). Where the Virtual Wards have targeted people at lower predicted risk for support (some patients in Devon and Wandsworth), these will also be studied.

Brief details of the team involved in undertaking the research

Lewis, Billings, Georghiou and Dixon were involved in the initial project to develop predictive risk models for the NHS. This was a joint project between the King's Fund (where Dixon, Georghiou and Lewis worked previously), New York University (Billings) and Health Dialog Analytic Solutions (based in Portland, Maine). In this large, multidisciplinary, trans-Atlantic collaboration, they completed a literature review and developed the original PARR and Combined Predictive Models. It was an extremely data intensive and analytically-sophisticated project, which was completed on time and within budget. Bardsley, Billings, Lewis, Georghiou, Steventon and Vaithianathan have recently completed a large project for the Department of Health examining the feasibility of predicting social care use according to patterns in linked health and social care data sets. Bardsley, Billings, Georghiou and Steventon are currently working on two national evaluations of community based interventions

using the techniques of risk stratification and deriving matched populations using propensity scores.

In this proposed research, both the research team and the project advisory group will meet quarterly for the duration of the project. Billings spends one week a month at the Nuffield Trust, and Vaithianathan will spend extensive periods in London throughout the duration of this research. Vaithianathan already visits the Nuffield Trust frequently (for instance being in residence in September and October 2009), and has a close and successful partnership with Lewis—having completed a number of joint papers.

We are therefore confident that this team of experienced academics, clinicians and public health specialists—who have researched and published together extensively—has all the skills and organisational capacity necessary to deliver this challenging research project.

Design

The research will involve three streams:

1. Difference in difference analysis of changes in hospital use over time, adjusted for risk, relative to a comparator group derived using propensity score matching on national data; coupled with
2. Economic modelling.
3. Analysis of length of stay on a virtual ward

Propensity score matching is a statistical technique that is increasingly being employed in medical and health services research. The technique is used to reduce the impact of treatment-selection bias in the estimation of treatment effects using observational data (Austin, 2007). With the introduction of this technique into standard statistical packages such as STATA, employing the technique in a technically correct manner and testing for robustness has become more straightforward.

We intend to use a number of different matching techniques (e.g. nearest neighbour approach, calliper approach, kernel based, and greedy matching). We will utilise STATA and/or SAS to undertake the analyses. At this stage we assume that the common-support assumption will be met, given that we have available national data from which to find suitable matched comparator group. However, we will also test for this in the data. Since we will not know the number of admitted patients before June 2010, it is hard to provide accurate number on the size of the anticipated treatment group. In determining the subsequent hospital use for those admitted to Virtual Wards we may require a period of up to 12 months to elapse (shorter time periods will also be tested). Individuals admitted to VWs shortly before the time of data extraction will have no corresponding 'downstream' data from secondary care, so we will subsequently seek an updated hospital data extract for these people.

Prognostic Score Matching

To avoid the problems associated with regression to the mean, we will construct matched control groups at the person level. There are several methods for constructing the control group, but the aim is always for the control group to have the same distribution of relevant characteristics as the intervention group in the time period prior to the start of the intervention.

- One method for constructing a control group is to derive a propensity score. This score summarises as a single figure those characteristics that reflect the likelihood that any given person received the intervention. A control group is then determined by selecting people with similar propensity scores to those in the intervention group.

- A variant of approach is to match according to a prognostic score. The prognostic score is a summary of the characteristics relevant to determining whether someone would experience the outcome event of interest, in the absence of the intervention.

- A final group of related approaches involves matching on several of the underlying characteristics at once, without attempting to summarise them into a single figure, using 'Mahalanobis metric matching' or 'genetic matching'.

Although we plan to implement and compare all three of these approaches for this project, our preferred approach is usually a variant to the prognostic scoring techniques developed by Hansen (Biometrica. 2008;95:481-488) since we find that it generally optimises the performance of our underlying predictive models. To derive our prognostic score, we will develop for each of the three sites a predictive model focussed on emergency hospital admissions. These models will be similar to the Patients At Risk of Re-hospitalisation (PARR) model that is used widely by the NHS in England. The models will attribute a number between 0 and 100 for every person with a recent inpatient admission that reflects their probability of having an emergency hospital admission in the next twelve months. We will calibrate the models based on people who were not admitted to a Virtual Ward at any point. This is in order to derive an estimate of the probability of emergency hospital admission in the absence of receiving the Virtual Ward intervention.

No predictive risk model is a perfect predictor of the future, and performance is usually measured by quantities such as:

- **The Positive Predictive Value (PPV):** This is the proportion of the people who the model predicts as being likely to have an emergency hospital admission, who in reality will go on to have an emergency hospital admission (i.e. the proportion of predicted cases that the model predicted correctly).

- **The sensitivity:** This is a related concept to the PPV, defined as the proportion of people who in reality will go on to have an emergency hospital admission, who the model predicts as being likely to have an emergency hospital admission (i.e. the proportion of people admitted correctly identified by the model).

In building the predictive models we consider it necessary to maximise their PPV and sensitivity, so that they offer the most reliable estimates as possible of the probability of emergency admission. We will therefore design separate models for each of the three sites areas, so as to calibrate the models as closely as possible to local patterns of hospital use. When fitting the models, we will not use information related to people identified as ever having been admitted at a Virtual Ward, because we assume that this may have altered the typical pattern of hospital use. After fitting the model, we will apply the calculated beta coefficients to the intervention group to derive their predictive risk scores.

Individuals admitted to one of the virtual wards under study span a long period of time: in Croydon, for example, the first individuals started to receive the intervention in 2006, and will still continue to be recruited while this project is underway. We will need to calculate predictive risk scores as close as possible to the point at which each individual was admitted to a virtual ward. We will therefore fit our models and calculate risk scores on a monthly basis.

Source of potential controls

We will aim to select matched controls for virtual ward patients at an individual level. We will therefore need to decide the areas from which to draw controls. Three options will be considered: controls drawn only from within the area undertaking the intervention, from similar areas across England, or nationally from all of England. For our base models we will choose the middle option: selecting controls from similar areas across England. There are some arguments for selecting controls from within the same area. For example, it might standardise the health and social care services received by the intervention and matched control groups. However, it would also have run the risk that controls would be indirectly affected by the changes in local services brought about by virtual wards. Depending on the number of patients admitted to the virtual wards, the number of people eligible but not admitted to a virtual ward may be limited. This could make close matches harder to find, and could potentially increase the risk of selection bias.[1] Drawing controls nationally is a possibility but will be very computer-intensive and may prove unnecessary if we find adequate controls from comparison sites.

Three potential comparator sites will be selected for each three sites. We will select areas with a similar age structure, deprivation level, urban/rural nature, ethnic mix, underlying utilization rates, area PARR scores, and supply-side characteristics. The predictive risk models will be developed in the Virtual Ward sites, and then applied to the comparator sites to produce risk sores for the potential controls. In theory we could fit a separate model in the control areas, but we consider that this would be less likely to balance the intervention and control groups on their underlying characteristics such as prior utilisation and diagnoses.
The predictive risk models will be developed in the Virtual Ward sites, and then applied to the comparator sites to produce risk sores for the potential controls. In theory we could fit a separate model in the control areas, but we consider that this will be less likely to balance the matched intervention and control groups on underlying characteristics such as prior utilisation and diagnoses.

Matching approach

Once we have derived the predictive risk scores we will face a number of choices about how to select, for each individual in the intervention group, one or more matched control. The objective in doing so was to ensure that each matched control has as similar as possible characteristics to the corresponding member of the intervention group, running up to the start of the intervention.

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[1] With an observational study, there is always the possibility that controls might in fact be ineligible for admission to a virtual ward for reasons that cannot be detected. We consider this possibility to be more likely using a within-area approach, because a significant number of eligible participants (those that received the intervention) will have already been removed from the pool of potential matches.

We suggest that the predictive risk score will be the most important characteristic on which to match our cases with controls. Our previous experience suggests that matching on the risk score should go a long way towards balancing such characteristics as prior inpatient and outpatient utilisation, diagnoses, age and sex. However, other characteristics are also important, such as prior emergency inpatient utilisation, number of chronic conditions,[2] and area-level deprivation.[3] We will therefore match on a range of characteristics using a technique borrowed from other epidemiological studies, namely Mahalanobis metric matching. For any given member of the intervention group, this technique will restrict the pool of potential matches to those with a similar predictive risk score,[4] and an exact match on sex and age group. It will then select the match with a similar balance on the other variables of interest, using a multi-dimensional distance measure known as the Mahalanobis metric, details of which are available elsewhere (Rosenbaum & Rubin: *Biometrica.* 1983;70:41-551985). We will use matching without replacement so that the control group will consist of distinct individuals.

We will generate predictive risk scores on a monthly basis. This will give us a choice, for a given Virtual Ward patient, whether to use the risk score calculated at the month end immediately prior to being admitted to the virtual ward, or the one calculated at the month end immediately following admission. Using the risk score from the month before will not capture very recent events that occur in the few days before bring admitted to the Virtual Ward. In one of the sites (Wandsworth) these recent events may define the intervention group in an important way because GPs may refer patients they regard as being at high-risk of hospital admission for admission to a virtual ward. For this reason, we intend to match using the risk score at the month end immediately following admission to the virtual ward. This means we will be matching using a limited number of events that occur after admission to a virtual ward, over a period of up to one month for some individuals; however, we suspect it will result in better matches.

Economic Modelling

A principal aim of this project will be to look at the costs of running the Virtual Wards and balance these against the net benefit of any avoided utilisation (hospital or social care). The costs of the VW include the time spent by the virtual ward staff with patients and on ward rounds plus the time spent by non-community staff (GPs, specialists etc.) in consulting with the virtual ward staff members.

For the treatment group we will construct a cost per patient per day on a Virtual Ward. To do this, we will ask the members of the VW staff to maintain "time diaries". This will enable us to cost the staff time, transport costs and other professional contact time and estimate an average cost per patient per day of admission on a VW.

The effect of the intervention on the outcomes (hospitalisation, mortality) will be estimated using prognostic score matching. This will enable us to correct for

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[2] Chronic conditions here include: diabetes, hypertension, congestive heart failure, chronic obstructive pulmonary disease, ischemic heart disease, asthma, angina, cardiovascular disease, renal failure.

[3] Deprivation has been attributed to the lower super output area of each individual's residence using the scores available from Communities and Local Government

[4] Defined as being within one-quarter of a standard deviation

differences in baseline outcomes and the estimated improvement in the outcomes can be assumed to be attributable to the intervention.

This estimated difference in outcomes will be divided by the costs to estimate the ratio of benefits avoided hospital bed days per £ invested in the Virtual Ward intervention). The costs will be estimated from the organisational perspectives (NHS and Local Authority) and from the users.

Sampling

Total population sample (i.e. all people cared for on a Virtual Ward in Croydon and Wandsworth since their inception) and matched comparator groups drawn from national data.

Setting

London Boroughs of Croydon and Wandsworth, and South Molton in rural Devon. These sites have populations that are highly diverse in terms of geography, demographics and socioeconomics).

Data Collection

We will collect pseudonymous local person-level data (Secondary Uses Service (SUS), Community, Social Services, and GP data) from Wandsworth and Croydon PCTs and Councils. From these data, the NHS Information Centre will generate for us a list of 'HESID' numbers for VW patients. These will be used to match to national Hospital Episode Statistics (HES) data. The HES data will be used to construct our comparator groups (see above).

Economic modelling: data as above plus interviews with finance and Virtual Ward staff; work diaries for Virtual Ward staff; and financial data on direct and indirect costs.

Data analysis

Stream 1: Difference-in-difference Analysis.

This evaluation will compare observed hospital utilisation in VW patients with a contemporary comparison group created by using propensity score modelling of pseudonymous national hospital data. Propensity modelling is a standard technique that involves characterising the people who received the intervention using logistic regression to select controls from national data with the same balance of characteristics. The analysis will proceed through eight key stages:

1. Agreement of permissions and approvals.
2. Data collation from sites (including test data extraction in Wandsworth) and national data. We are experienced in linking NHS and social care data using pseudonymous NHS number or constructed alternative ID.
3. Test and refine a propensity model (propensity scores reflect the likelihood of receiving the VW intervention).

4. Construct comparator groups for both Croydon and Wandsworth VW projects (with equivalent scores from national HES data) using nearest neighbour, caliper, kernel and greedy matching.
5. Analyses to compare hospital utilisation (risk-adjusted, and with subgroup analyses) between the intervention groups and the comparator groups using a difference-in-difference approach, and an assessment of the impact on social care.
6. Test whether the virtual wards are shifting their focus towards lower-risk patients over time (likely if there is a limited pool of high-risk patients).
7. Test for the phenomenon of regression to the mean, i.e. the tendency for patients at current high risk to show reductions in hospital use even without intervention (unlikely given that VW patients are selected using predictive models).
8. Sense-checking the findings with the sites.

Stream 2: Economic Analysis.

Working closely with managers, finance officers and clinicians from the PCTs and Councils, we will document the processes that occur on virtual wards and calculate the costs as they relate to social and health care and to society in general. The analysis will proceed through five key stages:

1. Derive per-patient marginal costs and fixed costs for a VW patient—from both the societal point of view (including opportunity costs) and from the PCT's and local Council's perspectives (purely direct costs paid by the PCT or Council).
2. Calculate the VWs' direct costs, including time costs for the PCT and Council (individual staff members' time, management overheads); travel and capital costs for VW staff (transport, facilities); and referral costs (additional laboratory tests, assistive living devices, pharmaceuticals, hospitalizations, care home admissions etc.).
3. Calculate costs for people who are not admitted to a VW (based on data of non-admitted patients from historical health and social care administrative data).
4. Estimate the average per-patient per-day cost of admission to a VW, and how that depends on the number of patients per ward; number of patients in the daily/weekly/monthly "beds"; frequency of ward rounds; number of admissions and discharges etc.
5. Estimate the optimal configuration of a VW in terms of the number and type of staff per ward; number of patients per ward; number of patients in the daily/weekly/monthly beds; and length of stay. The configuration of each VW may differ across the boroughs according to local health and social care needs.

Stream 3: Discharge process for patients on a virtual ward

This section of the study will gather information from each of the sites by means of a series of interviews augmented by a focus group with clinicians involved in the virtual wards: one at each site. Telephone interviews will be conducted with a commissioner in each site and a provider manager in each site and will clarify the processes used for agreeing and arranging discharge from the Virtual Ward. There will be no contact

with patients. All staff contact will be on NHS premises within their employing organisation or by telephone.

The focus groups and the interviews will be recorded and analysed to assess current practice and recommendations from those who are involved in the virtual ward. By collecting the information in this way, we hope to establish what the staff working on virtual wards believe are the factors that should be taken into account about when and how patients should be discharged from a virtual ward.

The information gathered from this part of the study should be useful to commissioners who are looking to either develop the virtual ward or ensure that their virtual ward is always targeting resources at those in greatest need and with the greatest capacity to benefit.

Contribution to Collective Research Effort and Research Utilization

The main knowledge outputs of this project will be:
1. Interim report
2. Final report and Executive Summary
3. Briefing
4. Interactive cost model

Copies of the interim report will be sent to the NIHR-SDO, to representatives of the organizations participating in this research, and to key policymakers. Its purpose will be to set out our progress to date and to prompt feedback as we enter the final stages of analysis.

Copies of our final report will be presented in a briefing to the NIHR-SDO. With the approval of NIHR-SDO, we would seek to publish the final report—both in hard copy and electronically on the Nuffield Trust website and the Virtual Wards emailing group. We would issue an accompanying press release.

We will submit papers for publication in peer-reviewed journals (e.g. British Medical Journal); articles to publications read by the NHS management community (e.g. Health Service Journal); and submit abstracts for presentation in health policy conferences (e.g. NHS Confederation annual conference).

The interactive software developed as part of this project will be made freely available for download from the Nuffield Trust website. We will provide detailed guidance to accompany the software, including a section on Frequently Asked Questions. The launch of the software will be accompanied by a press release.

The Nuffield Trust may also choose to produce a series of slim-line publications (under the Nuffield Trust banner) and/or breakfast seminars for commissioners and policy makers.

Virtual wards are being adopted in many locations in the UK as well as internationally. This project will generate useful information on the cost-effectiveness of this type of integration that will be of use to commissioners in PCTs, Practice-Based Commissioning Groups, and in Social Services departments for adults and older people that are considering opening Virtual Wards. The interactive software will be of particularly practical use for these organizations as they plan how best to configure or reconfigure such a project locally.

Approval by Ethics Committee

All routine data for this project will be obtained in pseudonymous format (i.e. person-identifiable fields such as name, address and date of birth will be removed and the NHS number will be replaced by a pseudonym). Since no member of the research team will ever have access to the key to decrypt the pseudonymous NHS number, the data will effectively be anonymous to the research team. For this reason we believe that we will be able to conduct this research without recourse to Section 60 of the Health and Social Care Act 2001. Nevertheless we plan to submit applications to both the Ethics and Confidentiality Committee of the National Information Governance Board and to the London & Surrey Borders Research Ethics Committee to ensure that we have full approvals in place before this project commences.

Difference in difference analysis: This involves an analysis of secondary data for which individuals have not provided explicit consent. We will mitigate the threat to privacy by using only pseudonymous data. Since the potential benefits of this research are substantial, we believe that the interference with privacy is not disproportionate and that therefore this research is morally justified. There are no significant ethical implications for PCT and Local Authority staff.

Economic modelling: This will involve new data collection in the form of staff interviews and staff diaries for the purpose of establishing the costs of Virtual Wards. There are no significant implications for the dignity, rights, safety or wellbeing of any individuals and there are no specific implications for any vulnerable groups. We will obtain written informed consent from all interviewees and from all staff being asked to complete diary cards. The consent form will stress that participation in this research is voluntary and that responses will only be reported in aggregate.

Analysis of length of stay: This will involve new data collection in the form of staff telephone interviews and staff focus groups for the purpose of establishing optimal length of stay for virtual wards. There are no significant implications for the dignity, rights, safety or wellbeing of any individuals and there are no specific implications for any vulnerable groups. We will obtain written informed consent from all interviewees and from all staff being asked to participate in a focus group. The consent form will stress that participation in this research is voluntary and that responses will only be reported in aggregate.

The Nuffield Trust is registered under the Data Protection Act with registration number Z900256X, renewed annually with a current renewal date 23 March 2010. The Project manager will determine which staff will be authorised to have access to the project data. All authorised staff will be bound by a confidentiality agreement, which includes agreement to the Trust's data security policy as an element. Other, non-project, staff will be advised of this security policy and any attempt by them to access confidential data will be regarded as a breach of confidentiality. Any breach of confidentiality will be treated as a disciplinary matter.

Project Management

For project management, the project will draw upon the skills of Elizabeth Eastmure. Elizabeth is an experienced project and programme manager who has managed many

projects for a range of clients in the public sector, including the Healthcare Commission, Lambeth Primary Care Trust and the Nuffield Trust. Elizabeth has managed large and complex programmes across multiple sites in the UK and US, resulting in delivery to time and within budget. At the Nuffield Trust, she has been project manager for the Person Based Resource Allocation, Social Care Costs and Whole System Demonstrator projects, all funded by the Department of Health. She is qualified to practitioner level in PRINCE2.

This project will fit within a portfolio of research projects undertaken by the Nuffield Trust that are overseen by Dr Martin Bardsley. Martin has many years' experience as a senior manager, analyst and researcher leading large teams as part of large and complex projects.

On social care costing, the Nuffield team has considerable internal experience in this field. For example, we are currently working on a large project aiming to predict social care costs, and are leading a strand of the Whole Systems Demonstrator evaluation (a large, multi-site randomized controlled trial of telehealth and telecare). One member of the research team in particular, Adam Steventon, has extensive experience of social care costing. Adam worked previously at the Pensions Policy Institute, where he wrote widely on the UK Government's recent reforms to state and private pensions. Adam developed a suite of models to project the individual, aggregate, and distributional impact of UK pension reform, and had been a researcher in an ESRC-funded project on the interactions between pensions and the social care funding system.

In addition we will seek to include a social care specialist on the steering group for this project, and would like to draw on the expertise of the Personal Social Services Research Unit (PSSRU). We are already working on joint projects with Martin Knapp (Professor of Social Policy) and Cate Henderson from the LSE.

Service Users

This project is predominantly an investigation of two existing services. However, service users will have an important role in ensuring that all patient and carer costs have been considered (for the economic analysis taking the perspective of society in general) and will provide a valuable perspective on any potential reconfiguration of Virtual Wards that might be suggested by the interactive software we shall be developing.

We will invite the participating organizations to nominate three service representatives (one each for Croydon, Devon and Wandsworth) to join the project advisory group, and will take steps to ensure that they are able to attend the advisory group meetings (either in person or by telephone) and to contribute actively to the discussions and decisions of the group.

Expertise and Justification of Support

The particular contribution of each member of the team will be as follows:

Geraint Lewis	Project oversight and coordination Methodological input Liaison with sites and other stakeholders
Martin Bardsley	Methodological input Analytical input Quality assurance
Jennifer Dixon	Health policy oversight Strategic and methodological input Chairing the project advisory group
John Billings	Methodological input Analytical input Propensity score matching and difference-in-difference analysis
Rhema Vaithianathan	Economic analysis and modelling Methodological input for difference-in-difference analysis
Theo Georghiou	Modelling and analysis Methodological input
Ludovic Chassin	Data collation and cleaning Analytical input
Adam Steventon	Modelling and analysis Methodological input (especially for social care data)
Elizabeth Eastmure	Project Management
Research Assistant	Data input
Elizabeth Bishop	Financial and administrative oversight

Theo Georghiou, Ludovic Chassin and Adam Steventon will be supervised by Dr. Martin Bardsley.
The research assistant will be supervised by Dr. Rhema Vaithianathan and will not travel to the UK for this project.

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