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Research and theory

Do 'virtual wards' reduce rates of unplanned hospital admissions, and at what cost? A research protocol using propensity matched controls

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Abstract

Background: This retrospective study will assess the extent to which multidisciplinary case management in the form of virtual wards (VWs) leads to changes in the use of health care and social care by patients at high risk of future unplanned hospital admission. VWs use the staffing, systems and daily routines of a hospital ward to deliver coordinated care to patients in their own homes. Admission to a VW is offered to patients identified by a predictive risk model as being at high risk of unplanned hospital admission in the coming 12 months.

Study design and data collection methods: We will compare the health care and social care use of VW patients to that of matched controls. Controls will be drawn from (a) national, and (b) local, individual-level pseudonymous routine data. The costs of setting up and running a VW will be determined from the perspectives of both health and social care organizations using a combination of administrative data, interviews and diaries.

Methods of analysis: Using propensity score matching and prognostic matching, we will create matched comparator groups to estimate the effect size of virtual wards in reducing unplanned hospital admissions.

Conclusions: This study will allow us to determine relative to matched comparator groups: whether VWs reduce the use of emergency hospital care; the impact, if any, of VWs on the uptake of primary care, community health services and council-funded social care; and the potential costs and savings of VWs from the perspectives of the national health service (NHS) and local authorities.

Keywords

delivery of health care, integrated, evaluation studies, clinical protocols

Background

Approximately 35 per cent of hospital admissions in England are classified as emergency admissions, costing approximately £11 billion a year [1]. Emergency admission rates in England have been rising relentlessly for many years but now there is an acute need to reduce emergency admission rates because of the combined pressures of rising health care costs, an ageing population, the increasing prevalence of various chronic diseases and a tightening of health care budgets [2].

The costs of hospital care are highly concentrated in the population, with just 5% of inpatients in England accounting for 49% of inpatient bed days [3]. If admission rates could be reduced for these very costly patients then large net savings might be possible, even if the costs of the preventive care were high [4]. However, some disappointing results from government-funded trials of hospital avoidance schemes, such as the UK Evercare pilots, the Medicare Health Support Experiment and the Medicare Coordinated Care Demonstration, are a reminder how difficult it can be to make these potential savings [5–7].

One reason why hospital avoidance interventions may fail is if they are offered to patients who are not truly at high risk of emergency admission. For example, the UK Evercare programme, which involved a comprehensive assessment and ongoing monitoring, was offered to patients aged 65 years and older who had experienced two or more hospital admissions in the preceding 12 months. However, today's high-cost patients may have markedly lower average costs in the future even without intervention due to the phenomenon of 'regression to the mean'. Indeed, an analysis of the UK Evercare pilots by Gravelle and colleagues showed that there was actually no reduction in admission rates above what would have happened anyway due to regression to the mean [7, 8]. This suggests that hospital-avoidance programmes are best offered according to the risk of *future* hospitalization rather than being offered to patients who are currently experiencing multiple hospital admissions [9].

One way to identify patients at risk of future hospitalization is to use a predictive risk model. In 2004, the English Strategic Health Authorities and the Department of Health commissioned two such models for the NHS in England: the Patients at Risk of Rehospitalisation tool (PARR) and the Combined Predictive Model [10, 11]. The ways in which these models are used in practice varies across the country. In many areas they have been used to find patients for community matrons or other case managers to work with, or used to select which patients should be offered telephone-based health coaching and advice. Elsewhere, they have been used to identify patients who are offered multidisciplinary integrated care in the form of 'virtual wards' (VWs).

Integrated care through virtual wards

Integrated care has been defined as, "a coherent set of methods and models on the funding, administrative, organisational, service delivery and clinical levels designed to create connectivity, alignment and collaboration within and between the cure and care sectors" [12, p. 3]. 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 [12–16]. Previous studies have identified a range of 'essential ingredients' for the delivery of high quality integrated care [12, 16]. 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 [15].

The current study will use the example of virtual wards [18, 19], which aim to integrate primary, community and social care at the *meso* (service delivery) and *micro* (clinical) levels. It will explore the cost-effectiveness of this type of integrated, multidisciplinary case management in reducing emergency hospital admissions for patients at high predicted risk, as well as any impact on social care services.

The original model for virtual wards was described by Lewis in 2006 (see Box 1) [18]. VWs seek to improve integration through a number of strategies, including a shared record, multidisciplinary team meetings ('ward rounds') and an automated alert system for informing VW staff when a patient accesses another care service, such as attending a local emergency department.

Table 1 describes the VW intervention using the taxonomy described by Roland and colleagues [20].

The current study will evaluate three examples of virtual wards in practice (see Table 2).

There are several reasons why integrated, multidisciplinary preventive care might be beneficial to high-risk patients. Such patients are typically older people with multiple chronic conditions and complex health and social needs. Often, therefore, they receive care from many different professionals. This can lead to problems of duplication (where several professionals deliver the same care) and, equally, of gaps in care (where no professional delivers a particular element of care, perhaps

Box 1. Summary of the virtual wards model as described by Lewis (2006)

- Patients identified by a predictive risk model as being at high risk of a future emergency hospital admission are offered 'admission' to a VW.
- VWs use the systems, staffing and daily routines of a hospital ward, however, there is no physical ward building—hence the term 'virtual'.
- VW patients receive multidisciplinary preventive care at home through a combination of home visits and telephone-based care.
- Each VW has a fixed number of 'beds'; once these 'beds' are full, no more patients can be admitted to the VW until a bed becomes available.
- Each VW is linked to a small number of specific GP practices.
- Specialist staff (e.g. a cardiac nurse specialist) may work across several VWs.
- The composition of the VW multidisciplinary team will vary according to the needs of local high-risk patients. It may include a community matron, district nurses, a ward clerk, pharmacist, social worker, physiotherapist, occupational therapist, mental health professional and a representative from the voluntary sector etc.
- Medical input comes from the duty doctor at each constituent GP practice as well as from the patient's usual GP.
- The role of the administrator ('ward clerk') is seen as being pivotal in supporting and co-ordinating members of the VW staff.
- The VW team uses a shared medical record.
- Systems are put in place to notify local hospitals, NHS Direct, the local ambulance trust and GP out-of-hours cooperatives about which patients are being cared for on each VW. This information is used to alert VW staff automatically should a VW patient present to any of these services (e.g. to a local A&E department).

because they wrongly assume that it is being delivered or secured by another professional). These patients might therefore benefit from the improved communication and coordination delivered by VWs.

Some theoretical advantages of VWs over case management by an individual case manager are that the VW staff may have the capacity to cover each other for sickness leave and annual leave and thereby provide a more continuous service; VW ward rounds may provide an added degree of discipline in that members of the VW team may feel compelled to prepare for the VW ward round in the same way that junior doctors in a hospital prepare for consultant ward rounds; and VW team members may be restrained by peer pressure from spending disproportionate amounts of time and effort with any particular patients to the relative neglect of other VW patients.

However, there is as yet no robust evidence of virtual wards' efficacy in reducing unplanned admissions, or of their cost-effectiveness.

Existing evidence

As reported by Gravelle and colleagues, a systematic review of home-based support for older people found no overall impact of such care on hospital admission rates, where as a review of integrated care pilots for older people suggested that they can reduce admission rates and costs of care, but that the effects are highly dependent on the system concerned [7, 21, 22]. Two other reviews concluded that there is limited evidence that case management reduces the use of health services, but both reviews suggested that the results of individual studies may not be generalizable [23, 24].

Table 1. Description of VWs using the taxonomy used by Roland and colleagues (2005)

Target population	Patients at high predicted risk of unplanned hospital admission in the coming 12 months as determined by a predictive risk model.[1]
Assessment and care plan	Initial assessment by a VW clinician and care plan developed by the members of the multidisciplinary VW team.
Monitoring	Monitoring and review conducted on 'ward rounds' (i.e. regular, office-based multidisciplinary team meetings of all VW staff).
Exit	Death; or Self-discharge; or Decision by the VW team that the patient's care has been optimised; or Reduced predictive risk score.

[1] In two of the sites, patients are identified exclusively according to the predictions of the NHS Combined Predictive Model. In the remaining site, patients are chosen according to a mixture of clinical referrals and the predictions of the PARR predictive model.

Table 2. Comparison of the virtual wards in Croydon, Devon and Wandsworth

	Population	Deprivation		Variant of the virtual ward model
		% of patients living in the most deprived quintile of lower super output areas	% of patients living in the least deprived quintile of lower super output areas	
Croydon	Inner-city and suburban	22%	5%	Multidisciplinary team led by a community matron. No regular input from a doctor.
Devon	Market town and rural	2%	0%	Multidisciplinary team led by a community matron with support from a 'GP champion' and regular input from a community geriatrician.
Wandsworth	Inner-city	14%	7%	Multidisciplinary team led by a dedicated, full-time virtual ward GP ('VWGP').

Moreover, there is little evidence to date on the optimal configuration of community-based hospital avoidance initiatives. In England, Department of Health guidance recommends that community matrons should have a caseload of 50–80 patients [26]. However, it is unclear whether this is truly the optimal number of patients in terms of quality and effectiveness. An analysis of the caseloads of 46 case managers concluded that higher case loads were associated with more reactive care and with increased hospital admissions [25]. This finding suggests that any intervention designed to reduce hospital interventions may be rendered ineffective if the caseloads are too large. However, whilst in general, smaller caseloads would be expected to increase the quality of a service, such increased quality might not be cost-effective. Clearly, then, this caseload vs. quality trade-off is of critical importance to case management, and it depends centrally on the types of patient seen, i.e. the 'case mix' of patients. This suggests that an index for caseload targets needs to be developed [27].

Research methods

For this study, we will conduct a retrospective analysis of the VWs in Croydon, Devon and Wandsworth using routine, person-level data. Only pseudonymous data will be used, i.e. data from which all sensitive fields such as names and addresses have been removed, and the unique key (NHS numbers) has been replaced by a unique, meaningless pseudonym. We will obtain pseudonymous NHS numbers of all patients admitted to the VWs in the three sites, together with their dates of admission and dates of discharge, or of death if relevant. We will also obtain Hospital Episode Statistics (HES) for the whole of England. And we will obtain pseudonymous extracts for the whole registered populations of Croydon, Devon and Wandsworth relating to hospital activity from the Secondary Uses Service (SUS); primary care clinical data from GP electronic systems; community health services data and social care data from local operational systems; and mortality data from the Office for National Statistics (ONS). These datasets will allow us to track the use of care services by the three populations and provide us with a range of explanatory variables. Within these data, we will be able to identify those individuals who received the VW intervention, and we will create comparator groups that match these people as closely as possible.

Two comparison groups will be created for each site:

- Patients drawn from comparable areas of England (ONS Corresponding Health Areas) that do not have VWs ('**national controls**'). These patients will be matched using hospital (HES) data and mortality data.
- Patients drawn from the same PCT who were not admitted to a VW ('**local controls**'). These patients will be matched using a combination of hospital (SUS) data, GP clinical data, community health services data, social care data and mortality data.

We will control for the observed differences between VW patients and control patients by selecting one or more control patients for each VW patient. These control patients will be chosen on the basis that they were similar in terms of a range of observed characteristics prior to the start of the intervention. Two methods will be used to ensure that the control group is as similar as possible to the intervention group across a distribution of characteristics, namely propensity score matching and prognostic matching (see Box 2).

We will compare the prognostic and propensity matching approaches, and our final set of controls will be

Box 2. Methods that will be used to ensure similarity between VW patients and controls

Propensity score matching

One well-established method for selecting controls is to estimate the **propensity score**, which is defined as the probability that an individual will receive the intervention, conditional on the characteristics observed at a given point of time [28]. The theory suggests that selecting controls on the basis of having similar propensity scores to the VW patients should reduce or eliminate any imbalances in observed characteristics asymptotically, assuming that the propensity score has been correctly estimated [28]. In practice, however, with a finite number of patients, some differences may remain between VW patients and matched controls, even if matching on a correctly estimated propensity score. One recommended approach to improve the balance in these circumstances is to match on a variety of variables simultaneously, including the propensity score and other important characteristics. This can be accomplished by the use of a multivariate distance measure, such as the Mahalanobis distance, to summarise the similarity of patients and potential controls over the range of variables [29]. The individual with the smallest Mahalanobis distance is selected as the matched control. On the assumption that there is no hidden bias caused by residual imbalances in unobserved characteristics, we will be able to obtain an unbiased estimate of the average impact of virtual wards on the subgroup of patients receiving the intervention by comparing the endpoints of virtual ward and control patients. Propensity matching is regarded as an iterative approach, so we will successively improve the propensity model until we obtain a satisfactory balance. One of the key recommended conditions for the use of propensity matching is that the assignment mechanism for choosing patients for the intervention should be well understood [30]. This condition is met for virtual wards, since patients are generally chosen using a predictive risk model.

Prognostic matching

Given the prominent role of predictive modelling in the intervention, we will also select controls by matching directly on the predictive risk score, combined with other relevant characteristics through a Mahalanobis distance. This method of selecting controls is termed **prognostic matching** and should also produce an unbiased estimate of the average impact of virtual wards [31].

chosen as those with the greater level of balance, as determined by accepted metrics [32]. For the national controls these will include variables recorded in Hospital Episode Statistics (age, sex, imputed deprivation, distance to the nearest hospital, diagnoses, and patterns of inpatient, outpatient and A&E use). For the local controls these will include variables recorded in Secondary Uses Service data (equivalent to those recorded in HES) plus variables recorded in GP data (including prescribing data, laboratory results and biometrics), social care data (social care needs assessments and service provision) and community health services data (services provided by district nurses, community physiotherapists etc.).

Study endpoints

The primary endpoint for this study will be comparative rates of unplanned hospital admission and mortality. The secondary endpoints will be the rates and cost of A&E attendances, cost of social care provision, rates and cost of GP visits, and cost of community health services. Each of the primary and secondary outcome endpoints will be measured at the individual patient level over the 90 days, 180 days and 360 days following admission to the VW, and compared to the outcomes of the matched controls.

Power calculation

To estimate the required number of patients for a study such as this, an assumption needs to be made about the magnitude of the change that it is reasonable to expect the intervention to generate. We have designed this study so that, with reasonably high probability, we will detect a relative change of 20% in the primary endpoint, should it occur, at power (1-Type II error) 90% and two-sided p-value (Type I error) <0.05.

Based on actual data provided by one of the sites, we shall take the rate of unplanned hospital admission to be 1.65 unplanned admissions per year with a standard deviation of 2.5 for patients receiving usual care. Using the formulae provided by Friedman and colleagues [33], we have calculated that the required sample size is 1206 patients. We will assess any differences in rates of health and social care utilisation between VW patients and matched controls using paired t-tests. We do not plan to conduct any subgroup analyses.

Economic evaluation

We will calculate the direct costs of the VWs in each of the three sites from the perspectives of the NHS and the local authority. In the three sites, the alternative to VW care is routine care. To establish the cost of routine care, we will use data on the utilization of health and social care services, including GP visits, hospital costs (inpatient, outpatient and A&E) and council-funded social care. The unit costs will be calculated using the actual costs to the NHS (hospital tariff, GP hourly rates etc.) [34]. Social care costs will be calculated according to activity recorded in social care data, multiplied by the unit costs published by the Personal Social Services Research Unit [35].

As well as using financial data from each site, the costs of the intervention will be validated by means of staff interviews, questionnaires and work diaries. The costs considered will include:

- **Staff costs:** these will be calculated for full-time virtual ward staff plus 25% on-costs. Those staff that split their time between VW activities and non-VW activities will be calculated pro-rata on the basis of diaries in which they will record the amount of time spent on VW activities for a sample two-week period.
- **Travel costs:** these will be calculated on the basis of the reimbursement for public transport or mileage paid to staff.
- **Land, computers and fixed capital costs:** these will be calculated on the basis of the lease costs paid for these items.
- **Management costs:** these will be calculated on the basis of the costs of management time that will actively be spent on VW activity using full time equivalents and salary bands.

We shall ignore pharmaceutical and laboratory costs because of the difficulties in obtaining the necessary data. We believe that these costs are unlikely to differ considerably between the intervention and control populations but we will attempt to check the reasonableness of this assumption during interviews of front-line staff.

The set-up costs of the VWs (including generating the predictive risk scores) will also be included in the cost estimates. We will ask the management and finance staff at each site what was entailed in setting up the VWs.

Inclusion and exclusion criteria

We will include all patients admitted to a VW between their inception at each site and 1 September 2010. The VWs in Croydon started on 15 May 2006; in Devon on 1 October 2008; and in Wandsworth on 1 March 2009. Patients will be excluded if they were admitted to a VW after 1 September 2010.

For the comparator group we will include the following patients subject to the exclusions below:

- **National**—all patients registered at the PCT of an ONS Corresponding Health Area
- **Local**—all registered patients

To ensure that the care provided to VW patients is different from the care provided to controls, we will exclude the following patients from the comparator group:

- **National**—all patients registered at the PCT of an ONS Corresponding Health Area that has a virtual ward scheme or similar in place during the period under study (which we have determined by contacting the local PCT).
- **Local**—all patients who have ever been admitted to a virtual ward.

See Table 3 for details at each site and ONS Corresponding Health Areas.

Ethical issues

Ethics approval was sought for this study because it will involve interviews, questionnaires and diaries administered to NHS and social care staff. The study was approved by the South West London Research Ethics Committee No. 4, dated 28 April 2010 (REC reference number 10/H0806/31).

Participation by staff will be entirely voluntary, and staff invited to participate will receive both a consent form and a covering letter, explaining that participation is voluntary and that the study will deliver anonymous returns. To protect the confidentiality of study participants, each participant will be assigned a unique Study Identification Number.

Table 3. Details for each site

Site	Period of study	Number of patients admitted to virtual ward (as at 15 June 2010)	ONS corresponding health areas
Croydon	15 May 2006–1 September 2010	1624	Enfield, Waltham Forest, Greenwich Teaching, Redbridge
Devon	1 October 2008–1 September 2010	106	Somerset, Cornwall and Isles of Scilly, Shropshire County, Herefordshire[1]
Wandsworth	1 March 2009–1 September 2010	196	Hammersmith and Fulham, Camden, Islington, Westminster

[1] North Yorkshire and York PCT and Dorset PCT have been excluded because they had virtual ward schemes or equivalent in place during the comparison period.

The evaluation team will not request or receive any identifiable patient data: only pseudonymous or anonymous data will be obtained. For this reason, we have been advised by the Ethics and Confidentiality Committee of the National Information Governance Board that we may use such data without recourse to section 251 of the National Health Service Act 2006 (previously section 60 of the Health and Social Care Act 2001). The project started in May 2010 and is due to end in November 2011.

Summary

Many health care organisations use predictive models to identify patients at high risk of unplanned hospital admission, so that they can offer these patients extra ‘upstream’ support aimed at keeping them healthier and hopefully avoid the need for emergency admissions ‘downstream’. In certain parts of the UK, including Croydon, Devon and Wandsworth, such people are offered extra, highly integrated, support through a system of virtual wards (VWs). VWs aim specifically to prevent unplanned hospital admissions by using the same staffing, systems and daily routines as a hospital ward, except that the patients being cared for live in their own homes throughout.

The research project outlined in this paper will evaluate the costs of running VWs and the potential benefits of any reduced use of health and social care in three areas of England: Croydon, Devon and Wandsworth. The research findings should help councils and NHS commissioners to decide whether to fund this type of integrated care and, if so, how best to configure and run VWs locally.

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