A 10-year service evaluation of an assertive community treatment team: trends in hospital bed use

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Abstract

Background: Studies of assertive community treatment (ACT) have shown various benefits, including reduced hospital bed use. In the UK, this finding was not replicated by randomised controlled trials (RCTs), which lacked fidelity to the model. Conversely, observational studies, while limited by their inherent weakness in implying causality, have shown lower bed use. Against this background many ACT teams are being disestablished in the UK.

Aims: To observe the long-term effect of ACT on bed use, incorporating methods of analysis which mitigate against some weaknesses of observational design.

Methods: Bed use was compared for equal periods of time either side of starting support from an ACT team.

Results: Ninety-three people were followed for up to 10.5 years after starting ACT. Hospital bed use was compared for each person, showing a reduction from a mean of 72 d per year prior to ACT to 44 d per year during ACT (p = 0.0018).

Conclusions: The results demonstrate that ACT is associated with reduced bed use in the UK and that it is possible to use an observational design with enhanced analysis techniques to increase evidence for causality. These techniques may have value in other service evaluations.

Introduction

The provision of assertive community treatment (ACT) in the UK National Health Service was mandated as part of a series of reforms in the late 1990s including the development of Crisis Home-treatment and Early Intervention in Psychosis teams (Department of Health, 1999). Studies outside Europe had shown that ACT resulted in reduced hospital bed use, improved engagement with services, and greater satisfaction with services (Dieterich et al., 2010). This failed to be replicated in the UK healthcare setting where standard community care was more comprehensive. The UK 700 study was well powered, but the intervention was intensive case management, without the other components of ACT, and failed to deliver reductions in bed use (UK700 Group, 1999).

In contrast, the REACT study achieved better fidelity to the ACT model, and while reductions in mean bed use were observed these failed to reach statistical significance (Killaspy et al., 2006). However, we calculate that the REACT study was underpowered, assuming a modest effect size of 20% and the standard deviations published in their paper, 700 cases would have been required to avoid a type II error.

Recently, there has been widespread disinvestment in ACT teams in the UK, perhaps as a result of a tendency to ‘‘dilute the evidence’’ for its efficacy, and in contrast with other forms of specialist treatment which have continued despite similar levels of evidence supporting them (Rosen et al., 2013). In addition, there has been interest in ‘‘flexible assertive community treatment (FACT)’’, a hybrid of ACT and community mental health teams (Van Veldhuizen, 2007). An observational study suggested that a change from ACT to FACT was associated with reduced bed use (Firn et al., 2013). However, there may have been a reduction in engagement as indicated by significant increases in rates of non-attendance for appointments, and reduced face-to-face contacts with keyworkers. This may have longer-term implications beyond the 12-month follow up of the study period.

It has recently been reported that UK services which had invested in ACT experienced fewer suicides than those which had not and services which subsequently disestablished ACT were associated with higher suicide rates than those which continued with them (National Confidential Inquiry, 2013). It is possible that this is linked to the finding in most studies including those in the UK that people were more satisfied and engaged with ACT than standard care, which might lead to reduced suicide risk.

Despite the lack of evidence from randomised controlled trials, longer-term follow-up in observational studies of ACT services within the UK has been associated with sustained reductions in bed use to a level of about half that at inception.
A retrospective mirror-image evaluation comparing those who received ACT with contemporaneous controls also demonstrated significant reductions in hospital bed use in addition to other benefits such as reduced wider use of resources (Mortimer et al., 2012).

However, there are inherent weaknesses in observational studies with respect to any attempts to demonstrate efficacy of a particular intervention. Changes may occur as a result of the natural time-course of the condition, regression to the mean, or because of other environmental changes such as the availability of new treatments, or reorganisation of services. Finally the placebo effect cannot be controlled for in this type of study.

Notwithstanding these difficulties, observational studies can readily take place in mainstream clinical practice, with minimal expense. We were keen to examine the performance of our own ACT service in this context, but in order to address some of the problems outlined above, we adopted a change-point analysis method in addition to a mirror-image analysis. Change-point analysis was developed in engineering, where detection of change is the subject of study, and has the advantage of being unaffected by outlying values, meaning that any changes detected are not artefact and is easy to use and interpret (Taylor, 2000).

The South Warwickshire ACT team formed in 2000 serves a mixed population including substantial rural areas as well as a number of small towns. It aims to support people with a history of severe psychotic disorders, with poor engagement with services and often with other co-morbid conditions including alcohol, substance misuse, and personality disorder. Although the staffing changed over the 10 years of the study, the team always included a mix of nursing, social work, occupational therapy, psychology, and medical members. The Dartmouth Assertive Community Treatment Scale (Teague et al., 1998) was used in March 2004 and July 2008, with scores of 4.4 and 4.2, respectively, indicating high fidelity to the ACT model (a score greater than four denotes this). An audit, carried out in July 2008, compared the service to the Mental Health Policy Implementation Guide (Department of Health, 2001). This showed the team to be compliant on 104 out of 107 items listed in the guide, which again demonstrates that it was very closely aligned to the ACT model.

We have very briefly referred to parts of our data in a correspondence (Sood & Owen, 2014). In this evaluation, we report detailed longer-term follow-up over a 10-year period, aiming to establish whether the provision of ACT was associated with a reduction in hospital bed use in people with severe mental illness using methods of analysis which enable separation of the effect of ACT from any other background influences.

**Methods**

We observed the entire cohort of people who had ever been open to the ACT team over its first 10 years. Case notes were reviewed to ascertain details of every admission, both prior to and following transfer to ACT. The nature of admission was recorded including whether detention under the Mental Health Act was required. It was anticipated that many people would have experienced contact with psychiatric services for some time during prodromal phases of their illness during which time admission to hospital would be unlikely. For this reason, it was thought that it would provide a more meaningful assessment of the impact of ACT if the study period for each individual started after their first admission to hospital, at which point the onset of their illness would be more fully established.

A mirror-image analysis was used, based on comparing equal time periods either side of a “mirror” which in this case was defined as the date ACT was started for each individual. For each person, the shortest of either the time from first psychiatric admission to the start of ACT or the time from the start of ACT until the date of analysis or date of discharge for those who had subsequently left the service was used. This enabled the maximum possible time to be compared, spanning up to 20 years for those who had been with the service throughout its existence.

In order to examine shorter-term effects of ACT, it was decided also to compare data limited to only 1 year either side of the start of the service for each individual. To some extent, this would control for the effects of changes in service provision over longer periods of time, as people were taken on to ACT throughout the 10 years of its existence. Data were analyzed using paired $t$ tests in comparing mean bed use pre and during ACT, both for data limited to 1 year and for long-term bed use. A permutation Monte Carlo test, as described by Good (2005), and originating from Fisher (1936), was used to compare corresponding median bed use. Like Fisher’s exact test, this gives a $p$ value which is calculated directly without any intermediate test statistic such as a Chi-squared, or $t$-value.

Change-point analysis was used to pinpoint if and when any significant changes in bed use occurred before or during ACT. It is a method of detecting when and with what statistical significance a change has occurred in any time ordered data. The procedure is robust to the effects of outliers, and the method can detect multiple changes using a combination of cumulative sums (CUSUMs) and random shuffling of the original data (Efron & Tibshirani, 1993). CUSUM indicates how the individual values compare with the mean of all the values. The CUSUMs are charted and a change in the direction of a CUSUM chart indicates that a change has occurred in the data series at a particular time.

The significance of a change is determined by principles of shuffling whereby the data points are randomly shuffled to see whether the randomly derived result differs from the original. The shuffling is repeated thousands of times, and in each case, the resulting data are analyzed for evidence of a change using the CUSUM method, as above. The number of occasions when the change is observed in the shuffled data is counted to establish the background level of a change by chance for the particular data set. This enables the probability of a change being observed by chance to be calculated for the original data. The confidence interval of the detected change is obtained by bootstrapping, a well-established method involving random data selection similar to shuffling, for establishing confidence intervals for various statistics, such as medians, means, and standard deviations.

The change-point analysis was carried out using Change-point Analyzer 2.0 (CHAMP, Burgh, PA) (Taylor, 2008) which calculates the confidence interval of when a change...
occurs and the significance of the change. This method was used to detect when a change in bed use occurred in relation to the start of ACT by aligning all data to individual ACT start dates and taking monthly time slices on either side to calculate the bed use per person per month. The number of people in each monthly time slice varied as people joined or left the service in a staggered fashion over the course of many years.

**Results**

A total of 93 people were included who had been open to ACT at some stage from its inception in September 2000 until February 2011. Of these, 65 (70%) were male. Six were excluded as a result of difficulties in collecting data relating to bed use, for example, because they had come from out of the area and hence accurate information about bed use was not available. Table 1 shows the demographic and clinical characteristics of the cohort.

**Mirror-image analysis**

During the time, when people were supported by ACT, they required 44% fewer admissions to hospital comparing identical time periods, using the ‘mirror method’ as described above (Table 2). The difference in the mean values was tested for significance using a 2-tailed paired t-test and was highly significant ($t = -4.98$, degrees of freedom (df) = 92, $p < 0.0001$). There were 30% fewer admissions under the Mental Health Act during identical time periods following versus prior to ACT ($t = -2.49$, df = 92, $p = 0.0146$). The mean length of these identical time periods was 4.8 years, while the mean time with the ACT service was 6.1 years. Hence, the mirror-image analysis was compared a mean of 4.8 years before versus 4.8 years during the time with ACT.

The total number of days per person per year spent in hospital was reduced from a mean of 73 prior to ACT to 46 during the same time period when they were open to ACT ($t = -3.06$, df = 92, $p = 0.003$). As a few outliers might affect the results, median values for bed use prior to and during ACT were also compared. This showed a median reduction from 54 d per year to 20 d per year (permutation test, $p < 0.004$). Hence, the typical person supported by ACT required approximately 60% less time in hospital compared with prior to receiving the service.

It is likely that other wider service changes over the 10 years of the evaluation such as the development of home treatment teams or reductions in bed availability might influence bed use patterns irrespective of any impact of the ACT team. In order to separate any background trends from the impact of ACT itself, we also looked at bed use over a much shorter 1-year term for each individual. This enabled the immediate impact of ACT to be examined without contamination by longer-term background effects, showing a mean bed use reduction from 78 to 52 d per year ($t = -2.77$, df = 92, $p = 0.007$) with median changes from 55 d to 10 d ($p < 0.004$).

**Change-point analysis**

Change-point analysis was carried out using monthly time intervals which started 60 months prior to the onset of ACT. This cut off was chosen as it coincided with the average mirror length and because of the staggered nature of the data, at any one time included at least 65% of the entire population set. Time intervals were aligned to the start date of ACT for

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<th>Table 1. Clinical characteristics.</th>
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<tr>
<td><strong>Pre-ACT</strong></td>
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<td><strong>Age in years at 1st psychiatric contact</strong> (mean (SD))</td>
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<td><strong>Total number of previous admissions</strong> (mean (SD))</td>
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<td><strong>Total bed use pre-ACT, days</strong> (mean (SD))</td>
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<td><strong>Bed use per year pre-ACT, days per year</strong> (mean (SD))</td>
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<th>Table 2. Mirror-image analysis (N = 93).</th>
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<tr>
<td><strong>Number of admissions</strong></td>
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<tr>
<td>All admissions</td>
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<td>Involuntary admissions</td>
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<tr>
<td><strong>Bed days per person per year</strong></td>
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<td>Mean (SD)</td>
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<td>Median</td>
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*aPermutation test after Fisher.*
was staggered over the 10-year period, this supports the start date of ACT was different for each individual and identified in the 5 years leading up to the start of ACT. As the use had reduced to less than half. Furthermore, no change was required to achieve the maximum benefit, by which stage bed prior to ACT. It can also be seen that a 3-year period was proximate to the time of starting ACT, irrespective at what point over the 10-year period this had occurred. Following each of the changes, the mean level of bed use was lower than that prior to the mean level prior to ACT. It is noteworthy despite the outlier (labelled “a” in Figure 1) that the change-point analysis did not detect any significant change prior to the onset of ACT.

Discussion
This study demonstrates that ACT is consistent with significant and sustained reductions in hospital bed use. Due to the changing nature of psychiatric provision towards more community care over the past 20 years, it might be expected that the pattern of bed use for any one individual would be reduced over time irrespective of the provision of ACT. However, it is notable that the cohort included people taken on to ACT throughout the 10-year period, and that the reductions were apparent even when a much shorter 1-year timescale was used.

The change-point analysis provided further evidence that there had been a significant change in bed use in close proximity to the time of starting ACT, irrespective at what point over the 10-year period this had occurred. Following ACT, mean bed use per month was always lower than that prior to ACT. It can also be seen that a 3-year period was required to achieve the maximum benefit, by which stage bed use had reduced to less than half. Furthermore, no change was identified in the 5 years leading up to the start of ACT. As the start date of ACT was different for each individual and was staggered over the 10-year period, this supports the conclusion that the changes were related to the ACT team rather than any background influences. Had the observed changes been due to background influences on bed use, it would be expected that the changes would have been observed prior to as well as following the start of ACT.

In addition, it could be hypothesised that the reason why there was a reduction in bed use following the start of ACT was a regression to the mean effect. In other words, people may have been more likely to be referred to the service at a time of peak need in their psychiatric careers, and as such irrespective of the intervention, there would be a likelihood of a reduction following this peak. The fact that the change-point analysis did not detect a peak over the 5 years leading up to referral provides evidence that the reductions were not as a result of regression to the mean. This observation would not have been possible with a traditional statistical analysis which only examines crude before and after measurements.

We have demonstrated a reduction in bed use in a service with high fidelity to the ACT model, and which occurred in close proximity to the start of the service but suggest that there is a need to replicate this in other teams in order to firmly establish the evidence base for the effectiveness of the ACT approach. This service evaluation has, however, addressed some of the limitations of observational studies by virtue of the fact that the start point of the intervention for individuals was spread over an extended period of time, combined with the use of the change-point method, which although little used in mental health is well established and robust. It has been applied to the study of stock markets (Lenardon & Amirdjanova, 2006), climate change (Beaulieu et al., 2012), and is used in control engineering to identify the point at which a normal background variation becomes a genuine deviation in production processes (Amiri & Allahyari, 2011). Frisch et al. (2009) used the technique to identify when hospital mortality rates deviated significantly from background variations. It has also been valuable in astrophysics in the detection of stellar variability, or other events in massive astronomical time series data (Chang et al., 2012). We suggest that change-point analysis would lend itself well to other observational investigations in mental health to evaluate the effectiveness of interventions or services.

In the context of concerns about the tendency to dilute the evidence for ACT in the UK setting, along with the recent...
evidence relating to reduced suicide rates associated with ACT, our evaluation lends support to the importance of reversing the trend of disestablishing these services.

Declaration of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

References


