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Original article

## Remote mood monitoring for adults with bipolar disorder: An explorative study of compliance and impact on mental health service use and costs

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### ABSTRACT

**Background:** Remote monitoring of mood disorders may be an effective and low resource option for patient follow-up, but relevant evidence remains very limited. This study explores real-life compliance and health services impacts of mood monitoring among patients with bipolar disorder in the UK.

**Methods:** Patients with a diagnosis of bipolar disorder who were registered users of the *True Colours* monitoring system for at least 12 months at study assessment were included in this retrospective cohort study ( $n = 79$ ). Compliance was measured as the proportion of valid depression and mania scale messages received in comparison to their expected numbers over the first 12 months of monitoring. Mental health service use data were extracted from case notes, costed using national unit costs, and compared 12 months before (pre-TC period) and 12 months after (TC period) patients' engagement with monitoring. Associations with relevant patient factors were investigated in a multiple regression model.

**Results:** Average compliance with monitoring was 82%. Significant increases in the annual use and costs of psychiatrist contacts and total mental health services were shown for patients newly referred to the clinic during the pre-TC period but not for long-term patients of the clinic. Psychiatric medication costs increased significantly between the pre-TC and TC periods (£ 235,  $P = 0.005$ ) unrelated to patients' referral status. **Conclusions:** Remote mood monitoring has good compliance among consenting patients with bipolar disorder. We found no associations between observed changes in mental health service costs and the introduction of monitoring except for the increase in psychiatric medication costs.

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## 1. Introduction

Bipolar disorder is a chronic illness characterised by episodes of depression and excessive elation. It represents a spectrum from mild mood episodes to severe mood disorders with psychotic symptoms. Bipolar disorder is often associated with other psychiatric disorders (e.g. substance abuse, personality disorder) or physical co-morbidities (e.g. diabetes, cardiovascular disease), and often results in poor social and physical functioning of the patients [1–3].

The lifetime prevalence of bipolar disorder is estimated to be between 1 and 6% in European countries [4]. Worldwide, it is one of the leading causes of disability with more years of life lost due to premature death and disability than asthma, heart attack, epilepsy

and dementia [5]. People with bipolar disorder are frequent users of health and social care services. In 2007, an estimated 1.14 million people suffered from bipolar disorder in the UK [6]. For the same year, the total societal costs of bipolar and related disorders were calculated at £ 5.2 billion with total service costs (health and social services and informal care) being £ 1.6 billion [6]. A more recent estimate by Young et al. [7] for the annual UK National Health Service (NHS) cost of bipolar disorder was £ 342 million at 2009/10 prices. Hospitalizations accounted for 60%, outpatient and community mental health for 26.7%, and medication in primary care for 7.4% of the overall direct costs of care [7]. A recent review suggests that costs in the UK are comparable with other European countries: cost estimates for the USA are much more variable [8].

The main objectives of bipolar disorder management are stabilization of mood thereby preventing acute episodes, unwanted hospital admissions and suicides, and improving quality of life by

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41 optimising social and physical functioning. Recent guidelines [9]  
42 have emphasized the potential for improving care by more expert  
43 clinical service provision. Specialist care reduced the risk of re-  
44 admission to hospital in bipolar disorder in comparison with generic  
45 care in Denmark [10] and this finding can probably be generalized to  
46 other developed countries. Monitoring of symptoms should be an  
47 essential component of bipolar disease management because it can  
48 track the effectiveness of interventions and facilitate early interven-  
49 tion when fluctuations in symptoms are identified to prevent or  
50 minimise the impact of episodes [11]. Timely access to specialist care  
51 is, however, often limited due to human, financial or geographical  
52 constraints resulting in waiting lists, suboptimal treatment and lost  
53 opportunities for early intervention or prevention.

54 Several attempts have been made to implement regular, remote  
55 mood monitoring for bipolar disorder to improve clinical outcomes  
56 and optimize access to specialist services at low direct intervention  
57 costs [12–17]. However, none of the relevant studies provided  
58 information on patients' real-world achievable compliance with  
59 monitoring or investigated the broader impact of monitoring on  
60 other costs to the mental health services. Moreover, currently there  
61 is no agreement whether remote mood monitoring increases mental  
62 health service use due to stricter follow-up or reduces service use as  
63 the consequence of less frequent visits and better health outcomes.  
64 With the growing number of such services worldwide, it is important  
65 to gain more insight into the real-life feasibility and acceptability of  
66 remote mood monitoring and to establish its likely wider economic  
67 impact on the mental health services. In order to explore these  
68 aspects and fill the relevant gaps in evidence, we conducted a  
69 retrospective cohort study of bipolar patients' compliance with  
70 monitoring and their mental health service contacts and costs before  
71 and during their first year engagement with the *True Colours*  
72 monitoring system at Oxford Bipolar Disorder Research Clinic in  
73 Oxford, UK (<https://truecolours.nhs.uk>).

## 74 2. Methods

### 75 2.1. The *True Colours* system

76 Remote mood monitoring for adults with bipolar disorder has  
77 been successfully implemented at the Oxford Bipolar Disorder  
78 Research Clinic at the Warneford Hospital, Oxford, UK using the *True*  
79 *Colours* system since 2006. The clinic provides secondary (for referrals  
80 from central Oxford) and tertiary service for around 300 patients with  
81 bipolar disorder. The *True Colours* system combines simple, widely  
82 used, convenient and low cost means of communication by SMS/  
83 email/internet with sophisticated software engineering. It allows a  
84 real-time, remote monitoring of symptoms and clinical outcomes by  
85 patients self-rating their mood using validated self-report scales for  
86 depressive (the Quick Inventory of Depressive Symptomatology  
87 [QIDS-SR<sub>16</sub>]) and manic symptoms (the Altman Self-Rating Scale for  
88 Mania [ASRM]), and their communication by weekly mobile-phone  
89 text messages or email [18,19]. Patients using *True Colours* either  
90 receive and reply to two, weekly text messages separately for the  
91 monitoring of their QIDS and ASRM scores, or receive one prompting  
92 email and log in to the *True Colours* website via a secure link to enter  
93 their relevant scores directly. In case of no reply or faulty response,  
94 the system sends additional reminder SMS messages/emails. The  
95 chosen method of communication is the preference of the patient and  
96 can be changed. The system also produces a graph-based output in a  
97 user-friendly format accessible through the web for the patients and  
98 their clinicians/care teams, allowing them to track a patient's  
99 condition and identify early signs of relapse in a collaborative way.  
100 *True Colours* meets the requirements of patient confidentiality and  
101 security as it has been designed to enable compliance with the Data  
102 Protection Act 1998 and 2003 [20,21] and the NHS Information  
103 Governance Assurance Framework [20].

### 2.2. Patients and design

104 A group of 159 potential participants aged 18 and over was  
105 obtained from the patient lists of the three consultant psychiatrists  
106 initially implementing *True Colours* at the Oxford Bipolar Disorder  
107 Research Clinic. The status of these participants as current or  
108 previous *True Colours* users was confirmed by their responsible  
109 clinician and further authenticated through cross-referencing with  
110 the *True Colours* database. Screening of the cohort was conducted  
111 to identify: a clinician confirmed diagnosis of bipolar disorder I, II  
112 or Not Otherwise Specified (NOS) using the Structured Clinical  
113 Interview for DSM-IV (SCID); registration with the *True Colours*  
114 system for a minimum of 12 months; and accessible paper or  
115 electronic psychiatric notes covering the full 12-month periods  
116 prior to and after enrolment with *True Colours* (pre-TC and TC  
117 periods, respectively) as of 2010.

118 Compliance with remote mood monitoring was measured for  
119 each participant as the proportion of valid SMS/email messages  
120 received by the *True Colours* system in comparison to the expected  
121 number of weekly QIDS and ASRM scale messages over the first  
122 year monitoring period. Anonymised patient-level data on the  
123 number of messages sent and received by the *True Colours* system  
124 were extracted directly by the system manager for the relevant 12-  
125 month periods. Individual case notes were screened for contacts  
126 with various mental health care staff and psychiatric hospital  
127 admissions for the 12 months before and 12 months after  
128 engagement with remote mood monitoring by an independent  
129 research assistant. Written consent was sought from all partici-  
130 pants. The study protocol was approved by the local Research  
131 Ethics Committee (Oxfordshire REC A, Reference: 10/H0604/13).

### 2.3. Analysis

132 The economic analysis had a before and after study design.  
133 Investigated resource use categories included mental health  
134 inpatient hospitalisations, face-to-face and phone contacts with  
135 psychiatrists (including trainees), psychologists, community men-  
136 tal care staff (community psychiatric nurse, community support  
137 worker, crisis team, occupational therapist, social worker) and  
138 psychiatric medications. Service costs were calculated in British £s  
139 for the last respective year of resource use using UK national-level  
140 unit costs [23,24]. For medications, we used average mg prices  
141 based on the British National Formulary [25]. Applied unit costs are  
142 listed in Table 1.

143 A frequency analysis of observed, patient-level mental health  
144 service use data and comparison of observed costs in the pre-TC and  
145 TC periods were carried out using t-test. In addition, mental health  
146 service costs were analysed in a multiple regression analytic  
147 framework [26–28] to explore the associations with age, gender,  
148 duration of illness and period of observation (pre-TC or TC), and to  
149 adjust for potential, a priori defined confounders such as the  
150 presence of significant manic and/or depressive symptoms at the  
151 time of engagement with *True Colours*, and patients' referral status to  
152 the Oxford Bipolar Disorder Research Clinic during the pre-TC period  
153 (newly referred vs. long-term patients). Statistical significance was  
154 considered at 5% (two-sided,  $P \leq 0.05$ ). All analyses were carried out  
155 in STATA 10 (StataCorp. LP, College Station, Texas, USA, 2007).

## 156 3. Results

### 157 3.1. Patients

158 Seventy-nine participants (33 male/46 female) aged 18 to  
159 71 years (mean age = 39 years, SD = 13 years) fulfilled all of the  
160 specified inclusion criteria and consented to the study. Par-  
161 ticipants' history of bipolar I ( $n = 52$ ), II ( $n = 9$ ) or NOS ( $n = 18$ )  
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