



OPEN ACCESS

# Introducing artificial intelligence in acute psychiatric inpatient care: qualitative study of its use to conduct nursing observations

Alvaro Barrera ,<sup>1,2</sup> Carol Gee,<sup>2</sup> Andrew Wood,<sup>2</sup> Oliver Gibson,<sup>3</sup> Daniel Bayley,<sup>3</sup> John Geddes<sup>1,2</sup>

<sup>1</sup>University of Oxford, Oxford, UK

<sup>2</sup>Oxford Health NHS Foundation Trust, Oxford, UK

<sup>3</sup>Oxehealth, Oxford, UK

## Correspondence to

Dr Alvaro Barrera, University of Oxford, Oxford OX1 2JD, UK; alvaro.barrera@psych.ox.ac.uk

Received 1 December 2019

Revised 8 January 2020

Accepted 10 January 2020

## ABSTRACT

**Background** All patients admitted to an acute inpatient mental health unit must have nursing observations carried out at night either hourly or every 15 minutes, to ascertain that they are safe and breathing. However, while this practice ensures patient safety, it can also disturb patients' sleep, which in turn can impact negatively on their recovery.

**Objective** This article describes the process of introducing artificial intelligence ('digitally assisted nursing observations') in an acute mental health inpatient ward, to enable staff to carry out the hourly and the 15 minutes observations, minimising disruption of patients' sleep while maintaining their safety.

**Findings** The preliminary data obtained indicate that the digitally assisted nursing observations agreed with the observations without sensors when both were carried out in parallel and that over an estimated 755 patient nights, the new system has not been associated with any untoward incidents. Preliminary qualitative data suggest that the new technology improves patients' and staff's experience at night.

**Discussion** This project suggests that the digitally assisted nursing observations could maintain patients' safety while potentially improving patients' and staff's experience in an acute psychiatric ward. The limitations of this study, namely, its narrative character and the fact that patients were not randomised to the new technology, suggest taking the reported findings as qualitative and preliminary.

**Clinical implications** These results suggest that the care provided at night in acute inpatient psychiatric units could be substantially improved with this technology. This warrants a more thorough and stringent evaluation.

## BACKGROUND

Acute inpatient care remains a crucial component of modern mental healthcare. In England, in 2017/2018, just over 103 000 people with mental health problems spent time in hospital.<sup>1,2</sup> Despite their importance, psychiatric inpatient units are still often experienced as frightening places where overwhelmed staff feel unable to provide therapeutic care in a rather unsatisfactory physical environment.<sup>3,4</sup> In 2016, 93% of wards were operating above the Royal College of Psychiatrists' recommended 85% occupancy rate, leading to extremely acute and challenging environments.<sup>5</sup>

Inpatient psychiatric units face distinctive challenges. A significant proportion of patients are

treated compulsorily under the Mental Health Act, and many pose a significant risk to themselves or others.<sup>3</sup> A key process on these units is that of the nursing observations. In order to monitor risks as well as provide therapeutic engagement, all people admitted to an acute psychiatric unit must be on one of three levels of nursing observations<sup>6</sup>: general observations, the minimum level for all patients, where the safety of patients is checked hourly; intermittent observations, where a patient's safety is checked at least once every 15–30 min; and constant observations, where the patient remains within eyesight of nursing staff at all times. Nursing observations must take place 24 hours a day, 7 days a week. Unfortunately, they can lead to iatrogenic disruption of patients' sleep as nurses routinely enter a patient's bedroom or switch on the bedroom lights to check patients.<sup>7</sup> Thus, waking people up hourly or every 15 min throughout the night to keep them safe could be having the paradoxical effect of causing insomnia, worsening of their mental health, as well as leading to incidents of aggression.<sup>8–10</sup>

The association between sleep disruption and mental ill health has become increasingly clear. Around 8 out of 10 psychiatric inpatients report clinically significant insomnia.<sup>11</sup> There is a negative correlation between sleep duration on admission to a psychiatric ward and subsequent length of time in hospital.<sup>12</sup> Also, short sleep duration and night-to-night variation in sleep duration are both associated with increased risk of aggression in psychiatric intensive care units.<sup>13</sup> Treatment of insomnia has been shown to lessen psychosis<sup>14</sup> as well as mania<sup>15</sup> and depression.<sup>16</sup> A pilot randomised controlled trial (RCT) of cognitive-behavioral therapy (CBT) for insomnia conducted on our ward showed a significant effect on insomnia and length of stay.<sup>17,18</sup> Therefore, the clinical usefulness of a system that avoids that nursing observations disrupt patients' sleep would be significant, in terms of reducing insomnia, promoting mental health recovery and improving patient's experience. In fact, some have even suggested that, given their negative impact on patient care, intermittent nursing observations, in their current form, should be abandoned.<sup>19</sup>

Artificial intelligence (AI) could provide a solution to these issues,<sup>20</sup> but its introduction in mental healthcare requires careful evaluation and implementation.<sup>21</sup>



© Author(s) (or their employer(s)) 2020. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

**To cite:** Barrera A, Gee C, Wood A, et al. *Evid Based Ment Health* 2020;**23**:34–38.

## OBJECTIVES

The service improvement project reported here took place within the National Institute for Health Research (NIHR) Oxford Health Biomedical Research Centre (BRC). The project introduced digital assisted observations on the Vaughan Thomas ward, Oxford Health Foundation Trust, Oxford. Specifically, we describe the process that has led to ward staff now carrying out night-time nursing observations using digital technology to monitor patients who are either on hourly or on 15 min intermittent observations. The aim of this project was to establish whether it is safe to conduct nursing observations remotely from the nursing office using the novel digital technology described further. This was established in two ways: first, by comparing the accuracy of the observations done using the new technology against the observation carried out in person, and second, by carefully ascertaining whether there were any incidents related to the new technology documented in the Trust's online incident reporting system. To our knowledge, this is the first time that digital technology has been used on a real-world clinical setting to carry out nursing observations at night.

## METHODS

### Technology: digital sensors

The key innovation in this project is the use of Oxehhealth sensors, which employ a software that uses computer vision, signal processing and AI techniques to track micromovements and colour changes (through photoplethysmography) on the body from several metres away. From these small signals, the pulse rate and breathing rate can be calculated. These techniques are akin to an automated version of the counting of chest movements commonly used in hospitals and a non-contact version of the widely used finger pulse oximeter. There is therefore no disturbance to the patient, and a breathing rate can still be calculated when the patient is fully covered by bedding. Previous studies have evaluated the technology in specific populations: renal patients undergoing dialysis,<sup>22</sup> neonates in intensive care,<sup>23</sup> adults in intensive care,<sup>24</sup> and patients and staff in a high-security mental health setting.<sup>25</sup> The British Standards Institute, acting as a notified body on behalf of the Medicines & Healthcare products Regulatory Agency, has accredited the sensors' vital signs measurement software as a class IIa medical device in Europe (figure 1). The sensors use an infrared camera, attached to a discreet wall-mounted monitor so they can function at night without having to switch lights on.



**Figure 1** Digital sensor in bedroom.

From a safety point of view, the sensors possess two very positive features. First, they are fitted in a fixed installation in an anti-ligature housing and, second, they do not require the patient to wear any potentially risky devices. From a clinical point of view, highly relevant in a patient population unwilling to cooperate in any medical procedure (such as ECG or any other monitoring), the sensors work passively and do not require any patient cooperation.

### Approach: partnership with Oxford Health NHS, Oxehhealth and Oxford University

Since this project would involve a significant change in a core area of inpatient care, a process of preparation and engagement at all the levels of the organisation, facilitated by the Trust-hosted NIHR infrastructure and Oxford Health Improvement, was undertaken over a period of 18 months. The project was managed by a team including NHS ward staff, Oxehhealth and the NIHR Oxford Health Biomedical Research Centre (a partnership between Trust and University of Oxford), with additional support from the NIHR Oxford Collaboration for Applied Health Research and Care. The core team met weekly and a more extended team met monthly. The project was presented to the Trust Executive Board, which enthusiastically supported and facilitated the subsequent phases of the project.

### Patient and public involvement (PPI)

There were extensive PPI activities, including meetings with former patients and patients' relatives. Similarly, meetings were held with front-line nursing staff, where the project was modified following suggestions. Patients as well as staff members asked challenging questions, including concerns about patients' safety, data confidentiality and impact on staffing levels.

### Clinical governance processes

This project was presented to and evaluated by the Trust's clinical governance structure, involving the innovation, audit and quality committees. Crucially, comprehensive formal agreements were established between the Trust and Oxehhealth, ensuring the protection of patients' confidentiality and data. Similarly, a commercial agreement was also established.

### Vaughan Thomas Ward: acute psychiatric ward

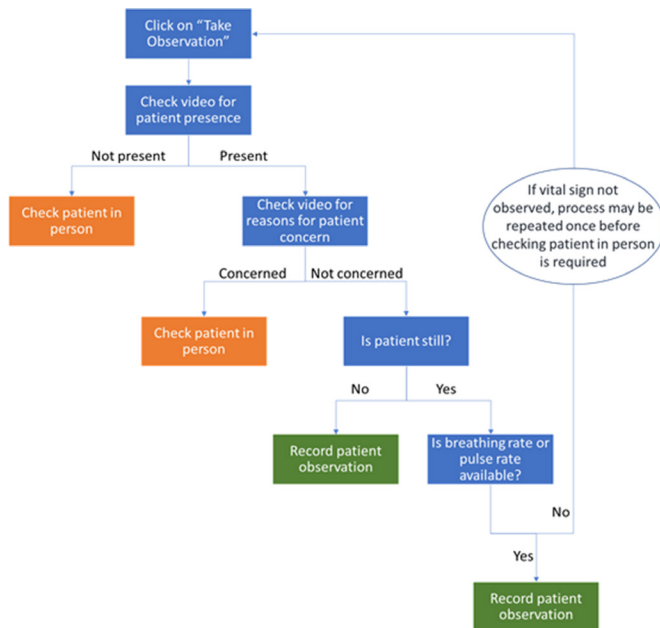
Vaughan Thomas Ward, an acute male ward with 18 individual bedrooms, provides inpatient care to patients with severe mental health disorders. Usually, at least 75% of the patients are compulsorily treated under the Mental Health Act. It was decided to instal the sensors in six bedrooms within the area where the more acutely unwell patients are nursed closer to the nursing staff office.

### Online incident report

The Trust has an online incident report system which members of staff must use to document any incident or 'near-miss' affecting patients, staff or property. This system was regularly reviewed to assess whether there was any incident related to the new system.

### Steering committee

A steering committee, composed of senior members of the Trust and Oxford University, including experts on safety in health-care, monitored the project and allowed movement through the successive stages that are described next.



**Figure 2** Digitally assisted nursing observations' protocol

### Blind running

Once installed, the system ran in the background for a period of remote monitoring to make sure it was running as expected. During this period, the staff did not receive any reports from the system. This time was used to ascertain staff and patients' views. Of note, while 11 out of 13 members of staff working at night indicated that patients were safely cared for through the existing nursing observations, the same proportion were concerned that they disturbed patients' sleep as well as their privacy and dignity.

### Developing a new observations protocol

An iterative process was carried out, always emphasising that the clinical judgement of staff was central. The new protocol was risk-assessed by the team and discussed with staff (figure 2), modelled on and compliant with the existing general and intermittent observations Trust policy.

Crucially, the new protocol removed the need for nurses to routinely switch on lights and/or enter patients' bedrooms, allowing staff to remotely obtain pulse and breathing rates readings. All staff were trained on the new protocol, emphasising that they should always check patients in person if they felt that anything might not be right. Thus, if the nursing staff using the sensors had any concerns (eg, patient on the floor, pacing or another person in the room), the member of the staff is prompted to go and check the patient in person ('Check video for reason for patient concern' in figure 2).

## FINDINGS

### Testing the new protocol against 'treatment as usual'

During this stage, the sensor-assisted observations ran in parallel to the existing observation protocol between 21:00 and 09:00. Initially, 52 observations using the modified protocol over six patient nights were taken in parallel and compared with conventional in-person observations. Subsequently, 275 observations over 22 patient nights were analysed. The observations using the sensors matched with the observations carried out without sensors in 100% of the cases. Regarding vital signs, from the 275 observations, 255 observations returned a vital sign first-time-round; three observations returned a vital sign

second-time-round; for 17 observations, the patient was clearly seen moving, which prevents obtaining vital signs readings. The ward incidents log was reviewed, and no incidents related to the sensors were found. Thus, the new observations protocol using the sensors was found to be as accurate as observations carried out in person. Following discussion with the steering committee, it was agreed to move to the next stage, which used an opt-out approach, that is, the sensor would be switched on, but the patient could request it being switched off.

### Test 1: first four nights of the new observations protocol

The aim of this stage was to test the sensor-assisted observations protocol overnight, between 21:00 and 09:00, alone, without the in-person running in parallel. There was significant supportive activity, including daily briefing of staff and Trust's senior managers attending each night to support the launching of the new protocol. Also, as an extra precaution, patients were checked in person by staff at midnight and at 04:00 hours.

During the first four nights of use, 308 observations were done using the new system. All the records of observation from the night shifts were reviewed, confirming that staff had performed and recorded their observations as required by the protocol. The incident report system was also reviewed, and no incidents related to the system were found. Eleven patients from rooms with sensors completed a questionnaire each night and no negative comments related to the system were expressed. This information was reported to the steering committee, which approved moving to the next stage.

### Test 2: further 4 weeks of evaluation

During this period, 2749 nursing observations using the sensors were done. There were no significant gaps or drops in usage, suggesting that staff were using them even when the project team's presence was less intense. On a few nights, usage was slightly lower than expected, so some staff members became 'sensors champions' ensuring all staff were trained each night shift.

Ten members of the staff were surveyed, and all reported that the sensors were easy and fast to use and had had a positive impact on patient and staff experience. Forty-three patient nights were surveyed using about their experience at night. While most comments from patients were not related to the sensors, the comments that did mention them were all positive, and some described their impact on sleep. Again, no incidents related to the system had been recorded. These findings were reported to the steering committee, which approved moving to the next stage.

### Ongoing evaluation

Since implementation of the new sensor-assisted observations, 17299 observations over an estimated 755 patient nights had been monitored to assess safety of patients as well as performance and adherence to the new system. After 4 months, 41 patients have spent on average 14.58 (SD 14.55) nights on bedrooms with sensors (minimum of one night and maximum of 86 nights). The ward incident report records have continued to indicate that no incidents related to the sensors have occurred. Thus, the sensors appear to be embedded on the ward's day-to-day clinical practice.

### Feedback from patients

During the PPI work undertaken with former inpatients prior to installing the sensors, a recurrent theme was sleep being



interrupted by the nursing observations. For example, a former patient said, 'I hate them, what's the point of observing me. They are loud and disturb me from sleeping. The slightest little noise would wake me up and I don't get much privacy'. Obtaining feedback from patients during the first days of their admission to the hospital has been a challenge, as they are particularly unwell, but some of the comments included 'staff keep opening my shutters - turning on the light' or 'sometimes turning the light on and off for checks is a bit disconcerting'.

### Feedback from relatives

During the PPI work undertaken with 10 relatives prior to installing the sensors, a recurrent theme was that the nursing observations were disturbing their loved ones' sleep at night. For example, the parents of a patient had concerns regarding the therapeutic value of observations, finding them 'intrusive and demoralising'.

### Feedback from staff

Eighteen staff members who had carried out sensor-assisted observations were surveyed and agreed with statements that the sensors disturbed patients' sleep less than the previous observation procedure, reduced verbal and physical aggression towards staff, were easy to use and allowed the observations to be done in less time. Seventy-eight per cent of surveyed staff agreed with the statement that the sensor-assisted observations improved the privacy and dignity of patients, and 94% agreed that the sensors maintained the same level of patient safety as conventional in-person observations. One concern expressed was that the moment of observation using the sensors could coincide with patients carrying out private activities, whereas with the previous system, patients realised that staff were approaching from hearing their footsteps in the corridor or moving the shutters.

### Safety

Crucially, and as indicated previously, the ward incident report system has revealed no incidents associated with the sensors thus far.

### Preliminary evidence of the impact of the sensors on recovery

The goal of this preliminary and qualitative study was to establish the feasibility and safety of using AI to conduct hourly and intermittent nursing observations at night in acute psychiatric inpatient care. However, very preliminary data described below also suggest that their use does not lead to worse sleep or longer length of stay, or to the use of more hypnotic or anxiolytic medication, or to the use of more rapid tranquilisation.

Regarding patients' sleep, this was assessed with the Insomnia Severity Index (ISI)<sup>26</sup> on admission to a bedroom with sensors (T1) as well as at the point of moving to a bedroom without sensors (T2). The ISI showed high internal reliability at both points (Cronbach's  $\alpha$  at T1 was 0.951 and at T2 was 0.934). There was a significant association between the number of nights a patient slept in a bedroom with sensors and the change on the level of insomnia between the T1 and T2 (Pearson correlation: 0.403,  $p=0.016$ , two-tailed,  $n=35$ ). In other words, the more a patient slept on a bedroom with sensors, the more their insomnia score decreased.

Regarding length of stay, there was a significant association between the number of nights a patient slept in a bedroom with sensors and the duration of hospital admission (Pearson correlation: 0.410,  $p=0.003$ , two-tailed,  $n=50$ ). In other words,

patients who slept more nights in a bedroom with sensors had longer hospital admissions. It is worth noticing that despite this group of patients being the more unwell patients, the duration of their hospital admission ( $n=41$ , mean=40.41, SD 37.88) was not longer than the duration of admission of all patients admitted to the ward in the 12 months prior to the sensors being used ( $n=131$ , mean=20.40, SD 35.90) ( $T=0.002$ ,  $df=170$ , two-tailed= $0.999$ ). The absence of a difference suggests that the sensors at least did not lead to lengthier hospital admissions.

Finally, there were no significant differences in the frequency of use of hypnotic medication (zopiclone and promethazine), benzodiazepines (lorazepam, clonazepam, temazepam and diazepam) or rapid tranquilisation while the patients were nursed on a bedroom with sensors compared with when they moved to a bedroom without sensors.

It must be emphasised that these results are exploratory and preliminary as, crucially, patients were not randomly allocated to bedrooms with or without sensors, so there could be many other factors at play, such as severity of the patient's mental ill health, non-clinical reasons for moving patients between bedrooms and medication's side effects.

## DISCUSSION

Sensor-assisted observations have been introduced in the day-to-day work of a busy acute psychiatric unit. They maintain patients' safety, and qualitative data suggest they reduce sleep disturbance as reported by patients. They also appear to have improved staff's experience of providing care at night. Very preliminary data found in this study suggest that sensor-assisted observations might have a positive impact on sleep, as indicated on a reduction of reported insomnia when being nursed on a bedroom with sensors. Also, very preliminary data suggest that sensor-assisted observations did not prolong length of admission compared with patients admitted to the ward in the year before to their introduction and were not associated with a higher use of hypnotics, benzodiazepines or rapid tranquilisation.

If these preliminary findings were replicated, they would support a significant change in the clinical care provided in inpatient units. Nursing observations are necessary to ensure that patients are safe on wards,<sup>6</sup> but there is growing evidence that repeatedly waking people up at night could be having the paradoxical effect of causing insomnia, hindering recovery as well as leading to incidents of aggression.<sup>8-10</sup>

This study has several limitations. It is narrative and qualitative in nature; patients were not randomised to the new technology; and clinicians involved in the study were not blinded to the goals and status of the patients nursed using the new technology. The sample size is also a limitation, in the sense that the reported findings were obtained from six individual bedrooms over a period of 4 months. These caveats indicate that the reported findings should be taken as qualitative, preliminary and in need of robust further evaluation.

### Clinical implications

Optical sensors have been introduced to conduct intermittent and hourly nursing observations at night on an acute psychiatric ward. Nursing staff can ascertain patients' safety in their bedroom as well as their pulse and breathing rate, without waking them up. To continue assessing in a robust way these preliminary and qualitative results, we are planning on conducting a randomised study of the impact of the sensors on insomnia and length of stay, as well as exploring the potential use of the information obtained (movement, pulse and breathing rate) as possible biomarkers

in this clinical population. The potential contribution of these two streams of work (effect on sleep and recovery as well as a biomarker research) could have a transformative impact if its results are extended to the whole of the NHS. From a wider perspective, the partnership approach taken in this project suggests the significant potential of the collaboration between academia, NHS and industry in addressing clinically relevant research to bring direct benefit to patients.

**Funding** The study was supported by the National Institute for Health Research (NIHR), Oxford Health Biomedical Research Centre and the NIHR Oxford Collaboration for Leadership in Applied Health Research and Care.

**Competing interests** None declared.

**Patient consent for publication** Not required.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available upon request. The data are deidentified participant data, available from the corresponding author.

**Open access** This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

#### ORCID iD

Alvaro Barrera <http://orcid.org/0000-0003-4716-8487>

#### REFERENCES

- Health and Social Care Information Centre. Mental health Bulletin 2017-18 annual report, 2018. Available: <https://files.digital.nhs.uk/41/AF9F60/MH%20Bulletin%20201718%20Report.pdf>
- NHS Benchmarking Network. *Mental health benchmarking*, 2016.
- The Schizophrenia Commission. *The abandoned illness: a report from the schizophrenia Commission*. London: Rethink Mental Illness, 2012.
- Modernising the Mental Health Act. *Increasing choice, reducing compulsion. final report of the independent review of the mental health act 1983*, 2018.
- BASW. *Old problems, new solutions: improving acute psychiatric care for adults in England*, 2016.
- Department of Health. *Practice guidance: safe and supportive observations of patients at risk. mental health nursing: addressing acute concerns*. London: The Stationery Office, 1999.
- Chu S. Special observations in the care of psychiatric inpatients: a review of the literature and developments in practice. *ARC Journal of Psychiatry* 2016;1:21–31.
- State of Victoria, Department of Health. *Nursing observation and the assessment and immediate management of suicide, self-harm, aggression and absconding risks in psychiatric inpatient units. A review of literature*, 2013.
- Ray R, Perkins E, Meijer B. The evolution of practice changes in the use of special observations. *Arch Psychiatr Nurs* 2011;25:90–100.
- Kamphuis J, Meerlo P, Koolhaas JM, et al. Poor sleep as a potential causal factor in aggression and violence. *Sleep Med* 2012;13:327–34.
- Haynes PL, Parthasarathy S, Kersh B, et al. Examination of insomnia and insomnia treatment in psychiatric inpatients. *Int J Ment Health Nurs* 2011;20:130–6.
- Langsrud K, Vaaler AE, Kallestad H, et al. Sleep patterns as a predictor for length of stay in a psychiatric intensive care unit. *Psychiatry Res* 2016;237:252–6.
- Langsrud K, Kallestad H, Vaaler A, et al. Sleep at night and association to aggressive behaviour; patients in a psychiatric intensive care unit. *Psychiatry Res* 2018;263:275–9.
- Freeman D, Sheaves B, Goodwin GM, et al. The effects of improving sleep on mental health (OASIS): a randomised controlled trial with mediation analysis. *Lancet Psychiatry* 2017;4:749–58.
- Harvey AG, Soehner AM, Kaplan KA, et al. Treating insomnia improves mood state, sleep, and functioning in bipolar disorder: a pilot randomized controlled trial. *J Consult Clin Psychol* 2015;83:564–77.
- Ye Y-Y, Zhang Y-F, Chen J, et al. Internet-Based cognitive behavioral therapy for insomnia (ICBT-i) improves comorbid anxiety and Depression-A meta-analysis of randomized controlled trials. *PLoS One* 2015;10:e0142258.
- Sheaves B, Isham L, Bradley J, et al. Adapted CBT to stabilize sleep on psychiatric wards: a Transdiagnostic treatment approach. *Behav Cogn Psychother* 2018;46:661–75.
- Sheaves B, Freeman D, Isham L, et al. Stabilising sleep for patients admitted at acute crisis to a psychiatric Hospital (OWLS): an assessor-blind pilot randomised controlled trial. *Psychol Med* 2018;48:1694–704.
- Veale D. Against the stream: intermittent nurse observations of in-patients at night serve no purpose and cause sleep deprivation. *BJPsych Bull* 2019;43:174–6.
- Luxton DD. An introduction to artificial intelligence in behavioral and mental health care. In: Luxton DD, ed. *Artificial intelligence in behavioral and mental health care*. San Diego: Elsevier Academic Press, 2016.
- Buch VH, Ahmed I, Maruthappu M. Artificial intelligence in medicine: current trends and future possibilities. *Br J Gen Pract* 2018;68:143–4.
- Tarassenko L, Villarreal M, Guazzi A, et al. Non-contact video-based vital sign monitoring using ambient light and auto-regressive models. *Physiol Meas* 2014;35:807–31.
- Villarreal M, Guazzi A, Jorge J, et al. Continuous non-contact vital sign monitoring in neonatal intensive care unit. *Health Technol Lett* 2014;1:87–91.
- Ede J, Darbyshire J, Vallance D, et al. Non-Contact monitoring of vital signs in intensive care. Research in Clinical Practice conference, John Radcliffe Hospital, Oxford, 2016.
- Das M, Murray K, Surrall S. Non-Contact health monitoring in secure mental health settings: patient and staff studies at broadmoor Hospital. Research in Forensic Mental Health Services, London, 2016.
- Bastien CH, Vallières A, Morin CM. Validation of the insomnia severity index as an outcome measure for insomnia research. *Sleep Med* 2001;2:297–307.