Non-Contact Vital Signs Monitoring at Broadmoor Hospital

Improving patient safety and care: Oxehealth demonstrates continuous, automated camera-based health monitoring in secure rooms at Broadmoor Hospital.

Summary

Oxehealth worked with the West London Mental Health NHS Trust, to undertake a collaborative proof of concept study at Broadmoor Hospital, of the Oxecam software, that turns cameras into health monitors.

Detainees in mental health hospitals and other secure room facilities are at high risk of self-harm, violence and rapidly deteriorating physical health. Current procedures, which involve periodic checks, can miss critical incidents, be inaccurate and disturb patients sleep, worsening relations with staff.

The aim of this study was to ascertain the ability of the Oxecam to monitor core vital signs and the potential to detect critical health problems. Staff volunteers were monitored in a room in a secure ward at Broadmoor Hospital, in both light and dark carrying out typical patient activities.

The study demonstrated that Oxecam was not only able to carry out extended monitoring of heart rate and breathing, while the subject is both awake and asleep (in complete darkness), but also detect signs of serious health problems, including sudden changes in breathing rate. The study also showed that the non-contact monitoring technology allowed subjects to sleep uninterrupted.
Clinical study: why non-contact patient monitoring is necessary

Patients detained under the Mental Health Act are at significantly higher risk of death due to sudden and long term health complications, intoxication and self-inflicted violence. According to the Care Quality Commission’s Mental Health Act Annual Report 2014/15 227 notifications were received following the death of people detained in hospital.

Current systems of monitoring require periodic checks by staff (e.g. every 15-30mins) which means crucial incidents can be missed between checks. Patients deemed to be at higher risk require constant monitoring which means a member of staff sits outside a patient room and observes a patient constantly, which draws resources away from staff providing other essential care.

These visual checks also disturb the patient, as lights are switched on and hatches opened. Disrupting patients’ sleep in this way reduces their quality of life and is counterproductive for therapeutic or rehabilitation work.

In addition to this the staff member’s view of the patient is often obscured, and it can be difficult to differentiate visually between a sleeping patient breathing normally, and a patient who is in a critical condition and has stopped breathing.

Missing critical signs that result in a fatality not only leads to emotional trauma for families and staff, it also requires costly and time consuming inquests and activities in accordance with duty of care for facilities.

Existing technologies are unable to provide accurate in room patient monitoring. Contact based devices and associated wires and electronics cannot be used in these environments, as they could be used for self-harm or violence towards staff.

The study

Five staff volunteers were monitored in a secure room on a disused secure ward at Broadmoor Hospital. An off-the-shelf Allied Vision Technologies camera and infrared illuminator were temporarily mounted near the ceiling with a view of the whole room, with data recorded in a nearby nurses’ office.

Reference signals were derived from a wearable sensor system (Stowood Scientific Instruments), which collected heart rate data from a standard finger pulse oximeter and breathing data from stretchable inductive bands worn around the thorax and abdomen.

During each session, the room lights (standard ward lighting) were initially switched on, with each volunteer performing typical daytime activities: watching TV, reading a book, walking around the room and resting in a chair. Volunteers also simulated situations which would present additional challenges to staff visual checks, e.g. concealment under a duvet on the floor. The lights were then switched off and each volunteer slept in the room overnight while being recorded throughout.
The recordings from each session (video and reference wearable data) were securely stored on disk for analysis using the Oxecam algorithms.

**Results**

The study successfully demonstrated that:

- Oxecam provides extended monitoring of heart rate and breathing rate from camera data during typical patient activities while awake (under standard ward lighting and/or daylight) and sleeping (in complete darkness).
- Oxecam successfully detected breath holding by volunteers (including when concealed under a duvet on the floor), showing the ability to identify sudden changes in breathing rate or cessation of breathing. This would allow staff to be alerted appropriately.
- Clear apnoeic events were observed in the Oxecam camera data for a subject known to have obstructive sleep apnoea, as he slept overnight. Identification of sleep apnoea is a considerable problem in secure settings; sleep apnoea affects quality of life and may reduce the effectiveness of therapy.
- Oxecam can provide non-contact monitoring of breathing patterns throughout the night. Summary reports can then be generated for clinical review.
- The Oxecam camera system was entirely non-contact and silent; subjects found it unobtrusive and it did not disrupt their sleep, allowing on average 7 hours and 10 minutes of uninterrupted sleep.

![Graph 1](image.png)

*Graph 1. The graph above shows Oxecam detecting two periods of breath holding, where a volunteer has laid down on the floor and deliberately concealed themselves using a duvet to try to obstruct the view of the camera. The wearable reference chest band confirms the breath holding.*
Conclusion

This study demonstrated the capabilities of Oxecam camera-based health monitoring technology in a secure ward at Broadmoor. Subjects’ breathing and heart rate were automatically monitored while awake, and while sleeping overnight, in light and darkness.

Breathing cessations were identified, even for a subject fully concealed under a duvet on the floor. One subject with pre-existing sleep apnoea showed distinctive breathing patterns in the Oxecam data, suggesting that Oxecam could provide a solution for identifying sleep apnoea in secure environments.

Since Oxecam is unobtrusive, works in darkness and is entirely silent, it can be used to monitor throughout the night. Patients can then have access to a longer period of undisturbed sleep, which is more conducive to rehabilitation. This was demonstrated amongst volunteers who were able to sleep uninterrupted using Oxecam camera based health monitoring.

Neil Ragoobar, Security Liaison Manager at Broadmoor Hospital said “We are excited about the outcome of this study. This technology provides us with the opportunity to deliver better quality of care to patients in our hospital. Current checks are counterproductive to rehabilitation and they are time intensive for staff, who could better use this time engaging with patients.”