EPIC: Evaluation of Palpitations In the Community

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Redesigning clinical pathways for palpitation patients with the South Eastern Health and Social Care Trust
Abstract

This case series presents an evaluation of a new arrhythmia detection pathway that utilises the zensor vital signs monitoring system. The overall objectives of the evaluation were; 1) To assess a novel primary care rapid diagnostic pathway for patients with new onset arrhythmia. 2) Evaluate the appropriateness of the zensor monitoring system for this application. 3) Determine the feasibility of the zensor monitoring system to act as a virtual ECG home monitoring ward.

Patients that currently present to their General Practitioner (GP) with palpitations will usually be referred to secondary care for further assessment, diagnosis and management. At present in some regions of Northern Ireland (NI) this diagnostic pathway can take on average 58 weeks for a patient case to be closed. This is largely due to pathway and device selection limitations. All too often the outcome can be inconclusive, which is unsatisfactory for both the patient and the clinical team.

A novel pathway for referral was agreed with the South Eastern Health and Social Care Trust (SEHSCT) Cardiology team (located in NI) and a local NI GP practice. This pathway would “shift left” the diagnosis and investigation of patients with palpitations, consistent with Transforming Your Care policy [1]. The pathway utilised the zensor monitoring system (Intelesens, NI), which provides comfortable, discreet and continuous wireless vital signs monitoring for patients as they go about their daily activities.

The GP practice and coronary care teams received education and training on device application and information transfer. 24/7 contact for patients to request advice and allow review of troublesome arrhythmias was put in place. This ensured the patient could communicate at any time of the day or night with an experienced cardiology nursing team by telephone, text or email. In the event of a significant arrhythmia, a diagnosis and decision was made by a consultant cardiologist within 24 hours of detection. Patients were provided with zensor by the GP Practice Nurse after the initial GP appointment at the Old Mill Surgery (Newtownards, Co. Down, NI). Due to the acuity of symptoms, patients were asked to press the event button on the device when they experienced palpitations. This activated an automatic wireless data transmission to a secure platform for interpretation by the coronary care nursing team and ultimately a consultant cardiologist at the Ulster Hospital (SEHSCT, Co. Down, NI).

Twenty patients took part in the evaluation and eighteen patients experienced symptoms during the monitoring period. Seventeen patients received a clinical diagnosis, with two of these patients having a significant cardiac arrhythmia that required referral to the secondary care cardiology team. Fifteen patients had a significant arrhythmia excluded, their palpitation cause was identified and reassurance and management strategy defined.

In comparison with the traditional pathway of direct patient referral, the proposed pathway had a dramatic 94% shorter time-to-diagnosis. Overall, from when the patient first presented with symptoms until the letter outlining diagnosis was available to the GP, the waiting time reduced from an average of 406 days on the current pathway to an average of 24 days on the proposed pathway. The largest reduction in waiting time for patients was found to be between presentation to the GP and undergoing initial cardiac investigation. This reduced from an average of 336 days using Holter within the current pathway to an average of 5 days using zensor within the proposed pathway.

Both the pathway and the technology were well accepted by patients and healthcare professionals (HCPs) that took part in the evaluation.
Background

Our healthcare systems are currently undergoing significant and rapid change in an attempt to respond to a growing, aging population with a higher incidence of chronic illness. This is despite increasing shortfalls in funding within the National Health Service (NHS) [2]. Various actions have been debated to help alleviate pressure, with productivity savings being a key focus. Reduced running costs, shorter length of hospital stay and development of innovative new care models have been suggested as ways to increase efficiency [2].

The challenge of shifting healthcare services from a largely reactive system to a preventative and pre-emptive system is unlikely to be met with the processes and tools that are currently in use. However with the ever-increasing level of technical innovation, there is new opportunity to restructure service delivery to meet individual patient needs more effectively while lowering costs.

A ‘Connected Health’ approach is being increasingly used to help improve the quality of care delivered to patients through the use of innovative technology and more efficient models of care. While recent technical advances are paving the way for improvement, it is acknowledged that this will form part of a wider solution, and continued efforts must address existing challenges in order for the goal of a truly connected health and social care model to exist. Within Northern Ireland (NI) a roadmap for change, Transforming Your Care [1], has been used to facilitate changes to healthcare services so more effective patient care can be delivered.

To gain a better perspective of the current demand placed on secondary care cardiology services in particular, an internal clinical audit was undertaken at the Ulster Hospital, part of the South Eastern Health & Social Care Trust (SEHSCT), Dundonald, NI. The audit highlighted that in 2014 there were a total of 3,300 cardiology outpatient clinic referrals and 1,320 of these were for suspected arrhythmias.

For many patients the presence of an arrhythmia is first considered when they describe feeling palpitations to their GP. Palpitation is the sensation of rapid, irregular, or forceful heart beats [3] commonly caused by types of tachycardia, atrial fibrillation, extrasystoles and may cause an increased awareness of the heartbeat [4]. The majority of palpitations are benign, however if undiagnosed some conditions may lead to adverse clinical events such as stroke, heart failure, or sudden cardiac death (SCD). The symptoms associated with palpitations can cause distress and anxiety in patients, potentially leading to deterioration of their physical and mental health [5].

Patients with palpitations presenting to their GP or emergency departments are usually referred to the cardiology department for further investigation [6]. The clinical audit undertaken at the Ulster Hospital highlighted that patients remain in the current pathway for an average of 58 weeks. This includes 38 weeks for initial cardiology outpatient assessment, 10 weeks for cardiac investigation, 2 weeks from analysis to final dictated report and 8 weeks before the outcome of investigation is provided to the GP by letter. On many occasions the outcome of the initial investigation is inconclusive, and the investigation is repeated if symptoms persist.

Presently Holter monitoring is the standard of care for patients that require cardiac investigation. Notable limitations include large device size preventing patients from undertaking activities that trigger arrhythmias; non-compliance of patients in maintaining an event diary; absence of real-time data [5,7] and a short 24-48 hour monitoring duration. These limitations combined with patients undergoing investigation long after first presenting to their GP, reduce the likelihood of a successful diagnosis.
Evaluation Overview

An evaluation to assess the feasibility and practicality of a proposed new pathway for patients with palpitations was conducted within SEHSCT at the Ulster Hospital, Dundonald and at the Old Mill GP Surgery, Newtownards, NI.

This proposed pathway was consistent with the SEHSCT Safety, Quality & Experience (SQE) agenda [8] and aligned with the Department of Health’s Connected Health [9], and Transforming Your Care [1] strategies. A comparison of the existing and proposed pathways is provided in Figure 1. The aim of the pathway redesign was to provide a rapid, community led symptom driven assessment, investigation and treatment (if required) of palpitations at the time of presentation. This was achieved through the use of innovative technology (zensor monitoring system, Intelesens, NI), shown in Figure 2, and near-real time cloud based information transfer. The pathway facilitated patient monitoring through a virtual ward and a specialist virtual consultant clinic. The technology bridged the interface between primary and secondary care and removed the need for the patient to travel to secondary care for assessment.

Patients that attended the Old Mill GP surgery because they were experiencing palpitations and that fulfilled the study inclusion criteria (listed in Table 1) were set up with the zensor monitoring system by the GP Practice Nurse or Healthcare Assistant.

During monitoring, patients phoned the Cardiac Care Unit (CCU) in the Ulster Hospital to notify the cardiology nursing team that they had pressed the event button on the zensor device as they had experienced palpitations. The cardiology nursing team used the online database (zensor online) to verify that the event button was successfully received and to review the ECG rhythm to determine if there was a need for urgent intervention. Emails notified the clinical team that a patient-activated recording had been received.

The research nurse and administration staff in the CCU assisted in completing patient logs, creating reports at the end of monitoring for cardiologist review, and compiling patient monitoring outcomes that would be filed in the patients’ clinical records.

The consultant cardiologist reviewed reports created for each patient and determined whether their palpitations were significant. An outcome report and management letter was forwarded to the GP for discussion with the patient. This included counselling and initiation of treatment if required.

![Figure 1: Comparison between the existing pathway and the proposed pathway for patients with palpitations](Image)
The key objectives of the evaluation were:

1. To assess a novel primary care rapid diagnostic pathway for patients with new onset arrhythmia.
2. To evaluate the appropriateness of the zensor monitoring system for this application.
3. To determine the feasibility of the zensor monitoring system to act as a virtual ECG home monitoring ward.

The evaluation captured baseline demographics, symptoms, triggers, anxiety index, ECG, and outcomes. The pathway and the device were assessed using an audit and questionnaires. This assessment appraised the:

- Reliability of the device
- Efficacy of the device in capturing relevant ECG data at the time patients experience symptoms
- Feasibility of sending physiological data from the home environment over MiFi and so create a virtual home monitoring ward
- Impact if any on the time-to-diagnosis compared with the current standard of care
- Acceptability of the device and pathway to patients and healthcare professionals
- Feasibility of a larger scale project.

The inclusion and exclusion criteria used for the evaluation are provided in Table 1 below.

<table>
<thead>
<tr>
<th>Inclusion Criteria</th>
<th>Exclusion Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult male or female, ≥18 years of age</td>
<td>Pacemaker or implantable cardioverter defibrillators (ICD)</td>
</tr>
<tr>
<td>Patients presenting to their GP at Old Mill Surgery with palpitations.</td>
<td>Skin condition or injury affecting the torso</td>
</tr>
<tr>
<td></td>
<td>Pregnant</td>
</tr>
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<td></td>
<td>Black-out when experiencing palpitations</td>
</tr>
<tr>
<td></td>
<td>Medical history of heart attack</td>
</tr>
<tr>
<td></td>
<td>Medical history of heart failure</td>
</tr>
<tr>
<td></td>
<td>Family history of sudden cardiac arrest</td>
</tr>
<tr>
<td></td>
<td>Abnormal GP examination.</td>
</tr>
</tbody>
</table>

Table 1: Evaluation inclusion and exclusion criteria
zensor Monitoring System

zensor is a 3 lead ECG monitoring system which allows clinicians to continuously record and monitor full disclosure ECG, heart rate, respiration rate and motion data, whilst allowing full patient mobility. Shown in Figure 2, the zensor device is a small, lightweight, wearable, non-invasive, re-chargeable battery operated system connected to single-use disposable electrodes placed on the patient’s body.

The device will monitor for out of normal range vital signs and key cardiac arrhythmias (atrial fibrillation, tachycardia, bradycardia, ventricular fibrillation, and asystole). It also features patient-activated event recording, that allows patients to press the button when symptoms are felt. This triggers diagnostic quality ECG to be recorded and transmitted to an online database (zensor online) over a wireless connection. The system provides full configurability of the duration and frequency of monitored data.

During the evaluation the zensor device was set up to record and transmit a 30-second patient-activated event button ECG trace and scheduled 30-second recordings every 6 hours to verify patient compliance and continued technical operation. A Huawei E5756 Ultrafast mobile Wi-Fi ‘MiFi’ unit was used to facilitate data transfer from the zensor device to the zensor online platform during monitoring.

The system also continuously recorded ECG on the device during monitoring to provide a back up to wireless transmission if required and to permit retrospective analysis of performance of the cardiac arrhythmia detection algorithms. zensor+ viewing and analysis software was used to import and review full disclosure data at the end of the evaluation.
Results and Discussion

Patient Population

Twenty patients (16 female and 4 male) aged between 22 to 82 years (average age of 46 years) were monitored using zensor.

Prior to monitoring, the GP completed a questionnaire with each patient to characterise their palpitations.

- Eighteen patients had experienced their palpitations for over one month prior to entering the evaluation
- Seventeen patients experienced palpitations weekly or more frequently
- A typical palpitation occurred for seconds (10 patients) or minutes (7 patients)
- Palpitations started suddenly for 19 of the 20 patients
- None of the patients reported that they experienced constant palpitations
- Patients reported stress and worry as being the two main factors that their palpitations could be related to.

Further characterisation of symptoms reported by patients is provided in Figure 3.

Figure 3: Description of symptoms experienced by patients during episodes of palpitations

<table>
<thead>
<tr>
<th>Palpitation Symptoms</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest Pain</td>
<td>17%</td>
</tr>
<tr>
<td>Collapse</td>
<td>0%</td>
</tr>
<tr>
<td>Shortness of Breath</td>
<td>36%</td>
</tr>
<tr>
<td>Dizziness</td>
<td>37%</td>
</tr>
<tr>
<td>None of the Stated Symptoms</td>
<td>10%</td>
</tr>
</tbody>
</table>

Figure 3: Description of symptoms experienced by patients during episodes of palpitations
The questionnaire contained the Generalized Anxiety Disorder-7 (GAD-7) scale to determine how the palpitations were affecting patients’ anxiety levels. As shown in Figure 4, the level of anxiety experienced varied between patients.

- Four patients reported experiencing severe anxiety
- Four patients experienced moderate to severe anxiety
- Five patients experienced mild to moderate anxiety
- Two patients suffered between no anxiety and mild anxiety
- Five patients did not indicate that they experienced any anxiety as a result of their palpitations.

Figure 4: Anxiety levels for each patient based on GAD-7 Scoring
Monitoring Summary

During the evaluation, 18 patients experienced symptoms. Of these, zensor successfully captured ECG at the time of symptoms for 17 patients. This would represent a much higher capture rate than traditional devices and pathways commonly used for investigation. ECG was not recorded for 1 of the 18 patients (P005) due to a weakness in the design of the casing that caused the device to fail. Subsequent investigation and review allowed the weakness to be addressed by a slight amendment in the case design, that has since been verified to have been a successful resolution.

Two of the 17 patients had palpitations with an underlying cardiac etiology and were referred to secondary care for further evaluation. P002 was diagnosed to have atrioventricular nodal reentrant tachycardia. P008 had palpitations due to isolated ventricular extra systoles and runs of ventricular bi and trigeminy. Figures 5 and 6 show the ECG recorded during palpitations for these patients.

The other 15 patients had significant arrhythmia excluded as being the cause of the palpitations. Of the 2 patients that did not experience symptoms, asymptomatic physiological information was captured in automatically scheduled ECG recordings for 1 patient (P003). Appropriate advice from the cardiologist and management by the GP was provided.

Reliability and Efficacy of the zensor Monitoring System

zensor was shown to be reliable and effective in capturing high quality ECG data when symptoms occurred. The system was operated successfully by intended users and within the intended use settings of the home and clinical environments.

All event buttons pressed by patients at the time of symptoms (with the exception of P005) were successfully transmitted to the zensor online database for evaluation by the secondary care team.
Feasibility of data transmission over MiFi

In general no major issues were experienced with the use of MiFi devices (Huawei E5756 Ultrafast mobile Wi-Fi 'MiFi') during the evaluation and ECG data was successfully transmitted to zensor online during monitoring.

There were some rare instances when blackspots due to poor network coverage delayed event transmission to the zensor online database. This meant that the secondary care team was contacted by the patient before they had received an ECG transmission. Initially this contributed to some confusion for both the evaluating professional and the patient, as it was believed this indicated there was a problem with the device. This in fact was not the case. The system is designed to ensure that any data recorded by the device will be transmitted when network coverage is available, or by healthcare professionals using a computer at the end of monitoring. Further evaluation determined that this lack of coverage was secondary to the selected mobile carrier and could be overcome by using a different network provider.

While this scenario would not be appropriate when monitoring patients in a virtual ward to facilitate an early hospital discharge, it would have negligible impact on the elective evaluation of patients with palpitations. A more appropriate wireless solution for higher acuity patients would be defined to ensure that zensor successfully meets the home monitoring needs of this patient population.

Impact on Time-to-Diagnosis

<table>
<thead>
<tr>
<th></th>
<th>Average number of days between GP Visit and Cardiac Investigation</th>
<th>Average number of days between Cardiac Investigation and Diagnosis</th>
<th>Average number of days between GP Visit and Diagnosis (Complete Patient Case)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Pathway</td>
<td>336</td>
<td>70</td>
<td>406</td>
</tr>
<tr>
<td>Proposed Pathway</td>
<td>5</td>
<td>19</td>
<td>24</td>
</tr>
<tr>
<td>% Difference</td>
<td>98%</td>
<td>72%</td>
<td>94%</td>
</tr>
</tbody>
</table>

Table 2: Comparison of average waiting times for patients within the existing and proposed pathways.

Table 2 outlines the decrease in waiting times for the main milestones within both the existing and proposed pathways. Measurement points included the patient presenting to the GP, the patient undergoing cardiac investigation (Holter on the current pathway and zensor on the proposed pathway), the investigation being completed, and the letter detailing the outcome of monitoring being made available to the GP. The proposed pathway figures are based on the 20 patients in the evaluation. The current pathway is consistent with an unpublished SET audit that determined a rapid access arrhythmia service need.

Within the current pathway the longest wait was identified as being when patients waited for the initial assessment with the consultant cardiologist after presenting to their GP. Combined with the time taken to undertake the initial cardiac investigation, this took on average 336 days. This portion of the pathway reduced dramatically to an average of 5 days with the proposed pathway. Overall, from when the patient first presented to the GP until the letter was available to the GP, the waiting time reduced by 94% from an average of 406 days on the current pathway to an average of 24 days on the proposed pathway.
Feedback from Healthcare Professionals

Healthcare Professional Population

Sixteen members of staff returned a completed questionnaire after 10 patients had been recruited to the evaluation. Within primary care participants consisted of GPs, practice nurses, healthcare assistants and administration staff. The secondary care team was made up of a consultant cardiologist, cardiac research nurses, registered nurses, a nurse manager and administration staff.

Figure 7 provides further information on healthcare professionals that returned questionnaires.

Ease of Use

Staff were asked to rate how easy it was to carry out use tasks relating to the zensor monitoring system. Ninety-five per cent of system interactions were rated as being easy, with the rest rated as neutral. The areas that received a neutral score will be reviewed in line with user documentation to assess whether user instructions can be enhanced to help further improve overall satisfaction with the system.

Clinical Utility

Fourteen HCPs felt the system was clinically useful and two were unsure on its clinical usefulness. One of the HCPs unsure stated that they didn’t have the opportunity to engage in a real world experience of the system during evaluation. The second commented that they had been given no rationale of what the evaluation was about, suggesting they may not have known enough about the system to determine its clinical usefulness. An internal review confirmed that all staff had been properly inducted. Comments provided by staff relating to the clinical utility of the system included:

“Very useful for quick diagnosis.”

“Patients have been positive about the experience so I would feel it to be useful.”
Permanent Use of the System

The system was well accepted by those in primary care with all respondents wanting to keep the system permanently for the evaluation of palpitations in the community. Five secondary care HCPs wanted to use the system on a permanent basis. Five were unsure as they were concerned about the impact on workload if the number of monitored patients was scaled up. Overall, ten confirmed that as a virtual ward the system could work very well but would require further exploration. One did not want to use the system on a long term basis.

Opinion on Alternative Pathway

Eleven HCPs felt the alternative pathway was better than the current pathway of direct patient referral and four were not sure. One HCP stated that this was due to the possibility of poor network coverage that has been discussed previously. Comments provided by staff on using the proposed pathway included:

“This is a more speedy assessment of palpitations.”
“This is modern, fast, effective, very reassuring and discreet. It is a great device that can address the problem of palpitations and give answers.”
“This is beneficial as patients don’t have to wait a long time to attend for a Holter monitor.”
“A patient is able to be reviewed immediately when they have symptoms rather than wearing a tape and having it reviewed at a later date. This means problems or arrhythmias can be picked up quicker.”
“Hospitals are no longer the centre for diagnostics. Patients can be monitored in their own home and this was investigated by the general practice team.”

Benefits

HCPs were asked about the benefits that the new pathway and technology could bring patients. Responses are summarised below.

“Capturing any palpitations that a patient was experiencing and having them addressed and acted on quickly.”
“Providing reassurance to patients about their health.”
“Preventing low risk arrhythmia patients being admitted to CCU or attending A&E. Allowing monitoring of symptoms and diagnosis at home with a very quick timeline.”
“Being able to determine abnormalities and heart rhythms in low risk patients.”
“Ease of use for clinical staff and patients.”
“We could use this to create a virtual ward for patients that present to emergency department with palpitations.”

Concerns

The majority of the healthcare professionals said that they had no concerns and that there were no negative aspects to using the zensor monitoring system. Any concerns that were raised covered teething issues that were encountered, which was noted to be expected with any new intervention, and how Wi-Fi coverage could vary at times throughout the evaluation.
Feedback from Patients

Nineteen patients returned feedback questionnaires at the end of their monitoring period.

Patient acceptability was very positive with patients preferring to have their palpitations investigated in their GP practice with specialist input, rather than waiting for an appointment in the local hospital. Being able to record their heart rhythm if they felt symptoms and the potential to be diagnosed faster were valued most by patients, as shown in Figure 8.

To investigate where potential improvements could be made, patients were asked what they liked least about the system (Figure 9) Most patients reported that they felt aware of the monitor while they were wearing it or that they experienced some discomfort while wearing the patch. Many patients indicated that they found nothing negative about the system.

![Graph showing what patients found most positive about the zensor monitoring system.](image1)

**Additional comments provided by patients that took part in the evaluation included:**

“I felt after a day or two that I did not notice I was wearing it. I definitely feel the monitor is a very positive and quick way to be diagnosed.”

“I felt confident using the monitor, and I feel it was a positive experience. I am sure the majority of patients would rather use this than having to wait many months for a hospital appointment.”

“I think it is a good idea to have a Wi-Fi enabled monitor that you can use in this way, as palpitations can occur randomly and infrequently.”

![Graph showing what patients found least positive about the zensor monitoring system.](image2)
Clinical Impact

The clinical advantages of the proposed new pathway were evident. Patients were able to continue with their daily routines with the ability to record their ECG as symptoms were experienced. This resulted in a high diagnosis rate, thus reducing the requirement for further cardiac investigation.

In addition to the high diagnosis rate, there was a significant reduction in time-to-diagnosis from when the patient first presented to the GP to the outcome of monitoring being communicated to the GP.

This pathway therefore has the potential to provide a reformed patient-centred healthcare model. At present such a model is highly desirable, as it removes the need for institutional referral, which may make this investigative pathway more cost-effective.

If implemented permanently, there is opportunity for the proposed pathway to improve quality and timeliness of patient care; reducing demand for outpatient services, inpatient intermediate and acute care beds and emergency department attendances; reduce follow up appointments within secondary care; and reduce the number of patients that will re-visit their GP while awaiting an outpatient appointment. Further robust assessment of these potential impacts is required to fully realise the redesigned service.

Additional Analysis

After the evaluation had completed, full disclosure ECG recorded during patient monitoring was reviewed in order to assess the performance of zensor’s cardiac arrhythmia detection algorithms. Over 3100 hours of data from 20 patients was recorded. Table 3 below summarises the false alarm rates for each of the algorithms utilised by zensor and provides the false alarm rate per patient per day. Overall the false alarm burden associated with zensor was 1.09 false alarms per patient per day.

<table>
<thead>
<tr>
<th>Alarm Type</th>
<th>False Alarm Rate (hours)</th>
<th>False Alarm Rate Per Patient Per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asystole</td>
<td>1 per 600 hours</td>
<td>0.04</td>
</tr>
<tr>
<td>Ventricular Fibrillation</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tachyarrhythm</td>
<td>1 per 300 hours</td>
<td>0.08</td>
</tr>
<tr>
<td>Bradyarrhythm</td>
<td>1 per 2400 hours</td>
<td>0.01</td>
</tr>
<tr>
<td>Atrial Fibrillation</td>
<td>1 per 25 hours</td>
<td>0.96</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1.09</td>
</tr>
</tbody>
</table>

Table 3: False alarm rate in hours and per patient per day for zensor

Standard publically available ECG databases are often used to develop and validate cardiac arrhythmia detection algorithms and to provide information on performance. Table 4 below shows the sensitivity and false positive rates for zensor algorithms when tested using well established clinically marked-up patient databases such as Massachusetts Institute of Technology (MIT), American Heart Association (AHA) and Creighton University (CU). Together these databases comprise 72 hours of ECG data recorded from 238 patients.

<table>
<thead>
<tr>
<th>Arrhythmia</th>
<th>AHA</th>
<th>MIT</th>
<th>CU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensitivity</td>
<td>FPR</td>
<td>Sensitivity</td>
</tr>
<tr>
<td>Asystole</td>
<td>100%</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Ventricular Fibrillation</td>
<td>100%</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Tachyarrhythm</td>
<td>96%</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Bradyarrhythm</td>
<td>100%</td>
<td>1.05</td>
<td>100%</td>
</tr>
<tr>
<td>Atrial Fibrillation</td>
<td>-</td>
<td>12.13</td>
<td>92.31%</td>
</tr>
</tbody>
</table>

Table 4: Sensitivity figures and false positive rates for zensor algorithms tested using standard databases
Conclusions

The results of the evaluation demonstrate that this novel primary care rapid diagnostic pathway for patients with new onset arrhythmia facilitates a rapid diagnosis without the need for secondary care referral in the majority of subjects. The zensor monitoring system was successfully operated in the home and clinical environments, recording patients ECG at the time of symptoms, providing healthcare professionals with the patient activated event data to facilitate diagnosis of palpitations. The system was easy to use for all staff. Primary care users responded very positively to the system and those that interacted with the system would use it after the evaluation. Secondary care staff raised concerns about workload constraints. These concerns were reviewed with unit management and suggestions to further improve integration with routine activities were provided. It would appear that this new technology could be easily implemented into the current investigative pathway with minimal disruption and high degree of confidence. zensor is an appropriate device to use in the primary care setting, and with enhanced network coverage, or other appropriate means of data transmission, could extend its role to facilitate the early discharge of patients from the hospital emergency department. This would include patients with a suspected arrhythmia or patients with confirmed arrhythmia requiring medication dose up-titration that would otherwise be performed in a hospital setting. More importantly an additional analysis of full disclosure data recorded during monitoring, essential for the virtual ward concept, revealed a low false positive rate.

EPIC has demonstrated that an effective and safe service redesign can be achieved without significant disruption to the current healthcare delivery model by using an innovative ECG monitoring technology and cloud based data management. A further large scale evaluation is required to test general applicability and cost utility.

References


This work has been supported by Intelesens Ltd., Old Mill Surgery and Ulster Hospital, within the South Eastern Health and Social Care Trust.

Special gratitude is extended to the staff and patients of Old Mill Surgery, Newtownards and the Coronary Care Unit and the Cardiac Research Team at the Ulster Hospital.

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