**Institution: University of Ulster**

**Unit of Assessment: 11: Computer Science and Informatics**

**Title of case study:**
**A new mobile-based reminding product for connected health**

**1. Summary of the impact** (indicative maximum 100 words)

An internet-based care model developed by CSRI at Ulster, facilitating all stakeholders (patients, pharmacists, carers, GPs) to dynamically manage the prescription of, and patient compliance with, medication has been incorporated into the [text removed for publication] service platform produced by [text removed for publication], a Telecare product provider. This has extended functionality of [text removed for publication], which is now being used by over 400 patients in [text removed for publication], with improved levels of medication compliance, reduction in caregiver burden, and improved workflow management for healthcare professionals. Incorporation of video-based reminders further led to a material transfer agreement between Ulster and [text removed for publication] to extend [text removed for publication]'s functionality.

**2. Underpinning research** (indicative maximum 500 words)

Findings from recent research studies indicate that 91% of adults aged between 57 and 85 consume at least one item of medication daily, around 76% of prescribed medications are taken incorrectly, and 29% are not taken at all. When not adhered to correctly, the efficacy of medicated treatment is sub-optimal, both physiologically and financially. The most commonly reported reason of non-compliance to medication is forgetfulness.

Research within CSRI has focussed on using technology to aid stakeholders within a Connected Health environment for over 15 years, with the main application areas relating to reminding technologies for medication management [3] and supporting people with dementia [1, 2, 4].

Ulster were co-ordinators of the EU FP5 MEDICATE project consortium (2000-2004). Through assessment of stakeholder needs conducted as part of the MEDICATE project, the patient pathway and stakeholder involvement in the process of reminding technologies required for medication compliance were elicited. This work formed the basis for the establishment of a novel Internet-based care model to support all stakeholders in the supply to intake chain of personal medication management [3]. Evaluation of this care model solution demonstrated its effectiveness, with two-thirds of users showing improved compliance with their prescribed medication regime, and a reduction in the average caregiver contact time required per week (from 4.87 hours per week without the solution, to 1.38 hours per week with the solution) [3].

The MEDICATE solution was extended to a mobile-based reminding application [3] (2004-2007), which inspired the concept of video-based reminders for persons with dementia. A video-based reminding system, utilising mobile phone technologies, was developed and evaluated [2] with cohorts of elderly users, persons with dementia and control groups, along with their carers; in total, over 400 days' worth of evaluations were conducted (2006-2012). The results from this work demonstrated the utility of the approach from both carer (reduction in caregiver burden) and patient (improvement in quality-of-life and levels of independence) perspectives [2, 5].

Analysis following evaluations provided insights into the most appropriate ways to use video-based messages for medication reminders and how user interaction with the technology should be designed for people with dementia [5]. Analysis also identified an additional key challenge: that of assessing and improving technology adoption [6]. A subset of data from 40 patients was retrospectively analysed (2011-2013) for user profiles to assess the success of using assistive technology for people with dementia. Using this user profile analysis, a technology adoption model based on a k-NN algorithm was developed to predict the likelihood of a person with dementia adopting the technology. Results identified 7 key features in a user's profile that can be used in the model to predict technology adoption with an accuracy of 84% [6].

This work has been conducted by a team of key researchers in CSRI:

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| Chris Nugent | Professor of Biomedical Engineering (joined as Lecturer, 05/2000) |
| Sally McClean | Professor of Mathematics (joined as Research Assistant, 1971) |

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| Bryan Scotney | Professor of Informatics (joined as Lecturer, 1984) |
| Norman Black | Professor of Medical Informatics (joined as Lecturer, 1985) |
| Dr Mark Donnelly | PhD student/Research Associate/Lecturer (10/2004-present) |
| Dr Dewar Finlay | Research Associate/Lecturer/Senior Lecturer (06/2000-present) |
| Dr Sonja O'Neill | Research Associate (03/2010-01/2012) |
| Mr Richard Davies | Research Associate/Lecturer (07/2001-present) |
| Dr Shuai Zhang | Research Associate/Lecturer (08/2009-present) |
| Dr Leo Galway | Research Associate/Lecturer (05/2010-present) |

**3. References to the research** (indicative maximum of six references)

* *References that best indicate the quality of the underpinning research*.

[1] * RJ Davies, CD Nugent, MP Donnelly, M Hettinga, FJ Meiland, F Moelaert, MD Mulvenna, JE Bengtsson, D Craig, RM Droes (2009). A User-driven Approach to Develop a Cognitive Prosthetic to Address the Unmet Needs of People with Mild Dementia, *Pervasive and Mobile Computing*, vol. 5, no. 3, pp. 253-267.
DOI: 10.1016/j.pmcj.2008.07.002
[***This paper is included as an output in the current REF submission.***]

[2] * MP Donnelly, CD Nugent, S Mason, SI McClean, BW Scotney, AP Passmore, D Craig (2010). A Mobile Multimedia Technology to Aid Those with Alzheimer's Disease, *IEEE Multimedia*, vol. 17, no. 2, pp. 42-51.
DOI: 10.1109/MMUL.2010.25
[***This paper is included as an output in the current REF submission.***]

[3] CD Nugent, D Finlay, RJ Davies, MD Mulvenna, JG Wallace, C Paggetti, E Tamburini, ND Black (2007). The Next Generation of Mobile Medication Management Solutions, *International Journal of Electronic Healthcare*, vol. 3, no. 1, pp. 7-31.
http://inderscience.metapress.com/content/154u24r9pp6j16xk/

[4] CD Nugent (2007). ICT in the Elderly and Dementia, *Ageing and Mental Health*, vol. 11, no. 5, pp. 473-476.
DOI: 10.1080/13607860701643071

[5] SA O'Neill (nee Weber), S Mason, G Parente, MP Donnelly, CD Nugent, SI McClean, BW Scotney, D Craig (2011). Video Reminders as Cognitive Prosthetics for People with Dementia, *Ageing International*, vol. 36, no. 2, pp. 267-282.
DOI: 10.1007/s12126-010-9089-5

[6] * S Zhang, SI McClean, CD Nugent, MP Donnelly, L Galway, BW Scotney, I Cleland (2013). A Predictive Model for Assistive Technology Adoption for People with Dementia, *IEEE Journal of Biomedical and Health Informatics*, (available on-line).
DOI: 10.1109/JBHI.2013.2267549
[***This paper is included as an output in the current REF submission.***]

***Key Grants***

***Project: Determining the Value of User Needs in the Product Design of Cognitive Prosthetics***
Funder: EPSRC (via Brunel: EP/G012393/1) £171,861 (to Ulster)
Dates: 01/10-10/13
Ulster grant-holders: CD Nugent, MP Donnelly, SI McClean, BW Scotney, D Dixon, B Meenan

***Project: Cell Phone Video Streaming in Alzheimer's Disease***
Funder: Alzheimer's Association (ETAC-06-26017) £70,673 (to Ulster)
Dates: 09/06-09/09
Ulster grant-holders: CD Nugent, MD Mulvenna, SI McClean, BW Scotney

***Project: TAUT: Technology Adoption and Prediction Tools for Everyday Technologies***
Funder: Alzheimer's Association (ETAC-12-242841) £128,205 (to Ulster)
Dates: 11/12-10/15
Ulster grant-holders: CD Nugent, SI McClean, MP Donnelly, BW Scotney

***Project: MEDICATE: The control, Identification and Delivery of Prescribed Medication***
Funder: EU FP5 (IST-2000-27618) £378,378 (to Ulster)
Dates: 11/01-11/04
Ulster grant-holders: ND Black, CD Nugent

**4. Details of the impact** (indicative maximum 750 words)

[text removed for publication], an [text removed for publication] SME telecare product provider, has incorporated our research results from the MEDICATE project relating to mobile-based medication management, for which Ulster were project co-ordinators, into their flagship telecare product [text removed for publication]. As a result, [text removed for publication] have reported increases in revenue, the number of [text removed for publication] users, and the number of R&D staff they employ to develop the product.

Based on the outcomes from the MEDICATE Project (2004) it was recommended by the European Commission/ Review Panel of Experts that efforts should be made to translate the project findings into commercial products [E1]. Based on this recommendation, CSRI and [text removed for publication] worked together to build upon the findings from the research (2004-2007). This led to the incorporation of research results on Internet- and mobile-based care models [text removed for publication] into [text removed for publication] product for a mobile phone-based service for medication management and improved workflow management (stakeholder needs, information flow between stakeholders, critical path analysis) for patients, pharmacists, carers and GPs.

Incorporation of this new functionality into [text removed for publication] during 2008 extended the services previously offered (vital sign monitoring, agenda management, video-conferencing) [E2]. The translation of our research results (mobile-based medication management and workflow management) into the [text removed for publication] product has been fully recognised and acknowledged by the company, along with the resulting positive economic impact for [text removed for publication] [E3]. Since incorporation of the new functionality into the [text removed for publication] product in 2008, the company has reported:

- securing [text removed for publication] contracts for the [text removed for publication] product, yielding a total revenue of [text removed for publication] [E3];
- creating [text removed for publication] additional new posts for research and development engineers to further develop the [text removed for publication] product [E3];
- use of the [text removed for publication] system by over 400 users within the [text removed for publication] region managed by the [text removed for publication] [E3].

From a healthcare perspective, General Practitioners have reported the positive benefits of being able to monitor patients remotely using the [text removed for publication] system without the need for home-based visits [E4]. From the patients' perspective, positive feedback has been provided about how [text removed for publication] provides a solution that offers constant monitoring and communication with a doctor [E4].

The collaboration between CSRI and [text removed for publication] to develop [text removed for publication] was extended further in 2012 through a Material Transfer Agreement and exclusive licensing option with CSRI [E5] (which [text removed for publication] opted to progress in June 2013). The agreement supported the incorporation into [text removed for publication] of the know-how acquired by CSRI about reminding solutions for persons with dementia. This know-how involved the architecture for video-based reminders being delivered via mobile phones, and the workflow associated with medication non-compliance. Prior to this, the [text removed for publication] platform did not provide tailored solutions for home-based support of persons with dementia. A joint commercial venture between CSRI and [text removed for publication] was established in November 2012, [text removed for publication] [E6]. The aim of the joint venture is to provide support for the [text removed for publication] product within the UK, from both marketing and installation perspectives, to promote the further uptake of [text removed for publication] within Europe; [text removed for publication] will also continue to investigate opportunities to extend the current levels of services that [text removed for publication] offers.

During 2012 the Institute for Employment Studies were commissioned by the Social Care Institute for Excellence to seek examples of how technology had been used to enhance the lives of people with dementia. The aim of the work was to draw together all the current research literature within the domain and to produce an up-to-date best practice guidance document that would support care workers in their use of technology when working with people with dementia. In this process, the Institute for Employment Studies highlighted the research being undertaken in CSRI relating to assistive technologies, and Prof Nugent was invited to join an Expert Panel with a brief to support the production of the best-practice guidance document. The outcome of the Expert Panel Workshop led to the production of a guide for social care providers that is described as "a short introduction to using information and communication technology (ICT) in activities for people with dementia" [E7]. The guidance document has been aimed at managers and staff in the care sector and providers of activities for people with dementia.

Based also on a general appreciation for the expertise acquired by CSRI [E8] from our research on technology-based solutions for persons with dementia, Prof Nugent was also invited by the NI Health and Social Care R&D Division to join a priority setting exercise to help support the agenda definition for research into dementia care in Northern Ireland [E9]. A call for proposals was subsequently launched by the HSC R&D Office in June 2013, which included the recommendations to include technology-based solutions as a thematic action line.

**5. Sources to corroborate the impact** (indicative maximum of 10 references)

[E1] Excerpt from the final report of the EU Commission on MEDICATE Project.
This item provides corroborating evidence of the recommendation to undertake further efforts to commercialise findings of the MEDICATE project to appreciate real impact.

[E2] Product brochure from [text removed for publication].
[text removed for publication] This item provides corroborating evidence of the medication reminding solutions incorporated into the [text removed for publication] product.

[E3] A Factual Statement in the form of a letter from [text removed for publication].
This item provides corroborating evidence that the company, [text removed for publication], achieved increased revenue and job creation, and of the extent of the usage of the [text removed for publication] product.

[E4] Stakeholder testimonials provided by patient and healthcare professionals who are users of the [text removed for publication] product.
These items provide corroborating evidence of positive experiences of using the [text removed for publication] product by healthcare professionals and patients.

[E5] Material Transfer agreement.
This item provides corroborating evidence of the exclusive agreement between University of Ulster and [text removed for publication] to license know-how in video based reminders.

[E6] Legal documents from the spin-out company [text removed for publication].
This item provides corroborating evidence of the spin-out company formation.

[E7] Using ICT activities for people with dementia: training material available on the Social Care Institute for Excellence website:
http://www.scie.org.uk/publications/ictfordementia/index.asp
This item provides corroborating evidence of translation of research findings into material to be used by carers.

[E8] Newspaper story (Newtownabbey Times) of a Technology Open Day run by CSRI at Inniscoole Day Centre, Belfast (16th August, 2012).
This item provides corroborating evidence of raising awareness of technology-based solutions within the community.

[E9] Letter of invitation from the Director of the Northern Ireland HSC R&D Division to join the Priority Setting Exercise on research in dementia care.
This item provides corroborating evidence demonstrating participation in the Priority Setting Exercise for Research into Dementia Care in Northern Ireland.