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Multi-faceted informatics system for digitising and streamlining the reablement care model

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ABSTRACT

Reablement is new paradigm to increase independence in the home amongst the ageing population. And it remains a challenge to design an optimal electronic system to streamline and integrate reablement into current healthcare infrastructure. Furthermore, given reablement requires collaboration with a range of organisations (including national healthcare institutions and community/voluntary service providers), such a system needs to be co-created with all stakeholders involved. Thus, the purpose of this study is, (1) to bring together stakeholder groups to elicit a comprehensive set of requirements for a digital reablement system, (2) to utilise emerging technologies to implement a system and a data model based on the requirements gathered and (3) to involve user groups in a usability assessment of the system. In this study we employed a mixed qualitative approach that included a series of stakeholder-involved activities. Collectively, 73 subjects were recruited to participate in an ideation event, a quasi-hackathon and a usability study. The study unveiled stakeholder-led requirements, which resulted in a novel cloud-based system that was created using emerging web technologies. The system is driven by a unique data model and includes interactive features that are necessary for streamlining the reablement care model. In summary, this system allows community based interventions (or services) to be prescribed to occupants whilst also monitoring the occupant's progress of independent living.

1. Introduction

The ageing population is projected to more than double by the year 2050 and the number of persons exceeding 85 years of age has almost doubled in the past decade [1,2]. Consequently, there is an escalating burden (both in terms of manpower and economics) on healthcare services to provide quality care for a growing number of elderly patients who have chronic diseases and co-morbidities. This is of concern in the United Kingdom where the National Health Service (NHS) is currently publically funded but may be forced into privatisation due to the expense of treating a large number of chronic illnesses [3]. This problem has been widely documented [2,4], and a number of healthcare models and potential solutions have been proposed. Such models often involve the use of telemedical and telehealth technologies [5], which have recently been branded as 'Connected Health'. According to [6], "*Connected Health is were all stakeholders in the process are 'connected' by means of timely sharing and presentation of accurate and pertinent information regarding patient status through smarter use of data, devices, communication platforms and people*". These models have a common objective, which is to provide high quality healthcare whilst reducing costs. Many models look to reduce costs by promoting the idea of the 'self-management' of disease [7–9]. The postulation is that if people were more informed (by increasing their health literacy) they would be empowered to take more responsibility for their own health, which would reduce the burden on public health services. In addition to these models, 'reablement' also emerged as a model to address these needs. Given this model has been conceived internationally, it has been branded as 'Reablement' in the United Kingdom [1,10,11] however both the United States and Australia have branded this model as 'Restorative Care' [12,13].

According to Francis et al. [11] reablement is a collection of services "...to help people learn or relearn the skills necessary for daily living which may have been lost through deterioration in health". The aim is to keep patients in their own homes by (a) facilitating independent living, (b) preventing deterioration of health and (c) avoiding the need for more expensive services [11]. A unique factor of reablement is that its provision includes the use of Voluntary and Community (VC) services which are managed by non-government agencies. Example VC services include nutritional advice, chauffeur services, domestic cleaning services,

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gardening, shopping assistance, social inclusion activities, general physical exercising and wellbeing activities, rehabilitation, risk management in the home and general pastoral care. According to [11], reablement will likely reduce costs within mainstream healthcare by reducing admissions to residential and nursing care. According to Glendinning et al. [14] there is a "high statistical probability that reablement is cost effective". In 2013, an Australian trial [15] found that users of reablement were significantly less likely to utilize mainstream healthcare services when compared to a control group. This study [15] estimated that this would save approximately AU $12,500 per person over a 5 year period. Tinetti et al. [12] also suggest that users of reablement services are less likely to use the emergency hospital. Nevertheless, the service user pathway for reablement has yet to be defined and a universally adopted format does not exist. According to Francis et al. [11] reablement interventions are initiated by a referral via a hospital discharge or from within the VC sector itself. The referral is normally made using basic communications such as email or a telephone call to a specially trained Occupational Therapist (OT). The OT would then undertake an assessment to identify the individual needs of the occupant, which may include an Activities of Daily Living (ADL) assessment, an environmental assessment and a risk assessment. Also, if it were appropriate the OT would refer the occupant to a Community Navigator (CN). A CN is a new role that includes the responsibility of aligning and prescribing VC services to the occupant's needs. The CN would meet the occupant to determine their willingness to engage with the VC sector and if consented the CN would enrol the occupant onto suitable VC services. Subsequently, the CN would continually assess the user at regular intervals and manage which services the user should enrol onto and graduate from.

Given that reablement is a new initiative and no 'gold standard' working models have been established, there remain a number of opportunities for researchers [1]. There is a lack of a unified electronic system for managing and streamlining the reablement care model. And given the importance of paperless patient record systems [16], an electronic system for managing reablement is also imperative. This paper suggests that reablement could be optimized and streamlined if an electronic system was designed using emerging web technologies. However, such a system needs to be stakeholder led given the collaborative nature of the reablement model (stakeholders include OTs, CNs, service users (also referred to as occupants) and representatives from the VC sector). This is important given that Francis et al. [11] observed the need for more research on what implications reablement has on stakeholders. Therefore this work aimed to discover the system requirements from stakeholders for building an electronic reablement system. Furthermore, we sought to build a prototype based on these system requirements and to allow potential system users to evaluate this prototype via a pilot usability assessment.

2. Methods

This work is based on a mixed qualitative methodology that has been reported elsewhere [17]. This work employed stakeholder-involved activities, which were borrowed from the 'living labs' methodology [18,19]. Living labs are "a collection of people, equipment, services and technology to provide a test platform for research and experiments" [20,21]. The rationale for adopting a living labs methodology over other approaches are in its offering for co-creation and ideation phases, which are utilised in this project by the creation of a 'pop-up' living lab at a known hacker space in the UK (called Farset Labs). Farset labs is an independent organization that host a number of hacker events and specializes in coordinating ideation events.

Fig. 1 depicts the various stages of the project. The methodology itself was stakeholder led as the study was coordinated by a

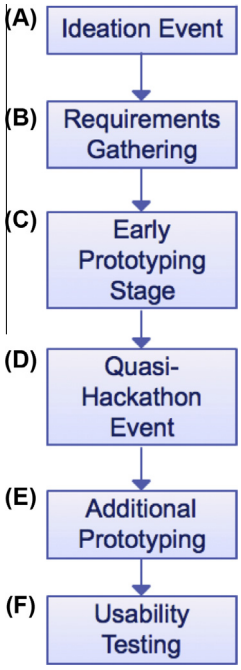

Fig. 1. The five phases of the project, which focuses on stakeholder-involved activities that contribute to requirements gathering and implementation of an electronic reablement system in the form of a prototype.

number of stakeholder organisations (refer to Ardmonagh Family and Community Group [22], Engage with Age [23], Volunteer Now [24], Oasis Caring in Action [25] and Shopmobility [26]). These organizations are members of the national Reablement Stakeholder Network (RSN). To be 'truly' user-centred stakeholders were involved in the design of research methodology, which is a concept from the patient and public involvement (PPI) initiative [27,28].

2.1. Ideation event

The purpose of the ideation [29] event was to provide an open platform for idea generation regarding opportunities for reablement services to be supported by new technologies. The event took place on the 20th May 2013 and was facilitated by Farset Labs [30]. A total of 33 stakeholders (16 female, 17 male) were present (and the organisations represented at the event are presented in Appendix A). We regarded a 'stakeholder' as a person or organisation who is directly involved in the entire reablement process. Hence, this not only includes the system users such as the OT or CN but other stakeholders such as occupants, service providers, policy makers and officials. Thus, we recruited stakeholders from a number of community and voluntary sector groups, charities, hospital trusts, community navigators, members the health board, members of the city council and potential users of reablement interventions. And according to our knowledge no stakeholder group was unrepresented. As criteria, each attendee was required to be a member or connected to the Reablement Stakeholder Network, which was officially setup in 2012. This could be regarded as a convenient purposive sample. However, recruiting 33 representative stakeholders to attend one event for four hours on one date is in itself challenging.

The ideation event involved organizing the stakeholders into five focus groups. As recommended by Krueger and Casey [31], each group consisted of five to eight participants. The rationale for using this approach is the fact that the translation of the reablement model from policy into practice is a complex problem and focus groups allow the researcher to gain a deeper understanding of its intricacies when compared to using other more superficial methods such as surveys. In addition, the event lasted four hours

to ensure a saturation point was reached. Moreover, given a large number of subjects are either experts in the area of reablement or they represent a large community, there is a high probability that a saturation point would be reached due to the generation of 'shadowed data'. According to Morse [32], shadowed data is where an expert or a representative subject is able to share experiences from other people or peers in addition to their own experience.

Each group was instructed to provide answers to the question: "Reablement would be easier if...?". All groups were informed that the aim of the session was to establish procedural problems and solutions to streamline the reablement model. A member of each group was tasked to record and later present their group's answers.

2.2. Requirements gathering and early prototyping

During the ideation event, the answers from each group were noted on a communal blackboard. This facilitated the identification of recurring themes and priority areas. These contributions were then transformed into a list of requirements, which were later used by the authors to storyboard and prototype a reablement system using basic web technologies. This prototype was developed to identify the technological issues that could be addressed at the quasi-hackathon.

2.3. Quasi-hackathon and prototyping

A 'quasi-hackathon' event took place in Farset Labs on the 3rd July 2013. A hackathon is a new approach to software development [33]. It can be described as an intensive event where a large number of technologists collaborate over a short period of time to provide a novel software solution. Given the 'hackathon' in this project was over one evening (6–11 pm) and involved a small number of technologists ($n = 10$), the event was classified as a 'quasi-hackathon'. This event involved ten technologists who received a didactic summary of the requirements. The quasi-hackathon mainly focused on technical solutions to the each of the requirements. The finale of the event involved a presentation of the early prototype, which elicited further contributions from the technologists. At this stage, all hackers were provided the freedom to view source code and to provide further technical contributions and recommendations. These contributions were then used to further develop the initial prototype.

As guided by the technologists, the decision was made to implement the prototype using emerging open-source web technologies as this would encourage further research and development from the wider community. Thus, the interface of the prototype was developed using the HyperText Markup Language version 5 (HTML5), Cascading Style Sheets version 3 (CSS3), 2D Canvas Graphics and JavaScript [34]. The server-side system was developed using the HyperText Pre-processor (PHP) scripting language and the MySQL open-source database. A series of additional Application Programming Interfaces (APIs) were also used (including Google Maps API [35], Google Charts API [36] and Chart.JS API [37]).

2.4. Pilot usability testing

This involved the recruitment of 30 subjects whose task was to evaluate the usability of the prototype. The subjects represented the three distinct user groups, i.e. 12 subjects were OTs, 10 subjects were representatives from the VC sector and eight subjects represented potential service users. No other 'users' of the system have yet been identified. We foresee an OT using the system to make the referral, the VC sector for maintaining service information and reablement occupants for identifying services within their geographical area and for co-completing the health and wellbeing assessments. The protocol involved providing each subject with a series of tasks whilst using the prototype on a Tablet PC (Apple iPad or a Samsung Galaxy tablet). Tasks involved (1) adding and editing services, (2) finding a particular user and analysing their summary timeline of services, (3) adding and analysing a service user assessment and (4) searching for relevant services. Each subject was then asked to complete an online questionnaire.

3. Results

3.1. Recurring themes

The ideation phase resulted in the identification of four key areas that the stakeholders classified as priority. These include, (1) Centralised Service Directory, (2) Governance and Oversight, (3) Impact Evaluation and (4) Data Capture and Sharing.

3.2. Centralised service directory

Stakeholders highlighted the need for an electronic centralised directory of community and voluntary services. It was suggested that the repository should store descriptions of the services, a URL, a video of the service, the geography of which the service operates and the maximum capacity for service users as well as the live number of users currently enrolled onto each service. This discussion resulted from a need for a single-point-of-access to VC services and the demand to offer service providers and service users the ability to search and discover geographically relevant services. Stakeholders emphasized a desire for an intelligent mechanism to filter services based on the service user's context. It is expected that such a filtering mechanism would be used by CNs to assign relevant nearby services to a reablement user. This could also be used as a decision support tool or a service recommender system.

3.3. Governance and oversight

Throughout the ideation event, stakeholders highlighted a range of governance issues. The main issue with a reablement system was that of ownership. Given reablement involves a myriad of public and VC sector organizations, it was not obvious as to who would own and maintain such as 'multi-user' and 'multi-stake holder' system. Stakeholders concluded that a reablement electronic system should be owned and maintained by a board of reablement stakeholders. It was also emphasized that the system should implement ICT security measures such as data encryption. Stakeholders were also concerned with the accuracy and quality of information stored on the electronic service directory. They recommended that service providers should be provided with limited access to the system so that they can maintain their own profile. Stakeholders also recommended mechanisms such as crowdsourcing to allow a viewer to submit a correction or flag a record for review.

3.4. Impact evaluation

All groups elicited that the system should feature an assessment tool for evaluating the impact of reablement services on the occupant's independence. Stakeholders suggested mapping the services each occupant is enrolled onto against the occupant's progress/regress in their ability to live independently. The assessment tool itself should be used to assess the service user's condition at regular intervals. The stakeholders highlighted an existing national single assessment tool (coined NISAT [38]), which is used to

determine the living conditions of an occupant and to subsequently inform and plan prospective home care support. However, the stakeholders deemed this assessment as too detailed to be useful for assessing 'continuous-care'. Stakeholders also discussed the Outcomes Star assessment tool [39] as a potential contender. However, this assessment tool has been commercialized by Triangle Consulting Social Enterprise and thus its license has significant cost implications. In summary, all stakeholders decided that an ideal reablement assessment tool should comprise an evaluation of the occupant's financial, environmental, mental, physical and social condition.

3.5. Data capture and data sharing

A point of discussion was determining which appropriate service user data should be stored in the system. It was decided that the reablement system should be linked to the mainstream patient record system (via a unique patient ID) however the reablement system itself should not store all of the service user's medical history. It was agreed that the system should only store referral information and retain basic patient demographics and limited medical information that is only relevant to reablement (e.g. the occupant has dementia). Given reablement is partly an external service and stores data outside of mainstream healthcare, patients should consent to reablement referrals. Different system users should also have limited access to system's features. The system should display features and data on a 'need to know basis'. For example, CNs should only gain access to data pertaining to users that are their responsibility.

3.6. Elicited requirements for an electronic reablement system

As seen in Table 1, the ideation event facilitated the identification of stakeholder-informed requirements for a comprehensive electronic reablement management system. These requirements were then used to develop a prototype. During this phase, four system users were identified, (User 1) Systems Administrator (SA) is a user that has complete access to the system and is responsible for authorising access to all other users, (User 2) Community Navigator (CN) is the primary user who will access the system for assessing occupants in their home and for prescribing pertinent services, (User 3) Service Organisation Administrator (SOA) is an employee at a service provider organisation who has limited access to the system for the purpose of maintaining their record (i.e. organisation and service details) and for accepting occupants who have been prescribed to one of their services by a CN and (User 4) Service User (SU) is the occupant in the home who can access the system to view their data and for searching for local services.

Table 1
A list of selected requirements articulated by stakeholders for an electronic reablement system. (SA = Systems Administrator, SOA = Service Organisation Administrator, SU = Service User, CN = Community Navigator).

#	Stakeholder	Reablement system requirement
1	SA	"I want to set permissions for other system users so that I can grant them access to various features of the system"
2	SOA	"I want to set permissions for other system users of my organisation so that I can grant them access to organisation level features of the system"
3	SU	"I want to be able to see what information is held about me so that I can verify its authenticity"
4	SU	"I want to be able to search for services in my area during my spare time"
5	CN	"I want to be able to search for services so that I can refer service users to relevant services"
6	CN, SOA	"I want to add a new service provider and create new services facilitated by the provider"
7	CN	"I want to be able to search for service users so that I can generate a report listing the ones that match specific criteria"
8	CN	"I want to view the services provided by a service provider so that I can decide which are relevant to a particular user"
9	CN	"I want to view current and historical services of a user so that I can visualise the overall service engagement by a service user"
10	CN	"I want to carry out an holistic assessment for a service user so that I can assess their financial, physical, mental, environmental and social wellbeing"
11	CN	"I want to refer a service user to a new service"
12	CN	"I want to find services in particular geographical areas so that I can assess whether an occupant is eligible for support"
13	CN	"I want to visualise services on a map so that I can assess if they are relevant to my service user"
14	CN	"I wish to carry out a number of tasks using the system in any geographical location and using any device"

3.7. Prototype and its functionality

3.7.1. Technical features

The overarching technical aim was to implement the prototype using ideas from evolving concepts within rich Internet applications and cloud computing. Thus, a responsive graphical user interface was implemented using CSS3 Media Queries. This involves an algorithm to adapt the user interface to match the screen resolution of the device being used (making it 'device agnostic'). This is important as CNs may assess service users using a Tablet PC or their smart phone whilst service organisations will likely maintain their record using a desktop PC. Furthermore, we tested the system using the new HTML5 cache feature, which allows users to access the system when the device has no Internet connection. This architecture is referred to as an 'offline web application' [40]. The reason for adopting these features is that there is increasing evidence that the future of health systems will be cloud based and will be available online/offline. And such web applications will be supported using algorithms to synchronise offline/online databases [41].

3.7.2. Graphical user interfaces

The main user interface includes a home screen that depicts a dashboard, which categorises system functions under three main categories, i.e. Service Providers (functions for managing details of each service provider and their services), Service Users (functions for managing details belonging to each service user) and Tools (links to functions such as the geo-service search tool). From the dashboard the system user can view the centralised directory of services where they can search, edit and add services. A novel feature is that the system provides a live number of occupants enrolled onto each service, which is important given services have a limited capacity and CNs should not over subscribe. Fig. 2 illustrates two other views in the user interface that is considered important. Fig. 2a shows a table of service users and their demographics. Within this interface, the user has the ability to refer and terminate occupants from services. Fig. 2b depicts a summary record for a reablement service user. This interface provides referral information, medical notes and a graphic depicting the timeline of services the user has previously used and is currently using.

3.7.3. FEMPS assessment user interface

Given there was a consensus that a reablement user should be assessed in five areas we developed an assessment tool called FEMPS (Financial, Environmental, Mental, Physical and Social Wellbeing). This tool includes a web-based pro-forma and is available online [42]. Table 2 summarises the data collected by a CN using the FEMPS assessment. And, as shown in Fig. 3, the FEMPS assessment score is summarised using a 5-point radar plot. Given the system facilitates numerous assessments for each occupant,

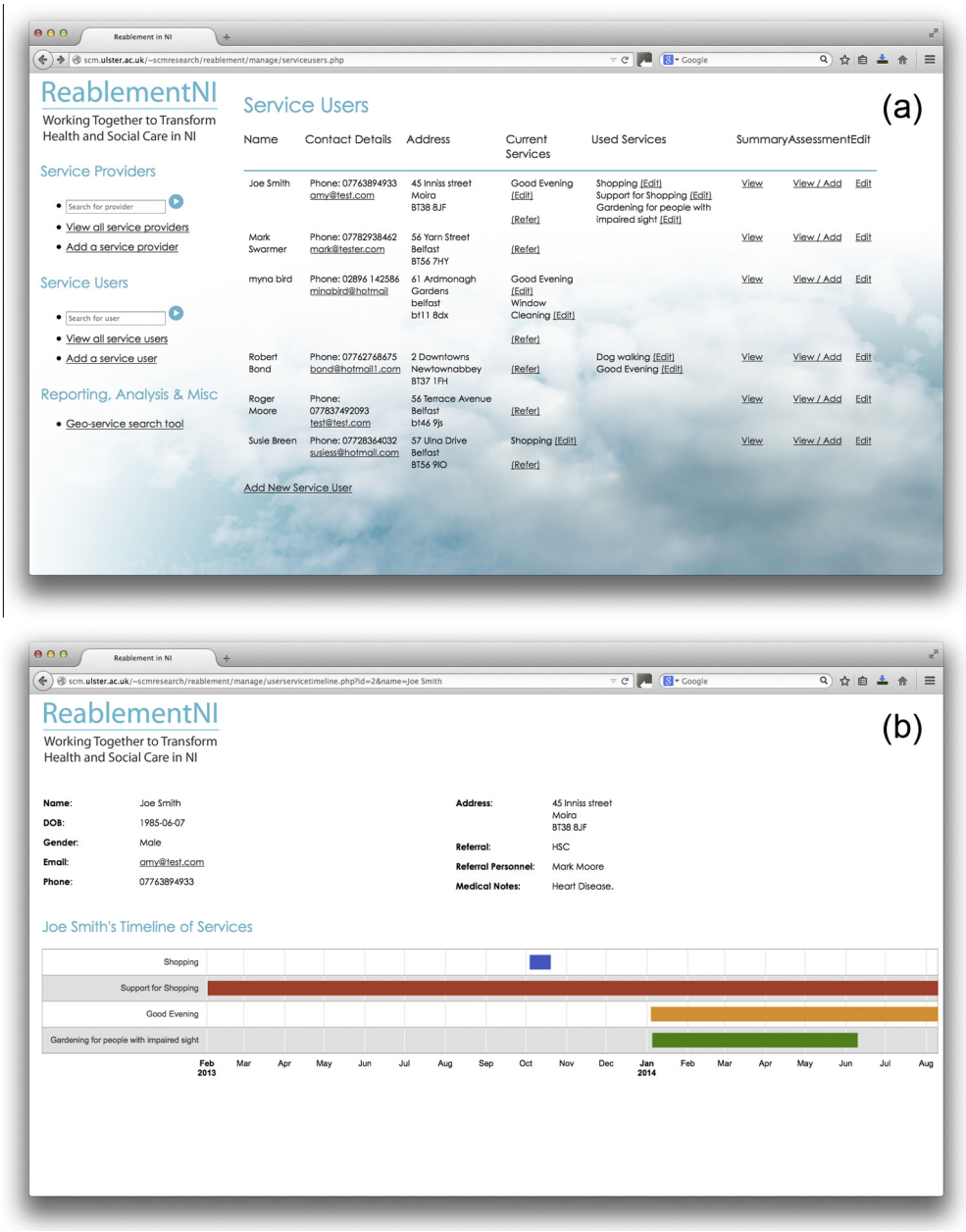

Fig. 2. (a) A list of pseudo service users and details which services they are currently enrolled onto and which services they have previously used. (b) A summary reablement record for an individual service user containing basic demographics and referral information.

Fig. 3 depicts a radar plot showing the difference between the results from a first assessment and the most recent assessment of an occupant. This provides a summary of an occupant's progress of independence. This continuous assessment can be used in combination with the occupant's timeline of service engagement. These radar plots are to be used by the healthcare team and the CN to identify patterns for determining the impact particular reablement services have on the occupant's independence.

3.7.4. Geo-service search user interface

An additional novel feature is the geo-service search tool as depicted in Fig. 4. This acts as a decision support tool as CNs can search for pertinent services that are available to a user who resides in a particular jurisdiction and who has specific needs. This tool allows the CN to filter services based on descriptive tags and on whether the service has capacity for new referrals. As shown in Fig. 4, this feature provides a visualisation of services using the Google Maps API.

3.8. Data model

Fig. 5 depicts the Entity Relationship Diagram (ERD) that represents the data model associated with the prototype. The figure depicts five core tables and their relationships (the *SystemUsers* table has been removed for simplification). The *ServiceUser* table retains the occupant's demographics, contact information and appropriate referral information. The *ServiceUser* table is related to the *UserAssessment* table given each occupant can have *zero-to-many* assessments (via the FEMPs tool). The *ServiceProviders* table retains data about service provider 'headquarters'. This table is related to the *Services* table given a service provider can have *one-to-many* services. Enforced by normalisation, the *ServicesInUse* table is a cross-reference structure (*many-to-many*) given *many* service users can enrol onto *many* services. This data model facilitated a number of SQL queries such as those described in Appendix B.

Table 2
Variables recorded by the FEMPS assessment tool.

Assessment measure	Data collected
Physical wellbeing	
Sleep	Average number of hours of sleep per day/night
	Self rating of sleep quality
Nutrition	Average number of meals per day
	From description of daily meals, the CN rates the quality of nutrition
	Total cups of water, soft drinks, tea and coffee per day
Activity	From description of weekly physical activities, the CN rates the user's level of physical activity
Mobility	Frequency of using public transport
Pain/discomfort	Frequency of experiencing pain/discomfort
Healthcare dependency	Hospital days since last assessment (if applicable)
	GP visits since last assessment (if applicable)
Mental wellbeing	
Anxiety	Frequency of feeling anxious
Depression	Frequency of feeling depressed
Optimism	Level of optimism/pessimism
Social wellbeing	
Family engagements	Frequency of home visits from friends/family per week
	Frequency of phone calls from friends/family per week
Community involvement	Total of social and community activities engaged in outside of the home
Social media	Use of social media technologies (e.g. Facebook)
Isolation	Frequency of feeling lonely/isolated
Environment wellbeing	
Hazards	CN identifies severity of health, safety and fire hazards in the home
Clutter	CN identifies the level of clutter in the home
Garbage	Determine if house bins be removed without inconvenience
Heating	Frequency of home and water heating hours
Security	Frequency of feeling unsafe in the neighbourhood
	CN checks for sufficient locks for home security
Financial wellbeing	
Heating	Affordance of sufficient heating without compromise
Food	Affordance of sufficient food without compromise
Eating out	Frequency of eating outside the home (Inc. restaurant visits per week)
Financial management	Frequency of bank visits per month

3.9. Usability results

Fig. 6 shows the necessity of the system where 87% of subjects ranked the prototype as either 'very useful' or 'useful'. A subject stated that this was a "...very useful tool for voluntary service providers and users..... .it can demonstrate to the user their progress and improvement in function/independence and help with exit planning..." Another subject stated that the system can "...make a big difference on how reablement can work..." However, an OT commented that "...a major trial is needed in the real world... the iPad is too big and heavy..... .a mini lighter tablet is ideal...". This is an important point however the system developed in the project is device agnostic. With reference to the FEMPS assessment tool, a subject identified a gap in the assessment, which is that "...it does not consider the state of repair of the house or the garden, yet these are important factors to many older and disabled people...".

Fig. 7 indicates the ease-of-use of the prototype as perceived by the subjects where 67% of subjects ranked the ease-of-use as either 'very easy' or 'easy'. One subject stated that the "the prototype is simple and easy to use – if properly rolled out and resourced it will provide a great way to inform older people and their families about local resources...". Fig. 8 shows the level of satisfaction amongst the subjects where 65% of subjects are 'very satisfied' or 'satisfied' with the system. A number of subjects stated that whilst the system is good – they would require training to use it.

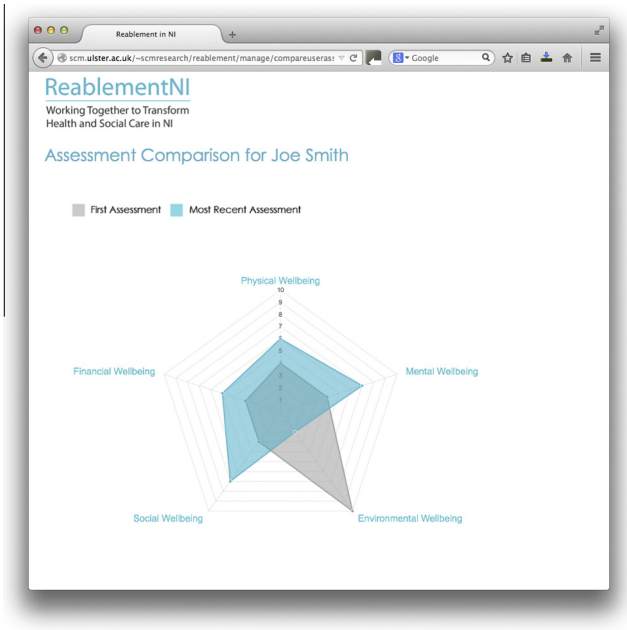

Fig. 3. FEMPS data visualisation that summarises user assessment scores in the form of a radar plot. Each point represents one of the five assessment themes, i.e. Financial, Environmental, Mental, Physical and Social Wellbeing. This plot in particular compares the first assessment score (grey polygon) with the most recent assessment score (coloured polygon). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Fig. 9 shows the level of security the subjects perceived the system to be. As indicated, 50% of the subjects perceived the system as either 'very secure' or 'secure', however 31% of subjects remained 'neutral'. An OT stated, "...safety firewalls would need to be assured as people at home could feel uncomfortable seeing their information being input onto a device..." In addition, an elderly service user stated, "...I would worry that other people would get my information". And another elderly service user stated that "...recent media reports underline that databases can be hacked. Any breeches will undermine future confidence in system...".

4. Discussion

Reablement emerged to tackle the problems of an ageing population such as the economic and manpower challenges of meeting the growing healthcare needs associated with ageing. By design and necessity, it involves a virtual, collective workforce that merges the services from the VC sector. As such, each agency working in this project expressed the collective desire to collaborate without loosing independent accountability, governance or the facility to demonstrate unique identity and impact. These issues are all important to sustain the commissioning of individual services. The adopted methods of living labs in this work facilitated strong stakeholder engagement and included a participatory design process. The net effect was that the stakeholders not only verbally informed system development but they also visually inspected the prototype via the usability testing phase. If developing the service user as the 'expert patient' is to be realised, it is crucial that information stored about each occupant is shared and understood by the patients themselves. To test this out, the system was presented on mobile devices to a focus group of potential elderly service users and their thoughts were captured to inform views on aspects of design, usability and indeed their general perspectives on the system.

If the technological innovation described in this paper is widely implemented, it will be a disruptive innovation within the sector. The potential of providing a cohesive, unique, personalised service for older people at home has been grasped as a

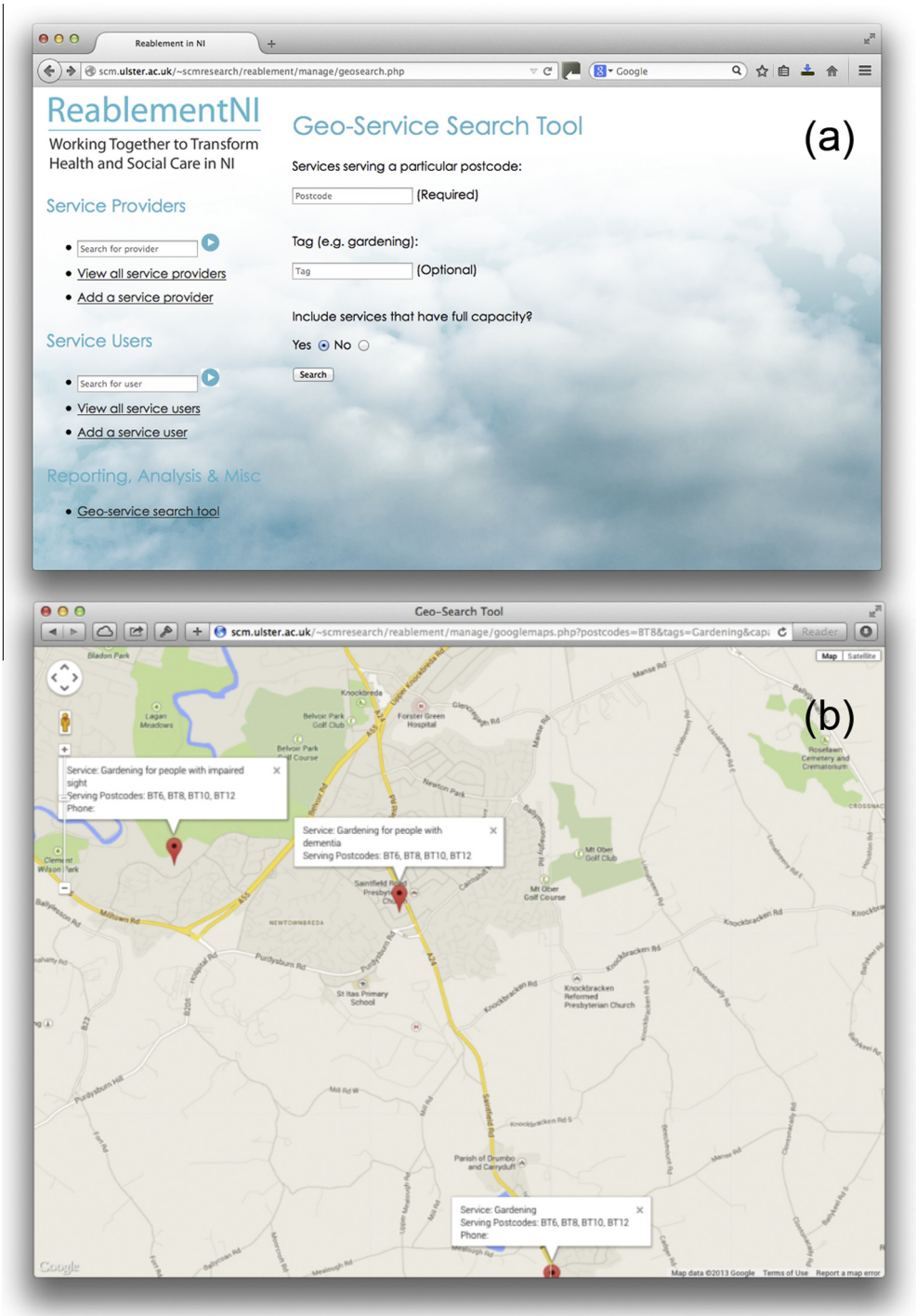

Fig. 4. Geo-service search tool where CNs can search for services available in a particular jurisdiction. The CN can filter services using tags and also whether the service has capacity for new service users.

necessity. The challenge does remain as to how the proposed system could be seamlessly woven into mainstream NHS systems. Complexities exist in this blended service with information being passed between the NHS and the VC sector. Thus, well-trodden issues of security and privacy of personal data arises. These challenges are mainly expressed by the NHS given the notion of data transfer in a two direction mode is muted from this digital platform to those mainstream platforms currently utilised in the public sector.

It is conceivable that the reablement model, if sustainable and effective, may evolve to improve the independence amongst all age groups. The notion of local engagement, promoting independence and social inclusion does resonate with a number of other user groups. And according to Francis et al. [11] "...there is no agreed threshold for entry to reablement services...". Thus, reablement could escalate to become an integral part of routine services for all age groups. However, at this point in time, an approach to reablement and its care pathway has yet to be standardised. The system described in this paper offers a flexible solution to the informatics needs of public and non-government agencies who are keen to maximise their service utilisation and deliver impact to older people in the home.

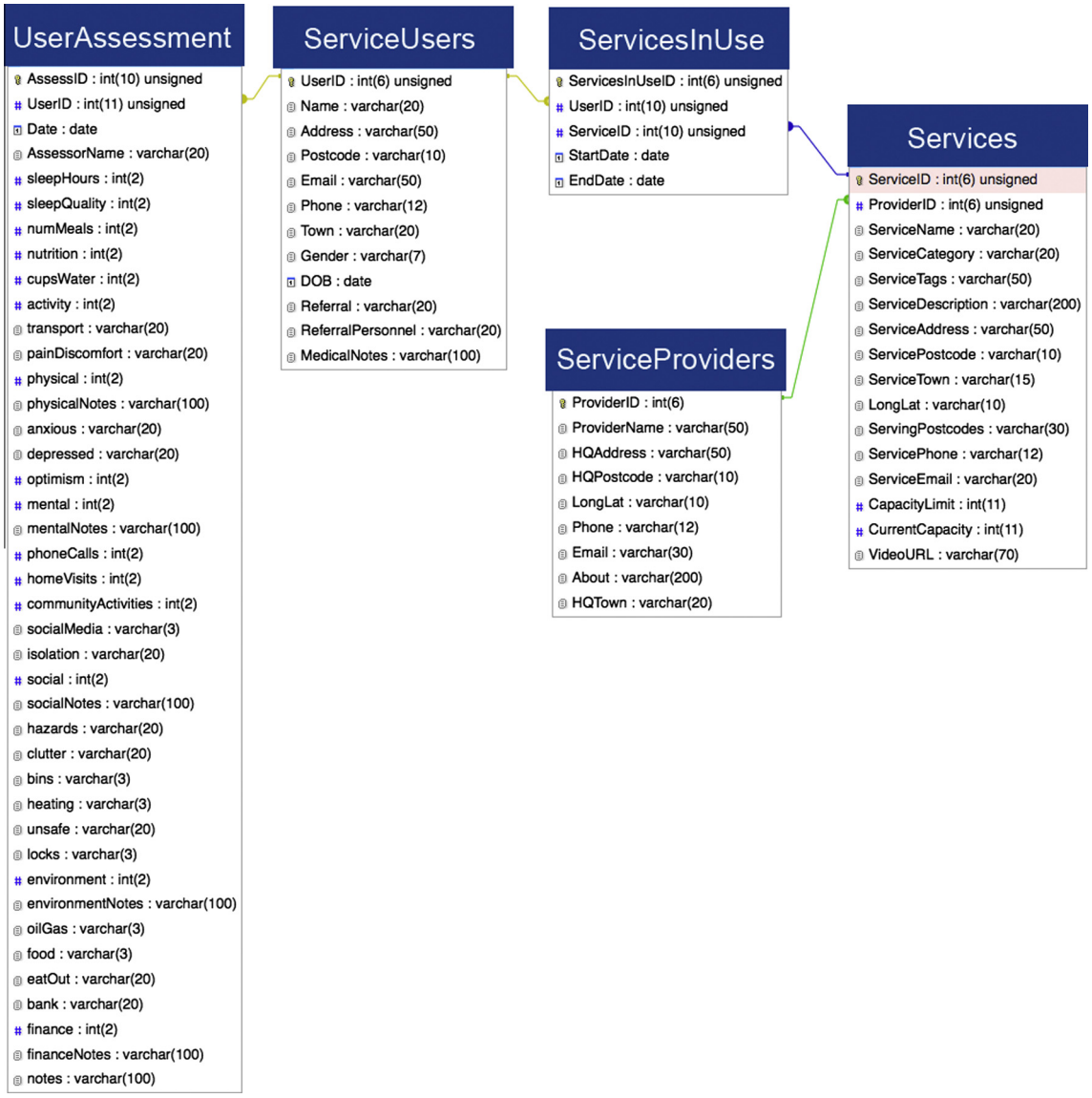

Fig. 5. Data model used in the reablement prototype (refer to Appendix B).

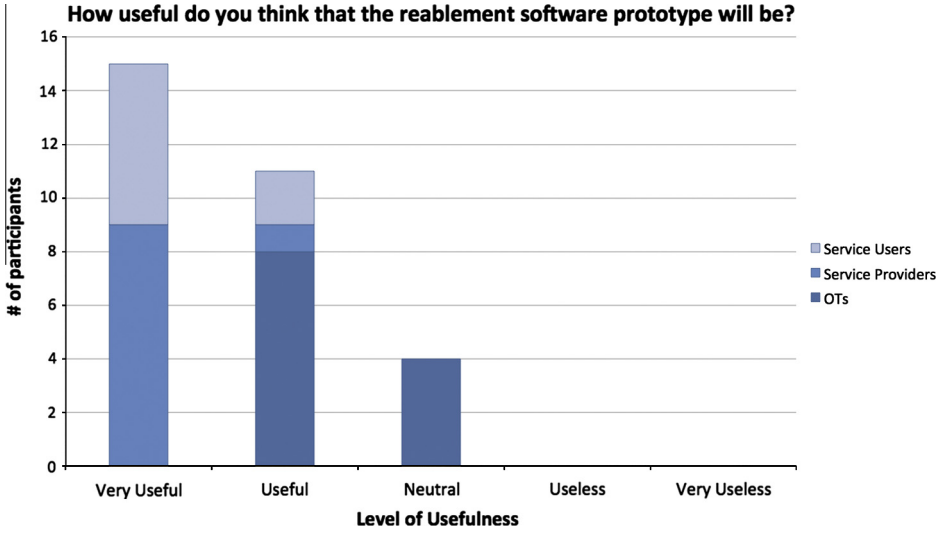

Fig. 6. Results to the question 'How useful do you think that the reablement software prototype will be?'.

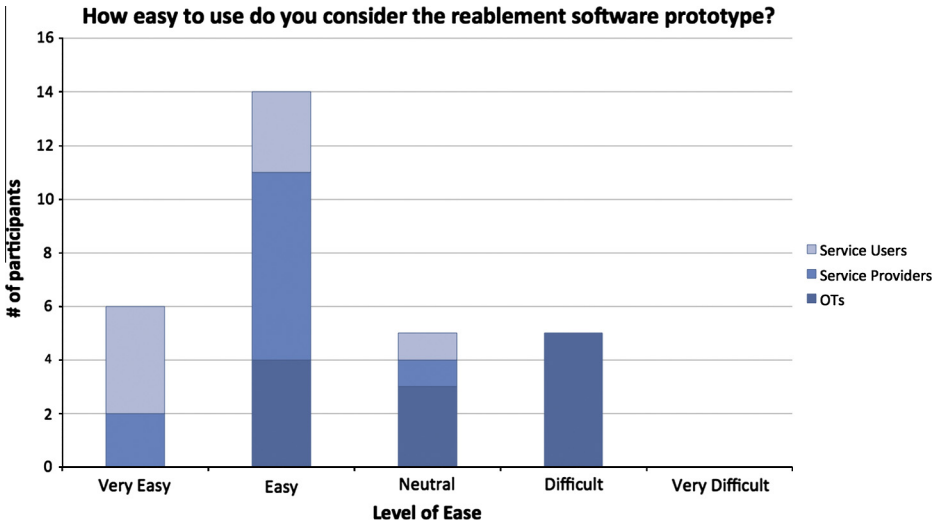

Fig. 7. Results to the question 'How easy to use do you consider the reablement software prototype?'.

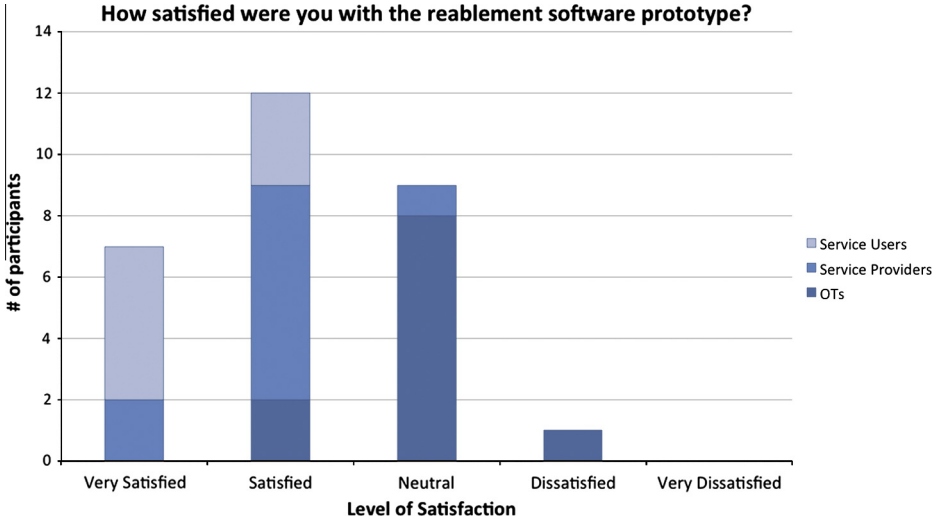

Fig. 8. Results to the question 'How satisfied were you with the reablement software prototype?'.

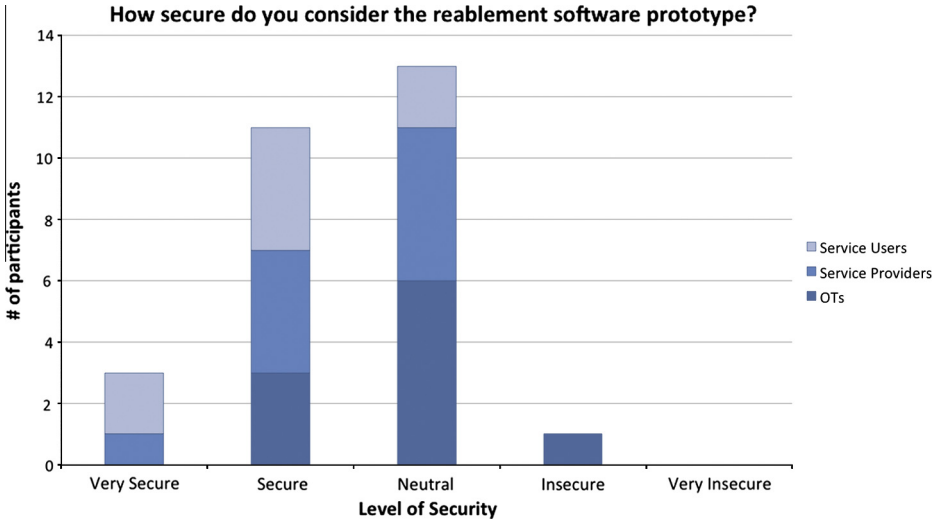

Fig. 9. Results to the question 'How secure do you consider the reablement software prototype?'.

4.1. Study limitations

This project has a number of limitations based on (1) sampling, (2) the FEMPS assessment tool and (3) the usability testing protocol. The sample of stakeholders have geographical and cultural biases given they were recruited from Belfast, Northern Ireland and may not be representative of the UK population. As a result, system features such as the FEMPS assessment tool may not be as useful in other cultures and jurisdictions. And whilst the FEMPS assessment tool was stakeholder and expert driven, the assessment itself would need further validated in the field.

The usability testing protocol did not involve the recording of user sessions via videography or audio. Thus any usability errors were not explicitly recorded. Therefore the usability testing protocol is sub-optimal since it is reliant on honest answers in the post-test survey. Furthermore, 30 subjects is a relatively small sample size and is not representative of the UK population. However usability experts have stated that 80% of usability issues can be unveiled with 5–8 subjects even if those subjects are a convenient sample [43,44]. Nevertheless, due to such limitations we classified this method as a 'pilot' usability assessment.

5. Conclusion

The aim of reablement coincides with the thoughts of the UK secretary of state, Andrew Lansley who stated that to reduce costs we must "keep people as independent as possible, for as long as possible" [11]. However, given reablement requires collaboration with a plethora of stakeholders and VC service providers, it can be postulated that this model can only be streamlined when an Internet-based reablement system has been integrated. This study derived stakeholder requirements for such a system and subsequently developed a prototype to address this issue. Therefore, the specific contribution in this paper is a potential solution that is evidenced based and stakeholder driven for translating the reablement model into routine practice. This is the first study that attempts to bring together representatives from all stakeholder groups to elicit requirements and to then develop a system to illustrate what a relevant technical solution would look like. Prior to this study there has been no knowledge available from experiments that investigate technological approaches to streamlining the reablement care model. However, as pointed out by an OT in the usability study, the reablement system "...will only work if all participants buy in and use it". This is impetus for future work, which should be based on defining protocols and procedures that are agreed upon by all stakeholders. Future work will involve addressing the security of an electronic reablement system as only 50% of the subjects perceived the system as being either 'very secure' or 'secure'. More work will also be carried out to evaluate the FEMPS tool as a validated instrument. And finally, the next generation of this system will be evaluated in terms of its utility and usability through a number of field trials.

Conflict of interest

All authors have no conflict of interests.

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Appendix A

See Table A1.

Table A1
Represented stakeholder organizations present at the reablement ideation event.

Stakeholder organisation	Short description
Shopmobility URL: www.shopmobilitybelfast.co.uk	Shopmobility is a charity that provides a free service to facilitate independent shopping to those who have a disability
Age NI URL: www.ageuk.org.uk	Age NI is a charity to help the Aged in Northern Ireland. Their mission is to "enhance and improve the lives of older people"
Belfast City Council URL: www.belfastcity.gov.uk	Belfast City Council is the local authority for Belfast city, which is the largest district council in Northern Ireland. The council is responsible for a population of approximately 268,700 persons
Oasis Caring in Action URL: www.oasis-ni.org	This charity provides services and initiatives to combat social isolation, depression, and mental health issues in the community
Volunteer Now URL: www.volunteernow.co.uk	Volunteer Now promotes volunteering across Northern Ireland. They provide training and information support to voluntary sector organisations
Bryson Charitable Group URL: www.brysongroup.org	Bryson Charitable Group is a registered charity, which has been providing community support since 1906. On average they enhance the quality of life for 400,000 people in Northern Ireland every year. They provide a wide range of services for the elderly
Good Morning Belfast URL: www.goodmorningni.org	Good Morning provides a free telephone service to reduce social isolation and increase independent living amongst vulnerable elderly people
Extra Care URL: www.extra-care.org	Extra Care is the largest provider of home care services in Northern Ireland. They provide a range of services to support older people in the home
Springfield Charitable Association URL: www.scaltd.net	This charity was initiated in 1980 to counter high levels of deprivation in Belfast. They offer an advice centre and a day care space for the elderly. They also coordinate an annual positive ageing week
Engage with Age URL: www.engagewithage.org.uk	Engage with Age is a community service that seeks to combat social isolation and support health and wellbeing amongst the elderly population
British Red Cross URL: www.redcross.org.uk	Through collective volunteering, the British Red Cross has been freely helping people who are in crisis since 1870
Action on Hearing Loss URL: www.actiononhearingloss.org.uk	Action on Hearing Loss is the only UK charity that specialises on supporting those who have hearing impairments deaf
South Eastern, Northern, & Western Health and Social Care Trusts URL: www.hscni.net	These are the official trusts in Northern Ireland that are responsible for providing all health and social care services to all 1.7 million citizens
Health and Social Care Board URL: www.hscboard.hscni.net	The board provides oversight, commission services and manages the current £4 billion budget for the trusts in Northern Ireland
Translating Research And Innovation Lab (TRAIL), University of Ulster URL: trail.ulster.ac.uk	The TRAIL lab represents the development of our research thinking to support research and innovation activities across several key disciplines including information & communication technologies, occupational therapy, health care, social care and clinical medicine

Appendix B

Series of typical queries that have been applied to the data model depicted in Fig. 5. Queries have been represented using SQL and relational algebra (where σ = selection, π = projection and $\bowtie$ = natural join).

SQL	Relational algebra	Description
SELECT Financial, Environmental, Mental, Physical, Social, Date FROM UserAssessment WHERE UserId = *x*	$\pi_{Financial,Environmental,Mental,Physical,Social,Date}(\sigma_{UserId=x}(UserAssessment))$	Where *x* is a unique identifier for a service user. Query returns assessment scores from all assessment instances as identified by date. The query was used to populate the interfaces depicted in Fig. 3
SELECT ServiceName FROM Services WHERE ProviderId = *x*	$\pi_{ServiceName}(\sigma_{ProviderId=x}(Services))$	Where *x* is a unique identifier for a provider. Query returns all services a particular service provider offers
SELECT ServiceName, ServicePostCode FROM Services WHERE ServingPostcodes LIKE '% *x*%' AND ServiceTags LIKE '% *y*%'	$\pi_{ServiceName,ServicePostCode}(\sigma_{ServingPostcodes=LIKE(x)\wedge ServiceTagsLIKE(y)}(Services))$	Where *x* is a given postcode and *y* is a given tag (i.e. service keyword). Query returns services of a particular classification and that serves in a particular jurisdiction that is perhaps pertinent to an individual service user. This query was used in the Geo-Service search tool depicted in Fig. 4
SELECT COUNT(ServicesInUseId) FROM ServicesInUse WHERE ServiceId = *x* AND EndDate IS NULL	$\pi_{Count(ServicesInUseID)}(\sigma_{ServiceId=x\wedge EndDate=NULL}(ServicesInUse))$	Where *x* is a given unique identifier for a service. Query returns the number of users currently using a specific service. The query is used for deriving service capacity as used in the interface depicted in Fig. 4b
SELECT ServiceName FROM Services LEFT JOIN ServicesInUse ON ServicesInUse.ServiceId = Services.ServiceId WHERE ServicesInUse.UserId = *x* AND ServicesInUse.EndDate IS NULL	$\pi_{ServiceName}(\sigma_{ServicesInUse.UserId=Id\wedge ServicesInUse.EndDate=NULL}(Services \bowtie_{ServicesInUse.ServiceId=Services.ServiceId} ServicesInUse))$	Where *x* is a unique identifier for a service user. Query returns services that are 'currently' being used by a particular service user. This query was used to populate the interfaces depicted in Fig. 2
SELECT ServiceName FROM Services LEFT JOIN ServicesInUse ON ServicesInUse.ServiceId = Services.ServiceId WHERE ServicesInUse.UserId = *x* AND ServicesInUse.EndDate IS NOT NULL	$\pi_{ServiceName}(\sigma_{ServicesInUse.UserId=x\wedge ServicesInUse.EndDate\neq NULL}(Services \bowtie_{ServicesInUse.ServiceId=Services.ServiceId} ServicesInUse))$	Where *x* is a unique identifier for a service user. Query returns services that have 'previously' been used by a particular service user. This query was used to facilitate the user interfaces depicted in Fig. 2

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