Development of a smart home suitability indicator and indicative self-assessment platform for the Disabled Facilities Grants (DFG)

Abstract

Purpose

Delay in housing adaptation is a major problem, especially in assessing if homes are suitable for the occupants and in determining if the occupants are qualified for the Disabled Facilities Grant (DFG). This paper describes the development of two self-administered intelligent integrated assessment tools from the DFG Adapt-ABLE system: (i) The Home Suitability Assessment Platform, which is a preventive mechanism that allows assessment of the suitability of homes based on occupants' mobility status. and (ii) an indicative assessment platform that determines if the applicants are qualified for the DFG to prevent lengthy delays.

Method of study

The adopted method aligned with a development study approach: a grounded literature review, a severity measurement approach, two stakeholder engagement workshops, four brainstorming sessions, and four focus group exercises. The system development relied on the Entity-Relationship Diagram (ERD) technique for data structures and database systems design. It uses DFG context sensitivity with alignment with DFG guidance, interlinkages, and interoperability between the assessment tools and other platforms of the integrated Adapt-ABLE system.

Findings

The assessment tools are client-level outcomes related to accessibility, usability, and activity based on the assessment process. The home suitability platform shows the percentage of the suitability of a home with assessment results that suggest appropriate action plans based on individual mobility status. The indicative assessment combines the function of referral, allocation, assessment, and test of resources into an integrated platform. This enables timely assessment, decision-making, and case-escalation by occupational therapists based on needs criteria and the eligibility threshold.

Impacts

These assessment tools are useful for understanding occupants' perception of their physical housing environment in terms of accessibility, suitability, and usability based on basic activities of daily living" (BADLs) and their mobility status. The indicative self-assessment tool will substantially cut down the application journey. The developed tools have been recommended for use in the CSJ Disability Commission report and the UK government Guidance on Disabled Facilities Grants (DFG) for local authorities in England.

Keywords:

Housing adaptation, Disabled Facilities Grants, assessment tools, home suitability score, lengthy delays, UK

1. INTRODUCTION

According to ONS (2022), there were 15,120 centenarians and 609,503 aged 90 years and over in the UK in 2020, an increase of almost a fifth (18%) from 2019 for the centenarians. There are twice as many women aged 90 years over as men; however, the gap has narrowed over the last three decades and will continue to narrow. It is evident that people now live longer, with health, mobility, and quality of life challenges. Elderly people are more likely to develop some conditions and illnesses (Age UK 2023) that will increase their risk of becoming frail and lead to a greater need for health and social care (Raymond et al., 2021). Miller et al. (2014) also established the correlation between ageing and long-term illness and disability.

The report by the National Statistics (2022) on the family resources survey for 2020/2021 indicates a 2% increase in the number of disabled working adults and a 4% decline in those over the state pension. The survey indicates that one in five reported disabilities in the UK, amounting to 14.6m people. In 2020/21 statistics, the prevalence of disability in the UK rises with age, about 9% of children, 21% of working-age adults, and 42% of adults over State Pension age. Mental health and mobility are the two main impairments identified; 42 percent of working-age adults have mental health and mobility impairment compared to state pension-age adults with only nine percent mental health and 63% mobility impairment (National Statistics 2022). With the high number of mobility problems, Lloyd and Parry (2015) postulate that over 85% of those aged 75 and over prefer to stay in their home compared to less than 80% of those aged 65-74.

To continue staying at home their homes need to be adapted to suit their mobility status to remain and live independently. According to Zhou et al., (2019a, b) housing adaptation is the modification of physical features indoors and outdoors to suit the elderly and disabled people's impairments and mobility status to reduce environmental barriers and allow them to live independently. There are several schemes for housing adaptation: Disabled Facilities Grant (DFG), local authorities and small adaptations scheme, housing association grants, National Health Service (NHS) intervention, and Local Care and Repair groups or Home Improvement Agencies (HIA) grants (Scope 2023). Home adaptations are aimed at restoring or enabling independent living through changes made to the fabric and fixtures of a home to make it safer and easier to get around for everyday tasks (Department of Health & Social Care 2022). Home adaptations are administered by local housing authorities for eligible disabled people of all ages and in all housing tenures. These are people with mental health conditions, physical disabilities, learning disabilities, cognitive impairments, and terminal illnesses (Scope 2023).

There are minor, major, and complex housing adaptations. Housing adaptations include the installation of equipment, bespoke home extensions, access to and from gardens, heating systems, insulation, and assistive technology (UK Government 2022a). However, this study focuses on major adaptation, a structural alteration to the home of disabled and aged people for better access to live independently. One of the challenges for the elderly and disabled people is the lack of preventive tools to help those needing adaptation recognise such needs. It is difficult for most people to recognise the need for housing adaptions because human beings adjust gradually to their environment with their increased level of disability. The MHCLG (2021) report on home adaptations 2019-2021 shows that 81% of households that required adaptations due to their health condition felt their home was suitable for their needs. This contrasts with 19% of households that required adaptations and considered their accommodation unsuitable.

It has been established that the DFG process is sequential and bureaucratic, with fragmented responsibilities and phases with lengthy procedural steps that lack collaboration between departments (Mackintosh and Leather 2016). Zhou et al. (2019a, b) identified delays in all six housing adaptation phases as one of the problems in the DFG process. The average time for the whole adaptation process for the three categories of the local authorities can vary from 193 to 227, and 243 days. For instance, in category II local authorities where the first three stages (referral, case allocation,

and assessment) are combined, a minimum of 28 days and a maximum of 573 days are used to complete housing adaptation. The funding approval phase takes a minimum of 23 days, a maximum of 630, a minimum of 30 days, and a maximum of 226 days for the installation stage (Zhou et al. 2019 a, b). This is in contrast to the 6 months maximum period set in the 1996 Act for a local authority to decide an application (Department of Health and Social Care 2022).

The Adapt-ABLE project aimed to develop an intelligent Adapt-ABLE system with four integrated platforms to streamline DFG processes to prevent delays. This paper presents the development of two assessment tools that are linked together: The Home Suitability Assessment Platform, which determines the suitability of homes, and the platform for Indicative Assessment to determine if the applicants are qualified for the grants. This allows the disabled and elderly people to know if their homes are suitable and if they qualify for the grant in less than 15 minutes. This paper presents the development of the two assessment platforms already in use. The construct was reported by Oyegoke et al., (2022); this paper reports the system development as the research project has been successfully delivered.

2. DISABLED FACILITIES GRANTS (DFG)

The Wilson (2013) standard note describes DFG as an essential adaptation intervention that gives disabled people better freedom of movement into and around their homes, enabling them to access essential facilities within the home. The guidance issued by the UK Government (2022a) for Local Authorities in England also indicates that housing adaptation can enable independent living, restore confidence and dignity for individuals and their families, and enhance privacy and safety. According to the guidance, "adaptations can include the installation of stair-lifts, level access showers, and wet-rooms, wash and dry toilets, ramps, wider doors and access to and from gardens." In some cases, it can also be bespoke home extensions and improvements, heating systems, insulation, telecare, and assistive technology (UK Government 2022a). The DFG maximum grant limit differs across the UK, with no upper limits in Scotland, £30,000, and £36,000 in England and Wales respectively. DFG is subject to means testing to ensure that those who are on the lowest incomes (least able to pay) are able to adapt to their homes. DFG also applies to applications made by owner-occupiers, tenants, and occupants as different rules apply to applications made by a landlord (The UK Government 2022a).

If the applicant cannot afford a contribution, local authorities have discretionary powers to provide a top-up to meet the cost (Zhou et al., 2019c). The DFG guidance stipulates that the social authority should assist where an applicant after the means test cannot meet their contribution, or the cost of the adaptation is above the upper limit or the need is outside the scope of the statutory DFG duty (the UK Government 2022a). Although the DFG grant applies across all tenures and people of all ages, it cannot be used to fund adaptations to local authority properties (Wilson 2013). The DFG Crisis and the Better Care Fund report (2020) indicates that saving up to £73,000 per person can be made from a typical home adaptation costing £7,000 by delaying entry to residential care by up to 4 years. Housing adaptation can reduce the risk of falls by 60%, and for every £1.00 spent £4.00 home care cost savings can be made.

Section 23 of the Housing Grants, Construction and Regeneration (HGCR) Act 1996 outlines the purposes for which a grant must or may be given and section 24 (1) empowers the local housing authority to approve DFG application. (2) When there is a need to acquire a qualifying owner's interest, approval cannot be given until the owner's approval is given. (3) Approval will only be given when the adaptation works are proven to be necessary and appropriate to meet the needs of the disabled occupant, and it is reasonable and practicable to carry out the adaptation work based on the age and condition of the building. (5) Approval is not given if a local housing authority is satisfied that the applicant has power or is under a duty to carry out the relevant works (Legislation.gov.uk 2023).

The timescales for moving through these stages will depend upon the urgency and complexity of the adaptations required. However, a total of 55 working days is set as a target for urgent and simple cases, 130 days for non-urgent and simple cases, 130 days for urgent and complex cases, and 180 days for non-urgent and complex cases (The UK Government 2022a).

The adaptation process has five main and after-use (inspection) phases, (Zhou 2019 a, b; the UK Government 2022a): referral, allocation, assessment, funding, installation, and after-use.

- The housing adaptation process begins with a former process called the referral phase. This is when an applicant is referred by healthcare professionals or can be a self-referral by the applicant. It was referred to as the first contact in the UK government guidance, providing good information, advice, and publicity. This stage will consist of pre-application processes and formal requests for adaptation services when the need for adaptation becomes known to the welfare authority. The guideline stipulates that the client will be informed of the next steps and the initial inquiry date is the starting point for a request for assistance in measuring against the target timescales (The UK Government 2022a).
- In the allocation phase, cases are allocated to specific fieldworkers, mainly occupational therapists (OTs), for assessment. This will be based on criteria for identifying and prioritising urgent cases based on the client's needs. OTs decide whether an assessed need matches the funding eligibility criteria and specify the types of adaptations required (Zhou 2019 a, b).
- The nature of the assessment will depend on whether the adaptation is likely to be minor or major, based on the structural adaptation changes required rather than cost. The other two factors are whether a person's situation is straightforward or complicated. This is determined by the nature of the person's condition, the type of activity the person wants to do, and how ready they are to have their home adapted (The UK Government 2022a). A major and complicated adaptation will require occupational therapist leads on assessment, but a major but straightforward adaption will need a trusted assessor to show on assessment under supervision. A minor and complicated adaptation requires a trusted assessor to lead an assessment under supervision. A minor and straightforward adaptation could be self-assessed by the disabled person with family and carers. According to Zhou et al. (2019a, b), the OT visits and assesses the client's need requirements to decide the type of adaptation needed based on four risk bands: critical, substantial, moderate, and low. The case is passed to the housing department for funding authorisation. In complex cases, a collaborative model of assessment involves the occupational therapist and the person identifying the most appropriate solution and considering whether it is reasonable to award a grant. (Zhou et al. 2019a, b).
- The case is then passed to the grant officers for funding approval. Landlord permission is required if the occupant is a tenant before any adaptation. The resource testing ensures that DFG funding reaches those on the lowest incomes and least able to afford to pay for the adaptations themselves. This means testing applies to owner-occupiers, tenants, and occupants of a qualifying houseboat or caravan. Different rules apply when a landlord makes the application (The UK Government 2022a). Where it applies, evidence of income and savings need to be provided. An applicant who is in receipt of means-tested welfare benefits (income-related benefits) can be passported (automatically eligible). There are other exemptions/waivers to the means test: where the cost of the adaptations is below a certain amount; and where the disabled person is a child or young person. The local authorities have discretionary powers to waive the means test if it will lead to financial hardships, and applications made by the landlords are not means-tested by the housing authority (Department of Health 2023). Due to the complexity and effects of the late application of the means test, a preliminary means test is suggested at an early stage. The assessment portals incorporate means testing to prevent unnecessary waiting and short-circuit delays and may encourage the disabled person to pursue other solutions (Department of Health and Social Care 2022).

- The client's needs are translated into a specification, standard specifications, and 3D design can prevent misunderstanding, save time, and communicate the use of the adapted home. In confirming the works, the client should fully involve in the design and specification of their home, and the aesthetics and functionality of adaptations should be considered by the authorities. Agreement and consent of affected parties (such as a landlord) may also be required (Clayton and Silke, 2010). Where planning approval is needed, e.g. for structural modifications, it is important to adhere to building regulations and obtain building approval. To prevent planning permission delays, the local housing authorities and the local planning department can develop procedures to resolve problems with planning permission. Where necessary permissions can be granted to use temporary planning permission. A dynamic procurement system (DPS) is well suited with a minimum of 2 competitive estimates (Department of Health and Social Care 2022).
- The next phase is to select a contractor for the applicant or choose from the list of qualified contractors from the authority's list of accredited builders. It is advisable for the client and the contractor to sign a formal contract and have pre-start meetings to understand the process and the sequence of events to avoid misunderstandings and disputes. Usually, the work must be completed within 12 months of the approval date. The finished work is inspected and approved before payment can be made (Zhou et al., 2019a, b). The contractor is paid directly by the authority in installments as the work progresses or in full upon completion, however, the applicant must be notified before approval of the application.

3. THE ASSESSMENT PLATFORMS NEED ANALYSIS

Home suitability platform

The Ministry of Housing Communities and Local Government [MHCLG] (2021) report titled English Housing Survey on Home Adaptations 2019-20 shows that 81% of households that required adaptations due to their health condition felt their home was suitable for their needs. This contrasts with 19% of households that required adaptations and considered their accommodation unsuitable. There is also a disparity in taking action between different age groups living in unsuitable housing with the option of moving to suitable accommodation. Under 55 years old are more likely to report that their accommodation was unsuitable (30%) than those that required adaptations in older age groups (20% or less). 17% of those under 55 years old wanted to move to more suitable accommodation compared with 12% of households with someone aged 55 to 64 years. Aged 75 or over are least likely to state their accommodation was unsuitable (13%), and 7% or less for those aged 65 or over who wanted to move to more suitable accommodation (MHCLG 2021). In terms of tenure, owner-occupiers are less likely to say that their home was unsuitable for their needs. In 2019-20 according to the housing survey report, 17% of owner-occupiers, 25% of private renters, 25% of local authority renters, and 21% of housing association renters who required adaptations said that their home was unsuitable for their needs. Also, most people feel that their home is suitable for their needs because ageing is a gradual process (MHCLG 2021). It comes with a deceptive view of the ability to cope, prompting changes to behaviour instead of the physical environment (Mackenzie et al., 2015). Negotiating hazards using their instinctive knowledge of their home Petersson et al., (2012) until they can no longer cope effectively at home and seek help. A self-determined/assessment tool that can predict the suitability of a home could at least help 81% of households that required adaptations but felt their home was suitable for their needs. This will be a preventive measure that will indicate where adaptation is needed based on occupant mobility status.

Indicative assessment platform

The DFG process is fragmented and bureaucratic, with lengthy procedural steps, which causes substantial delays due to a lack of collaboration between departments (Zhou et al. 2019a, b). Mackintosh et al. (2018) identified four types of DFG processes and their practice share: minimal approach 2%, DIY process 2%, traditional process 68%, and 'integrated' process (joint team) 27%. The waiting list in different phases includes waiting for an initial assessment for aids, equipment, or minor works; other waits for a full occupational therapy assessment; and further waiting for a DFG means test and grant approval (Mackintosh et al. 2018). The delay-related problems are identified by (Oyegoke et al., 2022 and Zhou et al., 2019a, b).

The timeline study carried out by Zhou et al. (2019) shows the time taken to complete the adaption process. The process was categorised into three due to differences among local authorities. For instance, It takes a minimum of 60 days and a maximum of 360 days to complete Category I while Category II takes a minimum of 90 days and a maximum of 474 days. Category III takes 84 days minimum and a maximum of 522 days to complete the adaptation process. In terms of delay in different phases, the delay in getting funding approval was the longest in all categories. An average of 85 days with 233 maximum days for Category I, an average of 118, and a maximum of 630 days for Category II, and an average of 112 and a maximum of 385 for Category III for funding to be approved.

According to Fänge and Iwarsson (2007), the housing adaptation evaluation process has many inherent challenges related to the organisational assessment framework in the municipalities and the methodology used for outcomes and follow-up assessments for disability grants. Chiatti and Iwarsson's (2014) study deals with interventions that integrate the economic perspective into occupational therapy practice. They postulate that there is a scarcity of housing adaptation (HA) evaluations aimed at removing environmental barriers and accessibility problems in the homes of people with disabilities. They also proposed strategies for economic evaluations of HA interventions by stimulating the dissemination and application of effectiveness, cost, and cost-effectiveness concepts used in health economics. The indicative assessment platform enables timely assessment by shortening qualified applicants' application journey from usually 50 to 360 days (Zhou et al. 2019 a,b) to about 30 min.

4. METHODOLOGY

To introduce social accountability in this development research a coproduction approach is relied on. This will enable the 'expert laity' according to (Nowotny et al. (2001) to contribute to shaping the research process in a less hierarchical and more distributed structure. Gillard et al. (2012) cited in King et al. (2019) described coproduction as an interpretive approach with high-value research decision-making distributed across the team. It is methodologically flexible with critical reflection in the research process to report how knowledge was produced. This research involved researchers, practitioners, and public sector workers to constitute valid knowledge development in housing adaptation.

Validating the construct

Oyegoke et al., (2022) reported that the research group carried out four brainstorming sessions at different stages of the development of the Adapt-ABLE construct. A three-part virtual stakeholder engagement workshop of 76 experienced practitioners facilitated by one of the project partners that oversees a national network of Home Improvement Agencies (HIAs) and handyperson providers and works with many local authorities across the country. A workshop is a useful tool in the coproduction

of knowledge and development studies. It is used to evaluate or co-create innovations in information systems (IS) and design fields (Thoring et al. 2020). Focus group is used to gather diverse experts' opinions to evaluate and validate the solutions as the work progresses. This supports Hennink's (2014) view that focus groups gather perspectives. The workshop and the focus group exercise were attended by the DFG applicants, occupational therapists Home Improvement Agencies (HIAs), equipment suppliers, DFG contractors, local authority staff, and social authority workers. A focus group exercise of six DFG experts was held to validate the implementation framework.

Suitability Assessment Platform

The aim of the first focus group for this platform is to evaluate:

- General design of the platform/concept
- System working development – taking into recognisance database development
- Intuitive user interface – user-friendliness/easiness of usage

The focus group participants agreed that **t**he general design should not be generic home suitability design/analytics as initially planned but should primarily focus on DFG since Adapt-ABLE is a DFG platform. A DFG home analytics on minor and major housing adaptation needs will be more useful in the majority view. As part of the outcome of the focus group, key areas of focus were identified for the design and development of the suitability assessment portal. It has been shown in Fänge and Iwarsson's (1999) studies that individuals with functional limitations living in housing with physical environmental barriers spend about twice the amount of time at home compared to those residing in accessible housing. Adequate consideration is given to the person and the environment mix in terms of functional limitations: security, privacy, accessibility, suitability, flexibility, home occupational performance, social contacts, and physical/environment barriers in the design of the home suitability assessment.

The focus group identified some key areas, which include:

- Providing ramps, widening doors, shallow steps
- Adapting or providing suitable washing, bathing, level access shower or toilet facilities
- Ensuring the disabled person can move around and access parts of the home
- Installing a stairlift or a 'through the floor' lift or ceiling track hoists

The key home features of housing adaptation were suggested:

- Access and pathway
- Using bathroom
- Bathing
- Toileting
- Access to upstairs
- Access to garden
- Widening of doors

The second stakeholder engagement of OTs focused on the evaluation of severity measurement. The measurement process aligned with Fänge and Iwarsson (1999) includes identifying a clear definition of concepts to be measured, determining the size and scaling technique level, and testing the instrument for reliability and validity. Severity measures are typically expressed as a proportion or percentage of the sampling unit; for example, if 3/4 of a colony's surface area is affected by a particular disease, the severity would be expressed as 75% (Thomas and Ashcraft 1991). Severity gives a more

accurate measure of a house's suitability for the occupant. The major outcome of workshop 2 is to redraft/improve the severity measurement questions so that they will cover the key areas suggested by the experts. The rating modalities were agreed upon to suit the user's needs. The computerised severity index (CSI) was developed based on a three-point system: no, minor, and major effects. When there is no effect, no action is required. Minor and major effects indicate minor and major adaptations are needed, respectively. This can be simplified as follows:

0 - Nothing - it's fine as it is (*no effects*)
1 - Minor adaptations or equipment (*minor effects*)
2 - Major adaptation / DFG (*major effects*)

The survey assessment matrix is based on seven mobility statuses and 25 factors of six home features. This is used to develop the assessment algorithms to arrive at the suitability score of the property for the occupant. A scoring system validated by the focus group severity index was found to give excellent predictions of the suitability of homes and predictive of exacerbations and quality of life-giving a broad assessment of disability severity.

Insert: Table 1: Example of severity measurement/assessment matrix

It was also suggested that:
1 – Minor adaptations - preferable to signpost/redirect to AskSara (2022), which maintained minor equipment and adaptation details.

2 – Major adaptations – Where major adaptation is required, which is the focus of this study, the system should suggest appropriate adaptation, with short descriptions and pictorial form.

An extensive literature review identified five key demographic questions to help assess home suitability. The questionnaire begins with the demographic information of the occupants.

- Age
- Gender: Male, female, or other nonbinary identities
- Marital status: Single, married, separated, widowed
- Living status: Own, rent, lease, other
- Career: If the applicant has a career

It also contains seven mobility statuses based on the OASIS (M1860) Ambulation/Locomotion resources for accurate Scoring, coded 0-6. The ambulation/locomotion scale presents the most optimal level and proceeds to more minor optimal mobility abilities (Centres for Medicare and Medicaid Services 2022).

- O – Walk: Able to independently walk on even and uneven surfaces and negotiate stairs with or without railings i.e., needs no human assistance or assistive device.
- 1 – Use a one-handed device: e.g. cane, single crutch, Hemi-walker, able to independently walk on even and uneven surfaces and negotiate stairs with or without railings
- 2 – Use a two-handed device: (e.g., walker or crutches) to walk alone on a level surface and requires human supervision or assistance to negotiate stairs or steps or uneven surfaces
- 3 – Personal assistance needed: Able to walk only with the supervision or assistance of another person at all times
- 4 – Independent wheelchair user: Chairfast, unable to ambulate but can wheel self independently

- 5 – Wheelchair with assistance: Chairfast, unable to ambulate, and is unable to wheel self
- 6 – Unable to leave bed: Bedfast, unable to ambulate or be up in a chair

Six home features with 25 factors were identified as critical features and characteristics in evaluating home suitability for disabled and elderly people (see appendix 1 for detail). Four stair types for access upstairs (stair types), four access types for access to the garden, four pathway and two-door width factors for pathway and access, six factors for shower and bathroom door dimensions, four shower types for bathing features, and a factor to determine if the toilet is a wash dry toilet. Toilet Transferring OASIS (M1840) is used for accurate Scoring toilets. This is aimed at measuring the current ability of the occupant to get to and from the toilet or bedside commode safely and transfer on and off the toilet/commode. It is coded from 0 - to - 4 (Centres for Medicare and Medicaid Services 2022).

- 0 - Able to get to and from the toilet and transfer independently with or without a device.
- 1 - When reminded, assisted, or supervised by another person, able to get to and from the toilet and transfer.
- 2 - Unable to get to and from the toilet but can use a bedside commode (with or without assistance).
- 3 - Unable to get to and from the toilet or bedside commode but can use a bedpan/urinal independently.
- 4 - Is dependent on toileting.

Indicative assessment platform – Qualification requirements

The Swindon Borough Council (2022) Practice Guidance, Policy, and Procedures for Adult Social Care was used to develop the theoretical requirements for assessing DFG. DFG eligibility is likely to be met when all of the following apply:

a. The person has at least one need for an adaptation as set out in the Housing Grants, Construction and Regeneration (HGCRA) Act
b. The adaptation proposed is necessary to meet the need; and
c. The adaptation proposed is appropriate to meet the need.

Additionally, basic and compulsory criteria were extracted from three local authorities and the HGCRA qualifications for Disabled Facilities Grants. This was validated by a focus group of occupational therapist experts. The basic and compulsory criteria are in all parts of the application. Examples of mandatory criteria can be seen in part one if the property requires a major repair (that is not economically viable) and if the property is a second home. Part two is about information about the applicant, and part three is about ownership and if the owner's consent is required. Part four is about additional information like insurance claims, and part five deals with the means test.

Part 1: Information about the applicant – It contains two sections (i) demographic information and (ii) information about the property - nature of the ownership and renting, and if the property needs a major repair.

Part 2: Information about the person completing the application – It has to be determined if the application is by a sole or a joint applicant or by the property owner, volunteer advocate, or a paid carer. The nature of the disability, difficulties in the property, the current difficulty that prevents the applicant from living safely at home, and the situation's urgency are all essential.

Part 3: Proof of Ownership section – to determine if the applicant holds the property title deeds or if the financial institution holds the title deeds to the property. A tenant must provide a tenancy agreement of five or more years. Knowing if the landlord permits the works to proceed is also important.

Part 4: Additional information you may need to include with the application pack: e.g. insurance claims regarding the works for which the grant is being sought and if there is a need for building regulations approvals.

Part 5: Means Test - The mandatory means test forms part of the completed application, which is to provide proof of your income to determine if the applicant is qualified and the exact amount of contribution by the applicant.

Table 2 presents the summary of the feedback from the focus group after the initial testing of the developed platforms.

Insert: Table 2 Summary of focus group feedback to improve the system

5. SYSTEM DEVELOPMENT, APPLICATION AND USABILITY

System development

The development of the proposed interactive and dynamic assessment platform follows an individual path for every user to compute the final assessment score. On the other hand, the dynamic nature is the ability to handle or incorporate new requirements into the assessment procedure. The system's administrator panel can adjust all assessment criteria or the mobility status. This dynamic ability is derived from consistent changes to the software requirements during the planning phase of the assessment platform. The development of the assessment platform is based on the Dynamic Data-Driven Applications Systems (DDDAS) paradigm (Blasch et al., 2018). In DDDAS, the home features and the assessment computation are integrated with a feedback control loop. The system prototype was presented to the focus group meeting to perform tests and trials to see the effects of any home feature on suitability score. Members of the focus group can adjust weights for all home features according to their choice. The DDDAS design supported these requirements as the system provides feedback on the computed suitability score (computation) back to the home features (instrumentation). The control loop provides a clear picture of the effects of individual features on the evaluator's final score. The prototype served as a tool for evaluating the selection and refinement of home features and their weights. The main purpose of the DDDAS paradigm is to enable efficient and accurate analysis and modelling of home characteristics for any given mobility status.

Figure 1 shows the back-end data model for developing dynamic assessment applications as an entity-relationship diagram (ERD). The rectangle represents the entity or the relational with their attributes as ovals. The dashed line between the two entities represents their relationship. The category entity holds information about key home features. Each category or key home feature stores several associated questions under the question entity. Similarly, different types of mobility statuses are stored in mobility relations. Applicant demographic information is stored in applicant relations. Icon attribute that holds a pictorial representation is associated with every entity, which is a basic requirement for accessibility. To make the system easier to understand, the provided information is

reflected with an iconic representation and the text throughout the assessment process (Ghayas et al., 2013). All responses to questions under different categories are stored in the response entity. Every question under a category with varying statutes of mobility is assigned a weight and stored in the assessment weight entity. The system matches applicants' responses with assessment weights to compute the final suitability score.

Insert: Figure `1 Entity relationship diagram – data model

System application and usability

The assessment application requires minimal input from the user to complete the assessment procedure. Minimum input is a requirement for software used by elderly people and individuals with disabilities. Every question is designed as a set of choices so that users can make a choice that reflects their condition. Navigation for forwarding or backward moving is provided, and users can restart the procedure if they want. All inputs are made through a mouse click or tap on the touch screen. The assessment system is developed for all platforms, including desktop computers, laptops, mobile, and tablets. Figure 2 shows the assessment system's desktop view (in the background) and mobile view (in the front).

Insert: Figure 2 Assessment tool for accessibility user interface

The suitability assessment platform begins with demographic information about the user's age, living status (own, rent, or shared property), and if they have a carer or not. The next questions are on their mobility status from being able to walk through to using one/two-handed devices or in a wheelchair on bedfast. The questions around the features of the house centred on the: pathway and access to the house, access upstairs, bathroom, shower, and garden. It also includes bath and the use of toilet mobility if it can be done independently or requires some help, the nature of showering (shower and /or bath), and the need for wash and dry toilet.

The disability-friendliness matrix is used to determine home suitability score whether people can age in place based on the functional impact of health/impairment conditions, and Instrumental Activities of Daily Living (IADLs) (Oyegoke et al., 2022). The suitability assessment algorithms rely on a single metric for the severity measurement and the hierarchical scale with equal-interval and interval-level measures (categorised as mild, moderate, and severe) to differentiate different levels of disability. The property's physical features, e.g. house features are unbiased by age, gender, and level of disability. The impairment severity index establishes a person's functional level in the context of their environment (property features) and their personal needs. Figure 3 presents two examples of (i) pathway and access into the house and (ii) help with using the bath and shower. The user can choose the appropriate option, linking the home features with the IADLs through home features analytics.

Insert: Figure 3 Linking the mobility status with IADL

This is used to establish weight modifiers to develop the index core (+ve and -ve) to determine aggregated home suitability scores. The suitability home score will be in percentages, with key demographic information and the possibility to edit the responses as in Figure 4. It also includes

assessment recommendations, and if the user is eligible for a grant through an indicative assessment platform (IAP). This will depend on a low suitability score, and at least one of the home features (based on individual mobility conditions) needs adaptation. The IAP is based on qualification decision options built into the system to establish the qualification requirements on eligibility and resources testing before indicatively advising if the applicant is qualified or not (Oyegoke et al., 2022).

After the appropriate options are selected by the user, the suitability score will show the percentage of the suitability of the property in relation to the user's mobility status and the possibility to view and edit the user's initial responses which will lead to viewing some recommendations on what that needed to be changed to make the house suitable for the user as in figure 4.

Insert: Figure 4 suitability score

The other option is to see if the user is eligible for a grant (eligibility check – indicative assessment). The quantification criteria are used to build the algorithms by factoring the level and nature of the disability, the use of mobility aids, the owner of the property, and if the property is the applicant's main house and in good repair, if the applicant will use it for the next 5 years, etc. The user can then proceed to the indicative decision for eligibility for DGF as shown in Figure 5. There is also an option to progress to an integrated means testing calculator which will lead to an overall indicative decision if the applicant will qualify for the grant.

Insert: Figure 5: The result of eligibility for grant qualification decision

6. CONCLUSIONS

As the population is ageing, the number of aged and disabled people is increasing. The government is also committed to investing £570 million in DFG annually from 2022–2025. However, 81% of households that required adaptations due to their health condition felt their home was suitable for their needs. The DFG process remains fragmented, bureaucratic, and with lengthy procedural steps. Therefore, there is a need to develop a preventive system that can help the aged and disabled to know if their homes are suitable for them and an indicative process that will determine if they are qualified for DFG funds.

The assessment system provides action plans for the users based on the suitability score against their responses. One of the action plans is the system's recommendations against all user responses. The recommendations guide users about what possible adaptations can be made to increase the overall suitability score of the home. These recommendations as textual statements include pictorial representations for enhancing clarity. Assessment systems produce these recommendations using a decision matrix approach. A decision matrix is a method to represent all conditions and their possible alternatives or actions in a tabular structure. All the cases and home features are represented as rows and different mobility categories as columns. The intersection of a row and column called the cell is filled with the rating value. By modelling the decision matrix, the assessment system can derive which recommendations are associated with the mobility category in terms of suitability. Users can print or email the final suitability score and recommendations as a report. In addition to recommendations, the assessment system guides the user to the DFG referral application or evaluates 'staying or moving to another home or informational resources. According to the mobility statutes, these action plans are based on different thresholds of suitability scores.

This paper presents the development of a home suitability assessment and the indicative assessment platform. These two platforms are linked to simplify the process and save time. A severity measurement/assessment matrix determines the effects of key home features. The DFG qualification criteria based on the Housing Grants (Construction & Regeneration) Act 1996 are used to develop. The Entity Relationship Diagram (ERD) technique is used to design data structures and database systems. Validation is done through a workshop and a series of focus group exercises. The assessment system is developed for all platforms, including desktop computers, laptops, mobile, and tablets. The Adapt-ABLE developed tool is recommended for use in the CSJ Disability Commission report, and the UK government Guidance on Disabled Facilities Grants (DFG) for local authorities in England. The assessment platform is one of the platforms in the Adapt-ABLE smart system, further studies can be focused on system integration and technological interoperability to connect different systems, provide an interface between organisations and the system, to exchange, integrate and communicate data with one another.

IMPLICATION OF THE STUDY

These assessment tools are useful for practitioners, homeowners, the elderly, and people with disabilities to understand the suitability of their homes and cut down the application journey. This will mitigate the challenges associated with delays and decisions can be made faster and safely. To support its practical implication in practice, the developed tools have been recommended in the government report and Guidance for local authorities in England. The study contributes to the theoretical understanding of disability grants in the UK and the application of the constructivism research approach to the DFG.

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