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# Reducing care home falls: a real-world data validation of a multifactorial falls-intervention digital application

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## Abstract

**Background** One in three adults over the age of 65 and one in two adults over the age of 80 will experience a fall a year. Falls account for a considerable cost burden for the National Health Services. Preventing falls in elderly care homes is a significant public health policy goal in the United Kingdom. The 2004 National Institute for Health and Care Excellence Clinical Guideline (CG21) recommends risk detection and multifactorial fall prevention interventions. Digital technology allows individualised monitoring and interventions. However, there is no certainty of the impact of multifactorial interventions on the rate of falls.

**Methods** A mixed methods Real-World Validation incorporating a retrospective multi-centre case–control study using real-world data and qualitative study to assess the effectiveness of a falls prevention application in 32 care homes in the Northwest of England. The study aims to assess if a multifactorial fall-prevention digital App reduces falls and injurious falls in care homes. The primary outcome measures were the rate of patient falls per 1000 occupied bed days in care homes for 12 months. A digital multifactorial risk assessment and a tailored fall prevention plan linking each risk factor with the appropriate preventive interventions were implemented/reviewed monthly.

For the intervention group two datasets were used. The first set was data recorded in the App on falls and resulting injury levels, multifactorial risk assessments, and number of falls. Sociodemographic variables (gender and age) of care homes residents were also collected for this group. Data for the first twelve months of use of the intervention were collected for early adopter intervention homes. Less than twelve months data was obtainable from care home adopting the intervention later in the study. The second dataset was constituted by intervention and comparable control anonymised data extracted from the care home residents' registries from Borough 1 Council and Borough 2 Clinical Commissioning Group, including quantitative data on the number of falls, number of injurious falls, and outcomes, with emergency room and hospital records for Borough 2.

For the qualitative study, twelve video interviews conducted by Safe Steps were analysed thematically to identify user perceptions of various aspects of the App including need, development, implementation, use and benefits.

**Results** The secondary outcome was the rate of injurious falls per 1000 occupied bed days. There were 2.23 fewer falls per 1000 occupied bed days in the Intervention group (M = 6.46, SD = 3.65) compared with Control (M = 8.69,

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SD = 6.38) (t(2.67) = -2.686, $p = 0.008$). The intervention had 3.5 fewer low harm injurious falls ratio per 1000 occupied bed days (M = 3.14, SD = 4.08) (M = 6.64, SD = 6.22) (t(144) = -3588, $p < 0.01$). There were significant differences between Intervention and Control on injurious falls resulting in ambulance calls (t(31.18) = -3.09, $p = 0.04$); and patients arriving at Accident & Emergency (t(17.25) = -3.71, $p = 0.002$).

Thematic analysis of the video interviews identified the following six themes: Alleviation of staff workload; the impact of falls on both the individual and on the health care system; achievement of health outcome benefits, including reduced hospital visits for falls and improved quality of life for the patients living in care homes; the improvement over paper-based risk assessments for staff; the uniqueness of the person-centred approach of the App; and the ability of the approach to track patients across boundaries in the health and social care system.

**Conclusions** In this real-world validation, the implementation of a multifactorial fall-prevention digital app was associated with a significant reduction in falls and injurious falls, and was perceived to be highly beneficial by care home residents, staff, management and care commissioners where the approach was implemented.

**Keywords** Real-world data, Falls-intervention, Digital application, Care home, Northwest England

## Background

One in three adults over the age of 65 and one in two adults over the age of 80 will experience a fall a year [1, 2]. The rate of falls in care homes is almost three times that of older people living in the community [1]. Injury rates are also considerably higher, with 10–20% of institutional falls resulting in a hip fracture, and 30% of these coming directly from a care home [1]. Falls can be life-changing for older people resulting in distress, loss of independence, and even death. Public Health England [3] identifies circa 255,000 fall-related hospital admissions with an associated cost of over £2.3 billion per year [4, 5].

While not all falls may require a medical response, the probability of injury from falls increases with age [6]. Some falls may result in bone fractures, with the cost of such fragility fractures in the UK estimated at £4.4 billion per annum. Around 10% of these falls can be prevented by addressing fall hazards in homes [2] and devising individualised fall prevention plans [5]. The 2004 National Institute for Health and Care Excellence (NICE) Clinical Guideline (CG21) recommends risk detection and multifactorial fall prevention interventions, including medication review, physical exercise, diet improvements, vision assessment, environment and other modifications [4]. Recent technological advancements use sophisticated individualised monitoring and evaluation programs for falls prevention [7–9]. These include pattern anomaly detection, multifactorial risk assessments, personalised care plans and fall prevention toolkits. One Cochrane review [10] on interventions for preventing falls in older people in care facilities concluded that there is no certainty of the effect of multifactorial interventions on the rate of falls and suggests that the individualised nature of falls prevention interventions has an important impact on reducing the rate of falls. Studies have reported that using a fall risk-assessment tool compared to care home staff judgement alone probably makes little or no difference to the rate of falls or risk of falling [11]. Recent evidence suggests that the individualised nature of falls prevention interventions significantly reduces the rate of falls [10, 12].

### Context

Working with a local Clinical Commissioning Group (CCG), the Safe Steps App was created to monitor falls and to develop personalised falls reduction plans for care home residents. Care home staff and leadership engaged in the co-design of the App, which facilitated development and adherence to the intervention protocol. The key features of the app include:

A full multifactorial risk assessment enabling early identification of risks;
A personalised fall reduction plan (from 50 + proven interventions) to reduce those risks;
Tracking of actions and interventions to prevent falls;
Collection of evidence on falls when they do occur—to drive continuous improvement; and
A digital audit trail to satisfy regulatory inspection requirements of the CCGs and Care Quality Commission [13].

The aim of this study is to analyse the effectiveness of the Safe Steps App in preventing falls in care homes.

### Intervention

Care home staff use the Safe Steps App to complete a monthly face-to-face multifactorial risk assessment

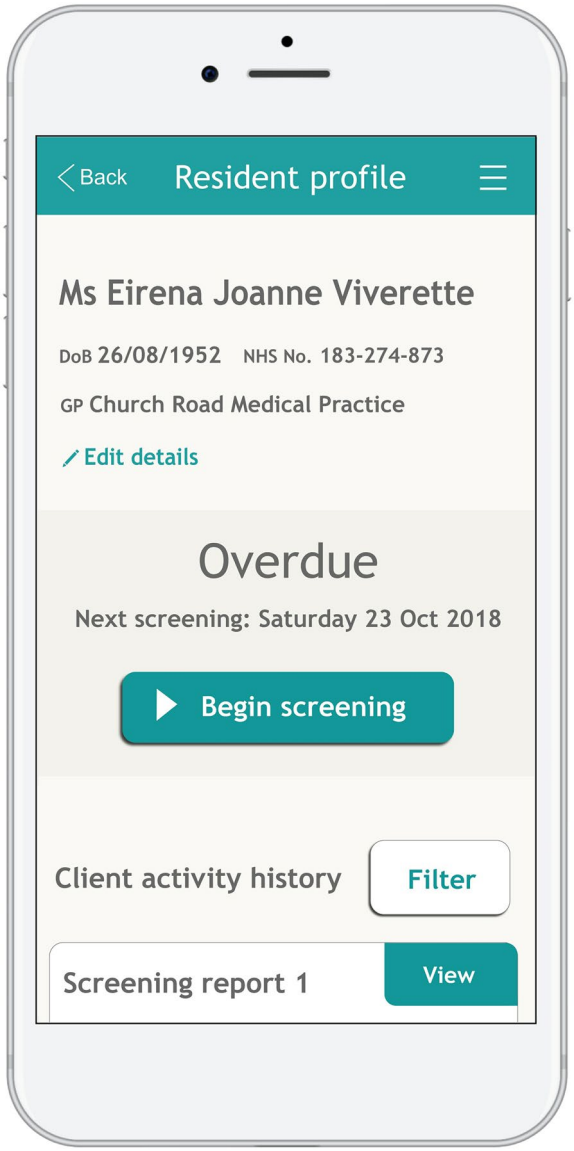


**Fig. 1** Safe Steps mockup care home resident's prevention plan (pseudonym). Source: Safe Steps website

assessing 12 risk-factors[1] for each resident to create an individual fall prevention plan (Fig. 1). The plan links each risk factor with the appropriate preventive intervention out of 50 + proven interventions. The plan is made available digitally in compliance with regulatory requirements [1]. A similar assessment is conducted in the event of a fall, and a multifactorial intervention is included in post-trauma rehabilitation [5]. Further App details are available on the Safe Steps web page [14].

## Methods

The evaluation of Safe Steps was undertaken as a Real World Validation [15] where multiple sets of existing data were analysed to assess the effectiveness of the intervention. Consequently a mixed-methods approach was used to compare the effectiveness of Safe Steps as a digital multifactorial falls prevention intervention in care homes viz a viz the usual care scenario between May 2018 and December 2019. For the quantitative evaluation a retrospective multi-centre case–control study of an interrupted time-series design was used to test the App's effectiveness in 32 care homes in the Northwest of England [16–20]. Intervention care homes were included in the study immediately after starting to use the intervention without any settling-in period [19]. For the qualitative evaluation twelve video interviews conducted by the Safe Steps company were analysed by the researchers to gather qualitative data on the innovation implementation, staff uptake and satisfaction with the innovation at the midpoint and end of implementation. Sixteen individual participants were selected by the company to be representative of key stakeholders and included four care home managers, four care commissioners, a nurse matron, a frailty clinical specialist, a care home staff member and a resident, a digital health senior academic, regional falls provision lead, a programme lead, and a senior Innovation Agency staff member. Members of the Safe Steps development team and a member of senior management were also interviewed. Each participant was interviewed individually to elicit their opinions. Several individuals were included in three montage videos discussing a particular aspect such as how the approach helps to prevent falls or to present a case study of a resident who had fallen in the past. As Real World Validation assesses previously existing evidence rather than collecting new primary data, the video interviews were developed and conducted by the Safe Steps staff and provided to the research team. No further information regarding the duration of the interviews, who conducted them, whether they were semi-structured, or any details regarding any questions asked were available to the researchers.

Thirty-two care homes across two Boroughs implementing the Safe Steps App (Intervention) were compared with thirty-two care homes in the same region that did not use the App (Control) stratified by size and care home type [21]. In Borough 1, a total of fifty-four care homes were included in the evaluation, twenty-seven in each group with twenty-one smaller homes with an average of thirty-five beds, and six slightly larger with an average of thirty-seven beds. In Borough 2 ten care homes

[1] History of falling, blood pressure, medication, long-term conditions, cognition, hearing and vision, diet, continence, foot care, footwear and clothing, beds, seating and transfers, walking abilities and gait, and environment.

were included with four smaller homes with an average of twenty-five beds and one larger home with thirty-eight beds in the intervention group, and four homes with an average of twenty-seven beds and one larger home with thirty beds in the control group. Due to the quality improvement nature of the intervention, all residents in each care home were eligible for enrolment in the study.

The primary outcome measure was the overall rate of patient falls per 1000 occupied bed days (OBD). The secondary outcome was the overall rate of injurious falls per 1000 OBD.

For the intervention group two datasets were used. The first was data recorded in the App on falls and resulting injury levels, multifactorial risk assessments, number of falls. Sociodemographic variables (gender and age) of care home residents were collected for the intervention group in the App. Data for the first twelve months of use of the intervention were collected for early adopter intervention homes. Less than twelve months of data were obtainable from care homes adopting the intervention later in the study. anonymised data extracted from the care home residents' registries for both the intervention and control groups from Borough 1 Council and Borough 2 Clinical Commissioning Group, including quantitative data on the number of falls, number of injurious falls, and outcomes, with emergency room and hospital records for Borough 2. This data set enabled the validation of the Safe Steps App data.

### Analysis

Quantitative data on multifactorial risk assessments, number of falls, and fall outcomes from the App and two Boroughs were entered into MS Excel to clean the data. Descriptive statistics were used to profile the care home residents. Tests of normality (Shapiro–Wilk test) were carried out on multifactorial risk assessments, the number of falls, and fall outcome, and all were normally distributed. Parametric tests (Independent Sample T-test) using IBM SPSS Statistics, Version 25 were applied to three measures; the significance level was set at $p \leq 0.05$.

The video interviews provided by the Safe Steps company were independently analysed by two research team members using thematic analysis. The process involved open coding of the material to identify core categories (themes) and the properties of those categories (sub-themes) using QSR International's N'Vivo Version 11 [22]. There was a high level of agreement, and disagreements were resolved by consensus discussion amongst the research team. This qualitative data was used to substantiate user views on the effectiveness and functionality of the App.

### Missing data

Whilst we are able to report on the primary outcome measure – reduction in falls – for both Boroughs, as no data was available regarding falls outcomes for Borough 1 (ambulance call, ambulance arrival to Accident & Emergency (A&E), and A&E attendance) we are only able to report on the secondary outcome—falls outcomes within Borough 2. Whilst sociodemographic information on care home residents (gender and age) was available in the Safe Steps App, we were unable to obtain the same information for residents of homes not using the App who comprised the Control Group.

### Patient and public involvement

A local Clinical Commissioning Group (CCG), care home staff and leadership engaged in the co-design of the App (Intervention); however, patients or the public were not involved in the design, conduct, reporting, or dissemination plans of our research.

## Results

The Intervention group included 1,221 care home residents. The sociodemographic characteristics of the fallers and non-fallers included in the Intervention group are summarised in Table 1. Safe Steps care homes residents all (100%) have a history of falls. There were no significant differences between fallers and non-fallers for age and gender ($p > 0.05$) across the two Boroughs.

Overall, 319,800 OBD and 2007 episodes of falls per month were analysed for Borough 1; and 112,830 OBD

**Table 1** Care home residents' profiling data from Safe Steps App (January 2018-October 2019) – $n = 1,221$ Source: Safe Steps App

| | | Borough 1 | | Borough 2 | |
|---|---|---|---|---|---|
| | | Mean (SD) | Count (%) | Mean (SD) | Count (%) |
| **Age** | | 85 (10) | | 89 (7) | |
| **Gender** | *Male* | | 298 (31.4%) | | 23 (18.0%) |
| | *Female* | | 652 (68.6%) | | 105 (82.0%) |
| **History of Falls** | *Yes* | | 950 | | 128 |
| **Falls per individual** | | 3 (1) | | 3 (1) | |
| **App screenings per individual** | | 4 (3) | | 3 (2) | |

and 901 episodes of falls per month for Borough 2. Table 2 provides a distribution of falls per month and care home occupancy bed days for Intervention and Control groups for Boroughs 1 and 2.

#### Primary outcome measure

Safe Steps led to a reduction of falls.

In Borough 2 there was a significant average reduction of 2.23 falls per 1000 occupied bed days between intervention group (M = 6.46, SD = 3.65) and control (M = 8.69, SD = 6.38) (t(142.67) = -2.686, $p = 0.008$), as per in Fig. 2.

No significant difference in falls ratio per 1000 OBD was observed between the groups, as seen in Fig. 3.

#### Secondary outcome measure

As previously stated, no data regarding falls outcomes was available for Borough 1. For Borough 2 however, Safe Steps led to a reduction of low harm injurious falls.

The majority (over 90%) of falls recorded on the App resulted in minor injuries. When significant injuries were recorded, those tended to happen to a small percentage of care home residents (less than 4%) and predominantly in the first four falls recorded in the 12-month period. The majority of falls were self-managed within the care home (87.99%), and only 5.19% of falls resulted in A&E attendances.

The intervention group had a statistically significant lower low harm injurious fall ratio per 1000 OBD (M = 3.14, SD = 4.08) compared with the control group in Borough 2 (M = 6.64, SD = 6.22) (t(144) = -3588, $p < 0.01$). There were 35% fewer falls with low harm per 1000 OBD in the intervention group.

There were 5.8% fewer falls in the intervention group that resulted in ambulance calls to the care home (M = 1.33, SD = 0.492) (M = 1.91, SD = 1.62) (t(31.18) = -3.09, $p = 0.04$); 6.2% fewer falls in the intervention group that resulted in ambulance arriving at A&E (M = 0.58, SD = 0.51) (M = 1.20, SD = 1.01) (t(17.25) = -3.71, p = 0.002); and 5.6% fewer falls in the intervention group that resulted in A&E attendance (M = 1.38, SD = 0.921) (M = 1.94, SD = 1.34). There were, however, no significant differences between intervention and control groups in Borough 2 concerning falls that resulted in A&E attendance (t(290) = -1.87, $p = 0.61$) (Fig. 4).

#### User perceptions

Six themes were identified during the analysis of the video interviews: workload alleviation, falls impact, health outcomes, transition from paper-based system, uniqueness of Safe Steps, and system integration. Whilst four users noted how Safe Steps could alleviate staff workload, one noted that as Safe Steps was considering "strength and balance, and coordinating all different areas that prevent falls, regarding footwear, high care, health and safety, nutrition, hydration. All these areas put together in a tool like Safe Steps will really make the difference".

The impact of falls on both the individual and on the health care system was noted by four individuals in three interviews. One stated "If we look into falls as a proxy measure of frailty. Frailty is one of the things that cost us the most in the NHS. Falls as a precursor, a fraction of the femur or a neck can cost anything between £16–40,000 in one incident. We want to prevent those incidents from ever happening in the first place. If this works as well as we hope it'll work, it'll save NHS millions". How these health outcome benefits could be achieved was discussed by five individuals in three interviews where one noted that benefits could include "reduced hospital's admissions for falls, reduce A&E attendance from falls, fewer ambulance calls from care homes, improve quality of life outcomes for the patients living in care homes".

One interviewee noted that they had "a number of homes that don't do falls risk assessments" and another commented that the "paper-based is quite long and this one it's much more straight forward", consequently six individuals in two of the interviews felt that the App approach would be beneficial, and further two noted their "excitement" and how the approach was "radical" in how they addressed safety.

**Table 2** Distribution of falls per month, care home occupancy and number of residents by intervention and control group for Boroughs 1 and 2

| **Borough 1** | **Intervention (*n* = 27)** | **Control (*n* = 27)** | **Total** |
|---|---|---|---|
| Fall per month *(n)* | 806 | 1201 | 2007 |
| Care Home Occupancy per month *(mean)* | 36 (SD 16) | 35 (SD 14) | 35 (SD 15) |
| Total number of residents *(n)* | 162 | 187 | 349 |
| **Borough 2** | **Intervention (*n* = 5)** | **Control (*n* = 5)** | **Total** |
| Fall per month *(n)* | 266 | 635 | 901 |
| Care Home Occupancy per month *(mean)* | 796 (SD 175) | 761 (SD 99) | 773 (SD 131) |
| Total number of residents *(n)* | 50 | 96 | 146 |

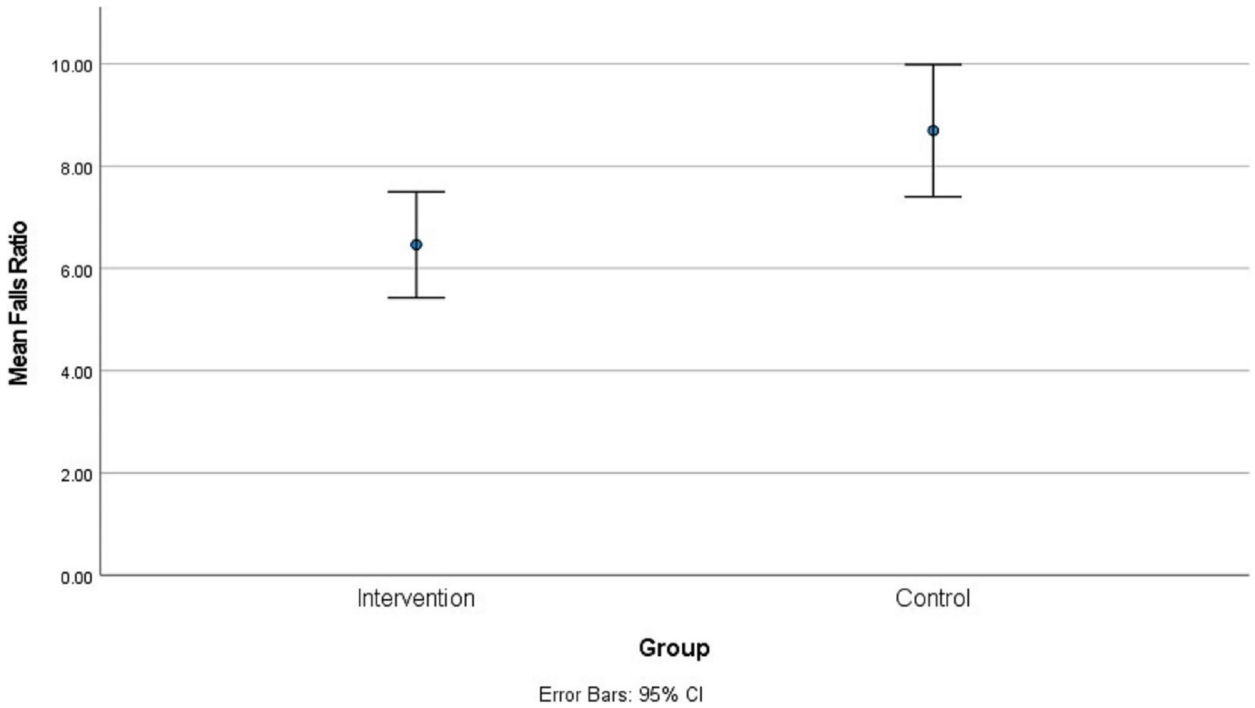


**Fig. 2** Mean of falls ratio per 1000 OBD in Borough 2. Source: Boroughs 2 CCG

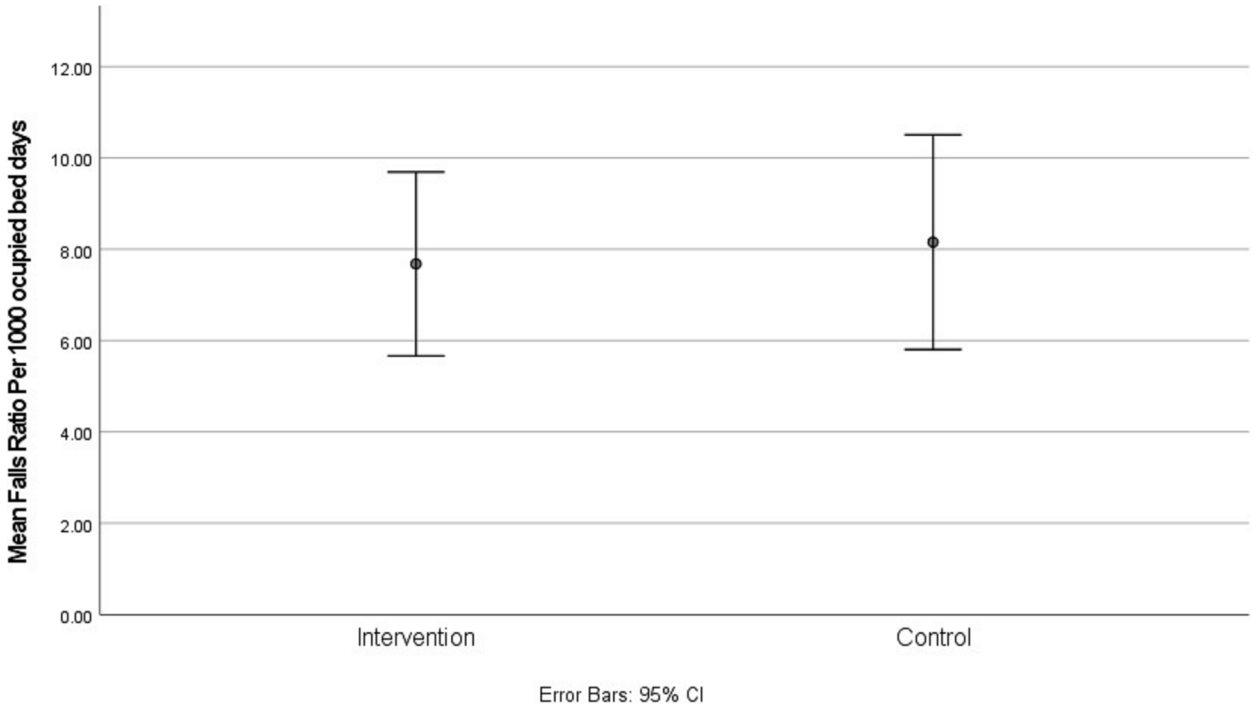


**Fig. 3** Mean of falls ratio per 1000 OBD in Borough 1. Source: Boroughs 1 City Council

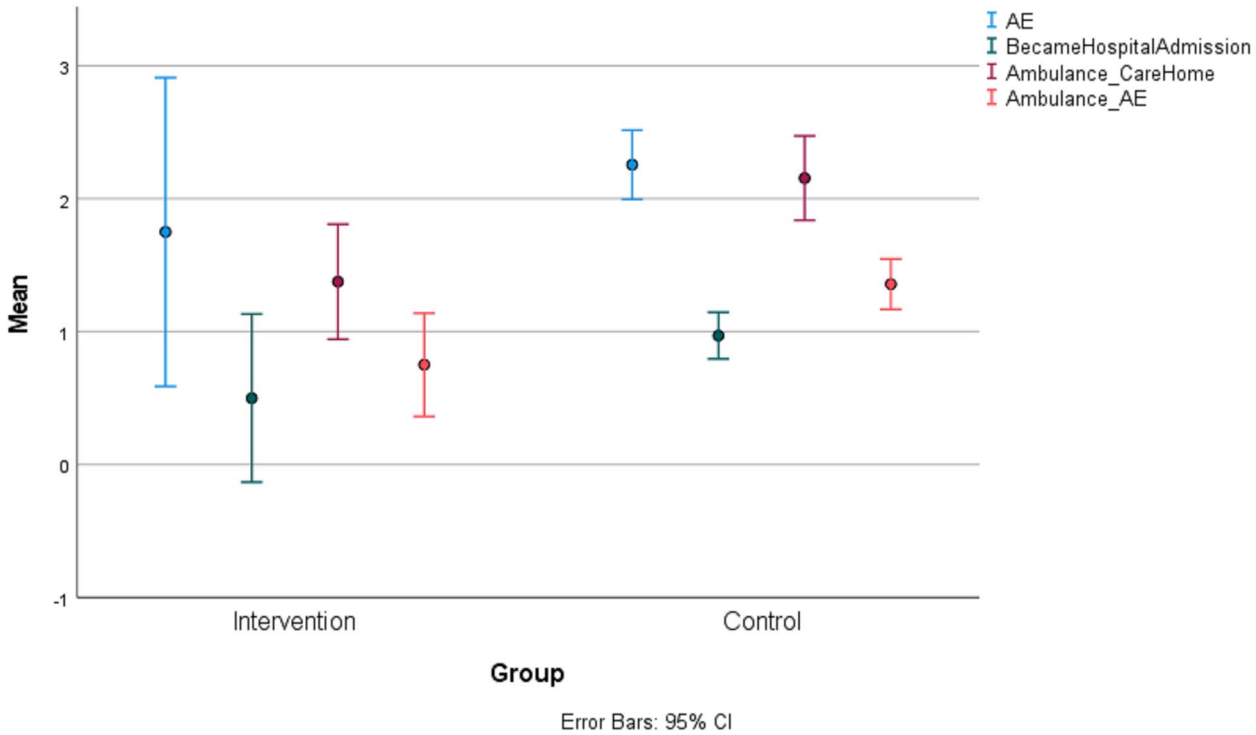


**Fig. 4** Mean comparison of A&E attendance, Hospital admission, Ambulance calls to care home, and Ambulance arrival to A&E in Boroughs 2. Source: Boroughs 2 CCG

Addressing how the Safe Steps App can be used across the health system and, four individuals in two interviews noted the individual level approach with one stating "Safe Steps can actually follow the patient around the system".

Finally, the uniqueness of the Safe Steps approach was noted by four individuals in two interviews. The person-centred approach was again highlighted as being able to "monitor that patient, see where s/he is going and hopefully we'll be able to see a fall reduction in these patients".

## Discussion

In our evaluation of the Safe Steps risk assessment and multifactorial fall-prevention digital App the intervention group mean age was 85 and all reported recurrent falls in the previous year; 50% more than the average number of fallers over 80 years of age reported by NICE [4]. There were 22.30% fewer falls in the intervention group (relative risk 95% confidence interval 95%). This finding differs from the Cochrane review that found no difference in the rate of falls and risk of falling between multifactorial interventions and control in older people living in care homes [10].

There is evidence that multifactorial interventions are associated with reduction in the rate of falls [23, 25–27]. Similarly, evidence supports the use of digital individualised falls prevention interventions [28]. However, only weak evidence is available regarding the impact of tools that combine both assessment and the risk of falling or the rate of falls [1, 3, 23, 24].

We found Safe Steps to be associated with a reduction in lower harm injurious falls and a reduction in injurious falls resulting in ambulance calls to the care home, an ambulance arriving at A&E, and A&E attendance. This study's findings support a digital intervention's added cost and outcomes benefits and suggest that Safe Steps can contribute to positive financial return on investment for the health care system.

As found in another study [29], moving from a paper-based system to a digital strategy, the intervention alleviated the administrative workload associated with assessing and logging multifactorial assessment of the risk of falls and recording falls incidents and falls outcomes. The digitalisation of the falls prevention strategies in care homes was part of a broader objective of health and social care systems integration as a priority policy for the NHS [2] and for the Boroughs in our study. Like other studies [30, 31], the integrated systems approach of this intervention fitted with the concept of improving the health outcomes, quality of care, quality of life, safety and patient experience of the older residents of these boroughs. The use of this systematic approach to falls risk-assessment and falls prevention highlighted

the deficiencies of the existing approaches used and data available in 'standard' care [3].

### Strengths & limitations

As identified in the interviews, the intervention described above is neither complex nor time-consuming, can be easily integrated into the care home practices, and supports digitalisation and care quality improvement quality agendas for UK health and social care systems [2].

This study has some limitations, in part due to conducting a Real World Validation study where the data available to conduct the study were provided by third parties. Conducting such studies requires the use of retrospective study design. Our multisite evaluation is a strength of this study which included 32 care homes spread across two boroughs of the Northwest of England, making our findings more representative of the general population and reducing the potential for selection bias. The study included a high number of patients and a high volume of falls per 1000 OBD, which corroborates the value to generalise Safe Steps. The engagement of care home leadership and staff in the co-design of the digital App was important for incorporating the intervention into the care home practice and guaranteeing high levels of fidelity and sustainability.

Our main limitation for the quantitative analysis was the limited access to pre-intervention data. Methods in the early phases of this project included pre-post intervention design [19]. The research team tried to overcome this limitation by adjusting the methodological design to an intervention-comparison group analysis using secondary data provided by Borough 2 CCG and Borough 1 City Council. As we were unable to obtain the real-world data on ambulance calls, ambulance arrival to A&E, and A&E attendance associated with falls in care homes for Borough 1, we are only able to provide statistically significant differences for these three outcomes for Borough 2. There was a lack of detail in the real-world data regarding older people with cognitive impairment. The track record of implementation of the intervention to date has been poor. Each care home incorporates Safe Steps into their care routine, and real-world and App data did not capture the nuances of the intervention implementation in each care home.

For the qualitative analysis, where evidence is generated and provided by third parties, there is an inherent risk of bias where incomplete interviews are collated for marketing purposes. There is also the potential for a non-independent interviewer to hold some influence on an interviewee depending upon their relationship. The provision of several complete, unedited video interviews, rather than transcripts that may be edited before being submitted, reduced these risks, however their scope and depth were limited when compared to that typically obtained during an academic-led qualitative study.

Despite these limitations, the research team analysed the available data with rigour producing reliable outputs. Future research is needed to understand better the benefits and cost-benefits of risk assessment and multifactorial fall-prevention digital apps in reducing the rate of falls and fall-related injuries in care homes. Although the study design did not allow for perfect comparability between intervention and control, its findings are robust enough to inform the effectiveness of Safe Steps in real-world care home environments to prevent falls and injurious falls. Although, a more extensive real-world validation is needed to fully evaluate generalizability.

## Conclusion

Safe Steps was designed to facilitate the digitalisation of falls prevention plans and to enable the integration of these plans into existing care home workflows. Our findings contributes to the body of falls literature by providing the first evidence that a tool that combines both assessment, using an individualised fall-prevention plan, and implementation, in the form of a digital multifactorial fall-prevention intervention, is associated with falls reduction when is consistently implemented and incorporated into care home residents' care program over an extended period (i.e., 12 months or longer). Care commissioners who contracted the Safe Steps intervention for the care homes in their boroughs, care home managers and their staff agree on the usability and efficiency of the App to enable care homes to digitalise, standardise and improve their falls prevention strategy. These stakeholders believe that the App will play a key role in supporting the integration between social and health care systems ultimately leading to an improvement in the health outcomes, quality of care and quality of life of older adults. Consequently this App has been embedded within the care planning of the case study sites.

### Recommendations & next steps

To achieve and demonstrate more significant reductions in falls ratios, falls risks, and financial costs may require careful consideration of the impact of variances in such factors as the quality of care, home facilities and the level of staff training. Staff training in completing the assessments needs to be of a sufficiently high standard. There may need to be a risk stratification of fall-prone individuals who will most benefit from assessment and intervention [4]. Safe Steps would also benefit from integrating a falls ratio calculation within the App dashboard to report the impact of the intervention in each care home accurately, and the provision of an upskilling training programme for care home staff, guaranteeing the skills to implement the interventions set out in a resident's action plan are in place.

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**Data sharing statement**
Anonymised Safe Steps App usage data, and control group anonymised data extracted from the care home residents' registries was shared with the research team by Safe Steps, from Borough 1 Council and Borough 2 Clinical Commissioning Group.

**Authors' contributions**
RNG contributed to the design of the study, performed data collection, analysis and interpretation, and drafted the article; DF contributed to the design of the study, and revising the article providing critical intellectual content; GS acquired the funding for the study, contributed to the design of the study and provided revisions to the article; AM contributed to the design of the study and provided revisions to the article.

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**Availability of data and materials**
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Ethics approval and consent to participate**
All methods were carried out in accordance with the Declaration of Helsinki, relevant guidelines and regulations. Ethical approval was provided by the Liverpool John Moores ethics committee. The requirement for written informed consent waive was approved by a Liverpool John Moore University Research Ethics Committee (UREC reference: 21/NAH/008), because individual information was analysed anonymously.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare no competing interests.

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