

Reducing falls among community-dwelling older adults from clinicians' perspectives: A systems modelling approach

Vanessa Koh Jean Wen^{1,2}; vanessa.kjw@u.duke.nus.edu

David B. Matchar^{1,3,4}; david.matchar@duke-nus.edu.sg

Angelique Chan Wei-Ming^{1,2,4}; angelique.chan@duke-nus.edu.sg

Lee May Ling June²; june_lee@duke-nus.edu.sg

Lai Wei Xuan¹; laiweixuan@u.duke.nus.edu

Dulcie Rosario²; dulciorosario@gmail.com

Anne George⁵; anne_george@cgh.com.sg

Vanda Ho⁶; vanda_wt_ho@nuhs.edu.sg

Noor Hafizah Bte Ismail⁷; noor_hafizah@ttsh.com.sg

Christopher Lien Tsung Chien⁸; christopher.lien.t.c@singhealth.com.sg

Reshma A. Merchant⁹; mdcram@nus.edu.sg

Tan Shuyan Melissa⁵; shu_yan_tan@cgh.com.sg

Wong Chek Hooi¹; chekhooi@yahoo.com

Xu Tianma¹⁰; Tim.Xu@SingaporeTech.edu.sg

¹Programme in Health Services and Systems Research (HSSR), Duke-NUS Medical School, Singapore 169857, Singapore

²Centre for Ageing Research and Education (CARE), Duke-NUS Medical School, Singapore 169857, Singapore

³Department of Medicine (General Internal Medicine), Duke University Medical Center, 3116 N Duke St, Durham, NC 27704, USA

⁴Singapore-ETH Centre, Future Health Technologies Programme, CREATE campus, 1 CREATE Way, #06-01 CREATE Tower, Singapore 138602

⁵Rehabilitation Services, Changi General Hospital, 2 Simei St 3, Singapore 529889, Singapore

⁶Department of Geriatric Medicine, National University Hospital, 5 Lower Kent Ridge Rd, Singapore, 119074, Singapore

⁷Geriatric Medicine, Tan Tock Seng Hospital, 11 Jln Tan Tock Seng, Singapore 308433, Singapore

⁸Department of Geriatric Medicine, Changi General Hospital, 2 Simei St 3, Singapore 529889, Singapore

⁹Division of Geriatric Medicine, Department of Medicine, National University Hospital, 1E Kent Ridge Road, Singapore 119228, Singapore

¹⁰Health and Social Sciences Cluster, Singapore Institute of Technology, 10 Dover Dr, Singapore 138683, Singapore

Corresponding author:

Vanessa Koh Jean Wen

Health Services and Systems Research

Centre for Ageing Research and Education

Duke-NUS Medical School, Singapore

8 College Road

Singapore, Singapore 169857

vanessa.kjw@u.duke.nus.edu

Author contributions

V.K: conceptualisation and design of the study; V.K, D.B.M, A.C, L.W.X: facilitated the workshop; V.K, L.M.L.J, D.R: data collection; V.K, L.M.L.J, L.W.X, D.R: analysed and interpreted data; V.K: writing – original draft preparation; L.M.L.J, L.W.X, D.R, D.B.M, A.C: writing – review and editing; D.B.M, A.C: supervision and funding acquisition; A.G, V.H, N.H.B.I, C.L.T.C, R.A.M, T.S.M, W.C.H, X.T: resources, writing – review and editing. All authors have read and reviewed the manuscript.

Funding

This research is supported by the Centre for Ageing Research & Education (CARE), Duke-NUS Medical School.

Acknowledgements

This research is supported by the National Research Foundation, Singapore under its Campus for Research Excellence and Technological Enterprise (CREATE) programme, and ETH Zurich. The authors would also like express gratitude to the Centre for Ageing Research & Education (CARE) at Duke-NUS Medical School. Data collected for the study can be made available upon reasonable request and permission from CARE at Duke-NUS Medical School.

Conflict of Interest

The authors do not have any conflicts of interest. A part of this work has been presented at the 18th Biennial European Conference of the Society for Medical Decision-Making (21-23 May, 2023).

Abstract

Background and Objectives: Falls among older adults are a significant health problem globally. Studies of multicomponent fall prevention programmes in randomised controlled trials demonstrate effectiveness in reducing falls, however, the translation of research into the community remains challenging. While there is an increasing interest to understand the factors contributing to implementation barriers, the dynamic relationships between factors are less well examined. Furthermore, evidence on implementation barriers from Asia is lacking as most of these studies originate from the west. As such, this study aims to engage stakeholders in uncovering the factors that facilitate or inhibit implementing community-based fall prevention programmes in Singapore, with a focus on the inter-relationship between those factors.

Research Design and Methods: Healthcare professionals familiar with fall prevention programmes were invited to discuss the enablers and challenges to the implementation. This effort was facilitated using a systems modelling methodology of Group Model Building (GMB), to share ideas and to create a common conceptual model of the challenges. The GMB employs various engagement techniques to draw on the experiences and perceptions of all stakeholders involved.

Results: This process led to the development of a Causal Loop Diagram (CLD), a qualitative conceptual model of the dynamic relationships between the barriers and facilitators of implementing fall prevention programmes. Results from the CLD show that implementation is influenced by two main drivers: healthcare provider factors that influenced referrals, and patient factors that influenced referral acceptance and long-term adherence. Key leverage points for potential interventions were identified as well.

Discussion and Implications: The overall recommendation emphasised closer coordination and collaboration across providers to ensure sustainable and effective community-based fall prevention programmes. This has to be supported by a national effort, involving a multidisciplinary stakeholder advisory group. These findings generated would be promising to guide future approaches to fall prevention.

Keywords: Accidental falls; Fall prevention; Prevention; Implementation; Systems dynamics; Group model building

Introduction

Falls among community-dwelling older adults are a significant health concern globally. About 1 in 3 older adults above the age of 65 fall annually, with 10% of fallers suffering from recurrent and injurious falls respectively^{1,2}. Falls are associated with many adverse consequences, including fear of falling, functional decline, reduced quality of life, and prolonged risk of hospitalisation^{1,3}.

Studies have shown that multicomponent fall prevention programmes are a comprehensive and effective way to prevent falls in older adults^{4,5}. A recent meta-analysis of 192 randomised controlled trials demonstrated that multifactorial interventions were associated with a 13% reduction in falls rate compared to the usual care⁴. Exercise-based fall prevention programmes such as Otago⁶ and Stepping On⁷ have demonstrated effectiveness in reducing falls. In Singapore, previous exercise-based interventions such as SAFE have also demonstrated effectiveness in reducing injurious falls⁸.

While the evidence from research supports the effectiveness and efficacy of fall prevention programmes, implementing and sustaining these initiatives in the community is challenging^{9,10}. A key challenge is that activities central to the programmes are carried out in multiple settings (e.g., in the community or outpatient medical care), and by multiple providers (e.g., doctors, physiotherapists, and trainers in programme centres) in an uncoordinated and fragmented manner¹¹. As such, the quantity and quality of fall prevention programmes, coordination among healthcare providers and patient factors influence the success of interventions^{12,13}.

It seems clear that the potential impact of fall prevention programmes is constrained by implementation barriers. While these implementation barriers have been increasingly studied¹⁴⁻¹⁶, the dynamic relationships between factors have not been explored. Understanding the dynamics between factors would provide insight into designing specific solutions to overcome challenges. The systems dynamics approach has been increasingly recognised as a powerful method to understand complex health issues¹⁷. This approach is suitable to visualise the relationships, feedback mechanisms and identify key leverage points for interventions¹⁷. A system dynamic modelling of the implementation of fall prevention programmes looks to incorporate the facilitators and barriers to reducing falls, which include healthcare providers' processes, health-related resources, and patient-related factors. In addition, implementation barriers may be unique to different regions and countries. Currently, studies on the implementation barriers are mostly from the west^{18,19}, making it vital to investigate the challenges in translating research into practice in an Asian context. As Singapore is a multi-ethnic country with a developed healthcare system, findings from this study will provide a unique and comprehensive insight into the implementation challenges in an Asian setting. These would be useful to inform the development and implementation of future fall prevention programmes.

This research aims to engage key stakeholders familiar with fall prevention through a system dynamics modelling methodology, Group Model Building (GMB). GMB is a participatory approach used to engage stakeholders, reach a consensus, and build a shared understanding of the system²⁰. As healthcare professionals oversee patient care, they would be familiar with issues regarding the effectiveness of programmes and feasibility issues during implementation. Hence, we aim to engage healthcare professionals to examine the nature of implementing fall prevention programmes in

Singapore and highlight important factors and relationships within the systems. Finally, a shared mental model of the barriers and facilitators of implementing fall prevention programmes will be generated to visualise the complexities and feedback perspectives to inform future interventions.

Methods

Group Model Building (GMB) has been increasingly used in health systems research to understand the complexities of policy initiatives, community-based programmes, and mechanisms of primary care in health and chronic disease prevention^{21,22}. The complex nature of the problem requires the development of shared mental models to gain a whole system perspective. GMB is a participatory form of systems dynamics modelling that engages stakeholders and facilitates understanding of relationships that determine system behaviours²³. Through formal exercises during the GMB, the dynamics of implementing fall prevention programmes were explored, and a conceptual model was created after the session. The GMB utilises activities from ScriptMap²⁴, which are formal exercises carried out to engage stakeholders to elicit variables, hypotheses, and the structure of conceptual models. Suitable scripts were selected based on the objectives of the GMB session.

Outcome

The outcome of the GMB was to develop a qualitative model elucidating the facilitators and barriers in implementing fall prevention programmes. The model aims to describe older adults' engagement in community-based fall prevention programmes, which include outpatient clinics, primary care settings and other institutions that host community programmes such as senior care centres and community centres.

Setting

The research team conducted a half-day workshop at Duke-NUS Medical School, Singapore on November 2022. Sixteen clinician-scientists, clinicians, researchers, and allied health professionals attended the GMB session. They represented the following institutions: National University Hospital, Tan Tock Seng Hospital, SingHealth Community Hospital, Changi General Hospital, Singapore Institute of Technology and the Geriatric Education and Research Institute (GERI). These stakeholders included six medical doctors, two physiotherapists, one occupational therapist and seven researchers. All stakeholders consented to audio recordings and photography during the session.

Design

Group activities were conducted with stakeholders during the workshop. Exercises were planned based on suitable scripts from ScriptMap and were facilitated by three research team members^{22,25}. The activities were designed to promote participation and discussion from stakeholders. This process involved stakeholders building on each other's ideas to enhance their shared understanding of the factors influencing the implementation of fall prevention programmes in Singapore. The half-day GMB was divided into two sessions, with a break between sessions. The first session focused on variable elicitation – where stakeholders were asked to list the variables that facilitated or impeded the effective implementation of fall prevention programmes. In the second session, stakeholders were asked about their policy recommendations and other plausible recommendations that could address the barriers identified. During these exercises, facilitators also explored and clarified definitions and the interdependencies among the factors. The GMB exercises conducted were summarised in

Supplementary Table 1. Finally, a qualitative causal loop diagram was developed based on the in-depth discussions from the GMB.

GMB Exercises

Three exercises formed the basis of the workshop. After introducing the agenda and icebreaker activities, the stakeholders were engaged in the following activities: outcome elicitation, variable elicitation and exploring policy options.

Exercise 1: Outcome Elicitation

In this exercise, stakeholders were asked to elicit key outcomes of fall prevention programmes they were interested in to assess the effectiveness of programmes. Stakeholders were presented with the question: “What are the key outcomes are you interested in when addressing falls?” In a round-robin fashion, stakeholders shared one outcome at a time and the process was repeated for all individuals. The facilitators of the workshop clarified definitions and identified how they could be measured. At the end of the activity, stakeholders were asked to prioritise key outcomes of interest (Supplementary Figure 1).

Exercise 2: Variable Elicitation

The objective of this exercise was to elicit causal factors influencing implementation issues surrounding fall prevention programmes. A guiding question was used to facilitate the discussion: “Based on your own experiences, what are the factors that promote or hinder the implementation of fall prevention programmes?” Stakeholders were asked to list all the facilitators and barriers influencing the effective implementation of fall prevention programmes based on their personal experiences. Stakeholders were given post-it notes to list down the variables, with one variable per post-it note. After which, in a round-robin fashion, individuals were allowed to present one factor they indicated. Facilitators probed to clarify the definition and causal relationships of variables. A variable is clearly described when a coherent story and hypothesis can be made of the variable, and its cause and effect on effective implementation can be explicated. This process was repeated for all stakeholders and variables presented. After clarification, each factor listed on a post-it note was affixed onto a wall. The research team then clustered the variables into eight groups: patient attitude, patient knowledge, patient perceptions, accessibility of programme, availability of the programme, characteristics of the programme, community building and family and societal norms (Supplementary Figure 2).

Exercise 3: Exploring Policy Options

The objective of this group exercise was to identify leverage points for intervention and discuss possible policy recommendations. Like the previous exercise, stakeholders were asked a guiding question: “What are some recommendations that can help increase the success of fall prevention programmes?”. Stakeholders discussed recommendations as a group and were asked to clarify how that recommendation impacted the facilitators and barriers previously identified, and how that related to older adults’ participation and engagement in fall prevention programmes. They were also asked to provide examples or anecdotes of the recommendations suggested. When the variable has been clarified, the facilitator wrote the variable on a post-it note and affixed it to the wall to indicate that consensus has been achieved. This process was repeated for all variables discussed during this exercise. The policy recommendations identified are presented in Supplementary Figure 3.

Causal Loop Diagram

A qualitative causal loop diagram (CLD) was developed by the research team using the variables elicited from the GMB. An overview of the variables is presented in Supplementary Figure 4. A CLD was selected to represent feedback loops and interpret underlying dynamics between variables and their effect on older adults' engagement in fall prevention programmes. The preliminary model was also shared with stakeholders to ensure variables and relationships elucidated were consistent with their shared understanding.

Essential to systems dynamics is the idea that systems behaviour emerges as reinforcing and balancing feedback loops that propagate or counterbalance the feedback system^{26,27}. This is dependent on the interactions of the variables within the feedback system. A reinforcing loop is described when the effect of a change amplifies other variables within the loop, where the increase of a variable leads to a further increase in itself. On the other hand, a balancing loop is described when the increase of a variable counteracts itself, leading to a decrease in the variable. The changes in the variables are described by polarities on arrows, where a positive sign '+' indicates a direct relationship and a negative sign '-' indicates an inverse relationship. Symbols found in a typical CLD is summarised in Supplementary Table 2.

Results

This section describes the conceptual model developed with stakeholders. The conceptual model is divided into two sectors: (1) healthcare provider factors influencing clinicians' referrals and (2) patient factors influencing joining and engaging in programmes from clinicians' perspectives. Figure 6 illustrates the full CLD, and Table 1 summarises the key feedback loops.

Healthcare provider factors influencing clinicians' referrals

Two loops illustrated how healthcare provider factors influenced the rate of referrals from healthcare professionals (HCPs) (Figure 1). Stakeholders identified that the main driver of referral rates made by HCPs is the availability of evidence-based fall prevention programmes. However, with more participants in programmes and limited resources available, this may negatively affect the availability of programmes (B1). The stakeholders expanded on the factors affecting the availability of evidence-based fall prevention programmes. They included: (1) the availability of tailored components, (2) infrastructure, and (3) manpower. Some examples of tailored components include vision and auditory management, medication reconciliation and cognitive training that can be recommended to patients specific to their condition, on top of regular exercise. ***Stakeholders mentioned that one-stop tailored components were not widely available in community-based fall prevention programmes in Singapore. A physiotherapist stated that a diverse range of components should also be available at different programme centres for customisations to be made based on the patient's condition. A geriatrician also noted that there is a lack of integrated programmes that begin interventions from home, and progress into centre-based programmes as patients improve.*** The necessary infrastructure such as equipment and facilities, and trained manpower should be available to increase the availability of evidence-based programmes as well.

Stakeholders identified other factors affecting the rate of referrals from HCPs. They are (1) clinicians' perception towards fall prevention programmes and (2) clinicians' awareness of programmes they can refer to. Stakeholders mentioned that not all doctors prioritise fall prevention in the clinic due to competing demands and time constraints. ***A doctor shared that nurses often ask questions regarding falls when triaging older patients, and patients with fall risk will be identified with a sticker. The main intention of this simple fall risk screening was to ensure that high-risk patients are closely supervised to prevent falls within the hospital. However, it is up to the doctor's discretion to evaluate the fall risk.*** As such, many patients may not be referred to fall prevention programmes should doctors choose to focus on other competing health needs. Furthermore, this workflow is often not known to other specialities beyond geriatric medicine. Several doctors also shared that available programmes are poorly referred by clinicians, or that doctors are often unaware of the programmes they can refer patients to besides physiotherapists.

The reinforcing loop R1 describes how the performance of fall prevention programmes leads to greater investments and resources for fall prevention programmes, which can eventually increase performance. The performance of fall prevention programmes is defined as the overall experience of the programme, which includes programme efficacy and patient satisfaction. Investments in fall prevention capacity are driven by (1) funding from national agencies and (2) co-payment by individuals. Funding from national agencies is determined by meeting corporate key performance indicators (KPIs). ***Stakeholders shared that due to the way KPIs are structured, physiotherapists may have to discharge patients for more patients to enter programmes.*** Premature discharge may result in a future fall which suggests the poor performance of the fall prevention programme. Hence, there may be competing priorities among providers (KPI-driven vs person-centred care), and current KPIs may negatively reflect the performance of programmes. In addition, co-payment by individuals is determined by patients' willingness to pay for programmes. This is influenced by patient factors, such as (1) patients' value perception of fall prevention programmes and (2) the cost of programmes.

Patient factors influencing participant engagement in fall prevention programmes

Three feedback loops define ways self-efficacy can lead to accepting referrals and adhering to fall prevention programmes (Figure 2). Older adults' self-efficacy for programmes determines their response towards doctors' referrals to fall prevention programmes (R2), as well as their consistent adherence to the programme (R3). Their self-efficacy for programmes is influenced by: (1) their intrinsic motivation for recovery, (2) exercise self-efficacy and (3) fear of falling. ***Stakeholders shared that patients who readily join programmes and adhere to them typically prioritise exercise and embrace the idea of healthy ageing. On the other hand, those who are averse to joining programmes have low exercise self-efficacy and are afraid of falling.*** Stakeholders also identified that family support is one of the key drivers of older adults' self-efficacy (R4). Informed family members can encourage, supervise, and support older adults' enrolment into programmes. This increased social support can strengthen older adults' belief in their abilities to carry out programmes, promoting the rate of accepted referrals and long-term adherence. However, overprotective caregivers may restrict older adults from joining programmes for fear of a future fall.

Promotion through word of mouth affect the rate of older adults accepting referrals into programmes (Figure 3). ***Stakeholders shared that being labelled as a faller is stigmatised among older adults in***

the community. They explained that older adults actively avoid being labelled as a faller as it is perceived to be associated with old age. However, with more participants in fall prevention programmes, and promoting the programme, this may be impactful in reducing the stigma on fall prevention programmes and changing older adults' value perception. A shift in value perception promotes a change in health behaviour, leading to more older adults accepting referrals to join programmes (R5). The promotion of the programme through word of mouth is also directly affected by the overall performance of the programme. With more participants, it may result in a lack of resources to run programmes, negatively affecting its performance. This may decrease promotion through word of mouth and eventually result in fewer participants accepting referrals (B3).

Patients' value perceptions are influenced by fatalistic beliefs about ageing and patient attitudes toward fall prevention programmes. **Falling is perceived as part of ageing and that it cannot be prevented, hence older adults see no real value in participating in fall prevention programmes.** Such fatalistic beliefs are entrenched at a community level and affect individual views on falls and fall prevention programmes. Additionally, patient attitudes are affected by their awareness of their own fall risk, awareness of the severity and consequences of a fall, as well as their knowledge of fall prevention programmes. **Stakeholders hypothesise that health literacy plays an important role in shaping patient attitudes, as they observed that patients who are typically more educated have a better understanding of fall prevention.** Furthermore, should participants feel that programmes do not align with their expectations (i.e. too intensive, or too manageable), participants may not perceive the value of programmes too.

Stakeholders also emphasised the importance of good group dynamics in directly influencing adherence to programmes (Figure 4). Good group dynamics would promote adherence to programmes (R6). However, with more participants joining programmes, this may negatively affect group dynamics due to groups being formed with participants with clashing personalities, preferences, and languages (B2). Group dynamics are influenced by (1) peer involvement, (2) community-centric class set up and (3) language barriers. Peer involvement in the form of peer-led facilitators can help build group cohesion. **Stakeholders identified that there are differences between peer-led versus trainer-led programmes, and different groups may prefer different methods.** Nonetheless, having peer involvement inculcates a strong sense of ownership which can promote adherence to programmes. A community-centric class design also promotes participant adherence to programmes. **Two stakeholders shared that in a previous fall prevention study, there was a space allocated for participants to interact before and after the programme. They mentioned that such a design not only encourages good group dynamics but facilitated the formation of social networks.** These show that creating a socially conducive environment, where older adults feel connected can influence adherence to fall prevention programmes. Lastly, language barriers impede group dynamics due to the lack of communication and operational challenges. **Stakeholders shared that in group settings, oftentimes, participants who communicate in different languages would exercise separately from the main group with a help of a translator by the side.** Hence, language barriers may discourage adherence to programmes due to poor group dynamics.

Lastly, the affordability and accessibility of programmes influence both participants joining fall prevention programmes and adhering to programmes (Figure 5). Stakeholders mentioned that there is a barrier to entry to certain types of programmes due to cost. **For example, home-based**

programmes are usually more expensive, hence may dissuade potential participants who were willing to join programmes but would prefer to do so in the comfort of their homes due to mobility issues or personal preferences. Furthermore, a geriatrician mentioned that household means-testing can sometimes make access to centre-based exercise programmes more expensive as well. Accessibility of programmes is influenced by: (1) the availability of accompanying caregivers, (2) distance to the programme centre, (3) inappropriate urban outdoor environment, and (4) COVID-19 disruptions. According to the stakeholder group, older adults tend to be reliant on their caregivers for decision-making, financial support, and mobility. **However, stakeholders have also noted that not all older adults require an accompanying caregiver. The younger older adults (i.e. 60-74 years old), tend to be more educated, are able to travel to programme centres and make decisions independently.** Distance is a huge factor in influencing the accessibility of programmes. The closer the programme centre is to the older adults' place of residence, the more likely they are to participate. This is due to mobility issues, convenience and time saved. Moreover, the urban outdoor environment is also another barrier to accessing programmes. The current outdoor environment is not mobility-aid friendly, and this discourages older adults from going out. And most recently, disruptions due to COVID-19 measures are a barrier to participation. In line with public health measures, group activities have been suspended especially in the early days of the pandemic. **Stakeholders explained that after avoiding group activities for almost two years, some older adults unwilling to participate in group exercise activities again.**

The GMB exercise generated three major insights. Firstly, the performance of fall prevention programmes can promote greater investments and resources to run programmes. This can result in the greater availability of one stop comprehensive person-centred programmes, and more referrals from HCPs. However, should more participants join and engage in programmes, this may result in overcapacity and affect the performance of programmes. This insight is referred to as the "limits to growth" archetype²⁸ (Supplementary Figure 5) – where efforts to invest in fall prevention programmes may be successful in increasing performance in the initial stages, but an overcapacity of participants may disrupt the growth eventually.

Next, more participation in programmes can gradually shift mindsets as the narrative of fall prevention programmes can change through word of mouth. However, an overcapacity of participants may affect the performance of programmes, which would negatively affect promotion through word of mouth. Similarly, these insights lead to the identification of the "limits to growth" archetype²⁸, demonstrated by the competing loops implicating the rate of accepted referrals by participants (Supplementary Figure 6).

Good group dynamics can promote adherence to fall prevention programmes. However, with more participants in programmes, this may unintentionally disrupt group dynamics due to issues like group size, clashing personalities and language differences. These insights lead to the identification of the "fixes the fail" archetype²⁸, where group dynamics can promote adherence to programmes but may be unintentionally disrupted due to the increasing number of active participants (Supplementary Figure 7).

Discussion

The dynamic relationship between facilitators and barriers in implementing fall prevention programmes was reflected in the CLD above. Based on the insights generated, key leverage points for interventions have been outlined to guide future implementation strategies. The policy recommendations serve to increase the promoting (virtuous) loops and break the inhibiting (vicious) loops. Suggested recommendations targeting specific facilitators and barriers are summarised in Figure 7 and Table 2.

A key insight attained was that older adults fallers are largely considered a homogenous population in current community-based intervention programmes in Singapore. In reality, they are a heterogeneous group of individuals, with various risk factors characterising different profiles of fallers^{29,30}. An older adult with falls typically has complex health needs and multiple underlying disorders like sarcopenia, osteoporosis, cognitive impairment, cardiovascular syncope etc³¹. At the same time, decisions to join fall prevention programmes are influenced by factors such as personal perceptions, social support, convenience and cost^{32,33}. Therefore, fall prevention needs to be understood as a cross-disciplinary issue which is not inevitable with ageing. Furthermore, the GMB process also provided insight that current fall prevention programmes were carried out in silos, hence there is a strong need to integrate efforts moving forward. Therefore, the approach to fall prevention and management needs to shift towards a higher level of coordination between multi-disciplinary teams and complementary provider groups.

National strategy for fall prevention

There is a strong urgency to develop an overall national strategy for fall prevention. From discussions, there is a general agreement about the limited national agenda on falls. Establishing a falls workgroup would be the first step to organising efforts, consolidating current learnings across all healthcare clusters in Singapore and driving the agenda of national falls prevention. The workgroup should integrate existing frameworks and establish appropriate frameworks to guide risk screening, referrals, prevention, and management programmes.

The workgroup needs to consist of a multi-disciplinarian team of professionals, comprising clinicians from various specialities (e.g., rehabilitation therapists, nurses, pharmacists, cardiologists, neurologists, dieticians, endocrinologists, geriatricians), researchers, and policymakers. It should be chaired by like-minded individuals from different organisations to ensure consistent leadership and to maintain diversity and continuity of work in the long run. The focus of the workgroup would be to harmonise the understanding of falls across all stakeholders and recommend concrete clinical and community guidelines on the various facets of fall prevention. A comprehensive evaluation of fall prevention programmes should first be conducted to understand the gaps between research and translation. The GMB highlighted that there is overwhelming evidence from research studies and geriatric clinics on the approaches to fall prevention in Singapore; demonstrating how Singapore is in a good position to translate findings in the community by building on existing capacities. However, there are still several gaps identified – such as the feasibility of implementation on a health-cluster level, maintenance of programmes, and the overall cost-effectiveness of fall prevention programmes. A national falls playbook with specific guidelines should be developed after evaluation. The playbook serves to inform decision-makers when adapting fall prevention programmes in their respective institutions. At the same time, it should incorporate flexibility, to enable decision-makers to shape

programmes according to their targets, resources, and capacity. Stakeholders also maintain that a mixture of top-down and bottom-up approaches should be adopted. However, the formation of a workgroup and establishing necessary agendas and guidelines should be done before introducing government involvement.

Establishing a national fall prevention strategy would pave the way for the implementation of various fall prevention programmes. A fall prevention programme should be efficacious, feasible for implementation and cost-effective. Hence, it involves obtaining the necessary capacity and allocating sufficient resources to run programmes. An organised national fall prevention strategy would work to increase resources available for programmes and promote the availability of evidence-based fall prevention programmes. Furthermore, the national strategy should also restructure current KPIs, to ensure that targets are realistic and patient-centred to ensure that resources are utilised appropriately. The availability of evidence-based fall prevention programmes should also include a structured screening process. Stakeholders shared that currently there is no systematic screening process for fall risk. As such, the national strategy should include identifying a valid, reliable, quick, and easy-to-administer screening tool to be used in the community. Existing clinical practice guidelines (CPG) ³⁴ on fall prevention should also be reviewed on a more regular basis, with greater specificity on the criteria or tools for fall risk assessments. Recommended tools can be integrated with existing screening frameworks, such as the Integrated Care for Older People (ICOPE) tool that screens for frailty. At the same time, a uniform criterion for patient referral should be developed alongside fall risk assessment guidelines. CPGs can detail specific programmes for clinicians to refer patients to. This ensures that clinicians have a structured and consistent referral pathway to follow through after risk assessment. This is especially important for a multi-disciplinary care team. Referral pathways could also be more inclusive to include patients with various conditions such as sensory difficulties and cognitive impairment, as these patients are at higher risk for falls. Further discussions need to take place to ensure fall prevention programmes are available for these individuals in strong consideration of their current abilities, safety, and possible progression. Stakeholders also shared that current healthcare clusters require guidance to administer systematic screening assessments, hence it is also necessary to develop guidelines and additional training for relevant personnel in the healthcare clusters. Lastly, fall prevention programmes should also be accompanied by consistent programme evaluations in both the short and long term, to ensure successful implementation in the long run. Some areas for evaluation include the effectiveness of programmes, financial modelling of programmes, and participant satisfaction.

Fall Prevention Programmes

Programme Components

Insights from stakeholders indicated that current programmes are insufficiently intensive and are not targeted enough to create an experience of value. For programmes to be efficacious, they need to have a degree of customisation. While this may be challenging to accommodate in a group setting, it would be beneficial to create programmes specially designed to incorporate principles of progression, for those who improve quickly and require more intensive exercises; as well as principles of regression, for participants who are unable to manage such high intensities. Balancing these principles would be pivotal in ensuring adherence to programmes in the long term. This also means that programme

facilitators ought to be cognizant of the differences within group programmes and create lesson plans accounting for the variety of physical and motivation levels as well as the dynamics of the group.

Socially conducive environment

Design features in community-based fall prevention programmes must be deliberate in promoting interaction between participants. This provides an arena for older adults to build their social networks, learn from others' experiences and progress together. At the same time, fall prevention programmes should be an enabling environment, where participants are comfortable with taking ownership of their health. Programmes should have structured components in place to educate and empower older adults; to give them the experience of self-efficacy and improvement of intrinsic capacity. Facilitators can begin incorporating this by working together with older adults to set realistic goals for improvements³⁵. A socially conducive environment can promote long-term adherence to programmes.

Building self-efficacy

Furthermore, the causal map suggests the importance of capitalising on the reinforcing nature of older adults' self-efficacy, and how engaging family members and caregivers would be beneficial in promoting self-efficacy among older adults. Trained facilitators³⁵⁻³⁷ in fall prevention programmes need to educate participants on the value and specific purpose of their activities. Stakeholders shared that this enables participants to understand the importance of each activity and are made aware of their progress throughout the programme. Furthermore, fall prevention programmes can also incorporate resilience-building workshops^{8,38,39}, to impart various strategies to build resilience – specifically to encourage participants to adhere to fall prevention programmes should they find it a daunting task. Actively engaging with family members is also key to promoting older adults' adherence to programmes. Facilitators or outreach staff should actively educate family members and caregivers on the importance of fall prevention programmes; and inform them of the dangers of being overprotective^{8,40}. There should also be opportunities for family members to attend fall prevention programmes with the older adult participants – this first-hand experience may be useful in understanding the value of fall prevention programmes, and they can also be involved in tracking participants' progress over time.

Fall Education

The CLD also identified patients' value perception as an important leverage point for intervention. Changing value perception involves shifting patient attitudes and education, hence falls education would be one key component in falls prevention programmes. Participants should be made aware of their own fall risk, the severity of falls as well as the importance of fall prevention programmes. Engaging their families and educating them on falls is an important aspect as well. In addition, a nationwide fall education campaign should take place, driven by the national fall strategy. Community guidelines should be established to ensure the public is aware of the importance of fall prevention, and how to conduct simple risk assessments to understand their fall risk. This helps to raise awareness of fall prevention among older adults and their families and encourages older adults to take charge of their health to enrol in programmes. In addition, the approach to conveying information to the participants is critical. Messaging practices such as positive versus negative messages or self vs family-centric approaches would be effective depending on the profile of the recipient⁴¹, and it would be important to take advantage of these approaches when communicating with specific groups in public.

Affordability and accessibility

Finally, fall prevention programmes need to consider participants' reliance on caregivers and provide options should caregivers be unavailable. For example, providing transportation services, therapists and assistants for older adults may be useful in reassuring both participants and their caregivers that the programme would be safe and beneficial. Working with providers such as medical social workers and elderly welfare voluntary organisations would be crucial in making these services available. Financial subsidies should also be available and accessible while ensuring programmes remain cost-effective for sustained implementation^{42,43}.

Strengths and Limitations

Having a group of clinicians, allied health professionals and researchers who play an active role in fall prevention examine and discuss implementation challenges is a strength of this study. This facilitated a deeper understanding of the fall prevention landscape from the perspective of diverse stakeholders, representative of the various health clusters in Singapore. The active participatory approach through the GMB was key in encouraging in-depth discussion and co-creation of policy targets through shared consensus. It promoted strong urgency and agency to advocate for the development of a comprehensive national strategy that encapsulates the various facets of fall prevention. Furthermore, by employing system dynamics methods, the relationships and interactions between factors can be elucidated and visualised in the conceptual model. While we recognise that these results may be unique and limited to Singapore, the insights gathered may be generalised for other Asian settings or multi-ethnic settings with developed healthcare systems. To the authors' knowledge, this study is the first done in an Asian context.

Conclusion

Through the GMB, stakeholders were engaged in discussing the challenges of fall prevention among older adults. This led to the development of a conceptual model to elucidate issues surrounding the implementation of fall prevention programmes. Key leverage points have been identified and recommendations have been put forward as well. The group acknowledged that there is a wealth of evidence in various geriatric clinics and research groups, but they have yet to be properly implemented on a national scale. Hence, it is imperative to consider developing a comprehensive national fall prevention strategy.

To generate more insights to support the development of a national fall prevention strategy, future work would involve developing a credible quantitative model for simulation. The CLD generated from this study would be further enhanced to generate the quantitative model. Future research would involve more stakeholders, including patients, caregivers, primary care clinicians, social welfare organisations and policymakers; to provide information for simulation inputs and to discuss specific action plans moving forward. In conclusion, the model generated, and future additional work would be useful to guide future approaches to fall prevention interventions.

References

1. Salari N, Darvishi N, Ahmadipanah M, Shohaimi S, Mohammadi M. Global prevalence of falls in the older adults: a comprehensive systematic review and meta-analysis. *J Orthop Surg Res.* Jun 28 2022;17(1):334. doi:10.1186/s13018-022-03222-1
2. Vaishya R, Vaish A. Falls in Older Adults are Serious. *Indian J Orthop.* Feb 2020;54(1):69-74. doi:10.1007/s43465-019-00037-x
3. Salvà A, Bolívar I, Pera G, Arias C. Incidence and consequences of falls among elderly people living in the community. *Medicina Clínica.* 2004/01/01/ 2004;122(5):172-176. doi:[https://doi.org/10.1016/S0025-7753\(04\)74184-6](https://doi.org/10.1016/S0025-7753(04)74184-6)
4. Dautzenberg L, Beglinger S, Tsokani S, et al. Interventions for preventing falls and fall-related fractures in community-dwelling older adults: A systematic review and network meta-analysis. *J Am Geriatr Soc.* Oct 2021;69(10):2973-2984. doi:10.1111/jgs.17375
5. Tricco AC, Thomas SM, Veroniki AA, et al. Comparisons of Interventions for Preventing Falls in Older Adults: A Systematic Review and Meta-analysis. *Jama.* Nov 7 2017;318(17):1687-1699. doi:10.1001/jama.2017.15006
6. Albornos-Muñoz L, Moreno-Casbas MT, Sánchez-Pablo C, et al. Efficacy of the Otago Exercise Programme to reduce falls in community-dwelling adults aged 65-80 years old when delivered as group or individual training. *J Adv Nurs.* Jul 2018;74(7):1700-1711. doi:10.1111/jan.13583
7. Sherrington C, Fairhall N, Kirkham C, et al. Exercise and fall prevention self-management to reduce mobility-related disability and falls after fall-related lower limb fracture in older people: protocol for the RESTORE (Recovery Exercises and STEpping On afterR fracturE) randomised controlled trial. *BMC Geriatr.* Feb 2 2016;16:34. doi:10.1186/s12877-016-0206-5
8. Matchar DB, Duncan PW, Lien CT, et al. Randomized Controlled Trial of Screening, Risk Modification, and Physical Therapy to Prevent Falls Among the Elderly Recently Discharged From the Emergency Department to the Community: The Steps to Avoid Falls in the Elderly Study. *Arch Phys Med Rehabil.* Jun 2017;98(6):1086-1096. doi:10.1016/j.apmr.2017.01.014
9. Horne M, Skelton DA, Speed S, Todd C. Falls prevention and the value of exercise: salient beliefs among South asian and white british older adults. *Clin Nurs Res.* Feb 2014;23(1):94-110. doi:10.1177/1054773813488938
10. Yardley L, Bishop FL, Beyer N, et al. Older people's views of falls-prevention interventions in six European countries. *Gerontologist.* Oct 2006;46(5):650-60. doi:10.1093/geront/46.5.650
11. Ganz DA, Alkema GE, Wu S. It takes a village to prevent falls: reconceptualizing fall prevention and management for older adults. *Inj Prev.* 2008;14(4):266-271. doi:10.1136/ip.2008.018549
12. Dykeman CS, Markle-Reid MF, Boratto LJ, et al. Community service provider perceptions of implementing older adult fall prevention in Ontario, Canada: a qualitative study. *BMC Geriatrics.* 2018/02/01 2018;18(1):34. doi:10.1186/s12877-018-0725-3
13. FM van Wijck S RC, Tsegai NS, Raybould T, Liu SW. Unexpected challenges to preventing falls in older adults: a mixed methods study of an emergency department-based falls prevention referral pilot project. *Health Edu Care.* 2019;4doi:10.15761/HEC.1000158
14. Goodwin V, Jones-Hughes T, Thompson-Coon J, Boddy K, Stein K. Implementing the evidence for preventing falls among community-dwelling older people: A systematic review. *Journal of Safety Research.* 2011/12/01/ 2011;42(6):443-451. doi:<https://doi.org/10.1016/j.jsr.2011.07.008>

15. Reckrey JM, Gazarian P, Reuben DB, et al. Barriers to implementation of STRIDE, a national study to prevent fall-related injuries. *J Am Geriatr Soc.* May 2021;69(5):1334-1342. doi:10.1111/jgs.17056
16. McMahon SK, Greene EJ, Latham N, et al. Engagement of older adults in STRIDE's multifactorial fall injury prevention intervention. *J Am Geriatr Soc.* Nov 2022;70(11):3116-3126. doi:10.1111/jgs.17983
17. Homer JB, Hirsch GB. System dynamics modeling for public health: background and opportunities. *Am J Public Health.* Mar 2006;96(3):452-8. doi:10.2105/ajph.2005.062059
18. Child S, Goodwin V, Garside R, Jones-Hughes T, Boddy K, Stein K. Factors influencing the implementation of fall-prevention programmes: a systematic review and synthesis of qualitative studies. *Implement Sci.* Sep 14 2012;7:91. doi:10.1186/1748-5908-7-91
19. van Rhyn B, Barwick A. Health Practitioners' Perceptions of Falls and Fall Prevention in Older People: A Metasynthesis. *Qual Health Res.* Jan 2019;29(1):69-79. doi:10.1177/1049732318805753
20. Siokou C, Morgan R, Shiell A. Group model building: a participatory approach to understanding and acting on systems. *Public Health Research & Practice.* 2014;25(1)
21. Gerritsen S, Harré S, Rees D, et al. Community Group Model Building as a Method for Engaging Participants and Mobilising Action in Public Health. *Int J Environ Res Public Health.* 2020;17(10):3457. doi:10.3390/ijerph17103457
22. Ansah JP, Matchar DB, Koh V, Schoenenberger L. Mapping the Dynamic Complexity of Chronic Disease Care in Singapore: Using Group Model Building in Knowledge Elicitation. *Systems Research and Behavioral Science.* 2018;35(6):759-775. doi:<https://doi.org/10.1002/sres.2517>
23. Király G, Miskolczi P. Dynamics of participation: System dynamics and participation—An empirical review. *Systems Research and Behavioral Science.* 2019;36(2):199-210. doi:<https://doi.org/10.1002/sres.2580>
24. Ackermann F, Andersen DF, Eden C, Richardson GP. ScriptsMap: A tool for designing multi-method policy-making workshops. *Omega.* 2011/08/01/ 2011;39(4):427-434. doi:<https://doi.org/10.1016/j.omega.2010.09.008>
25. Matchar DB, Ansah JP, Hovmand P, Bayer S. Simulation modeling for primary care planning in Singapore. 2016:2123-2134.
26. Richardson GP. Reflections on the foundations of system dynamics. *System Dynamics Review.* 2011;27(3):219-243. doi:<https://doi.org/10.1002/sdr.462>
27. Sterman J. Business Dynamics, System Thinking and Modeling for a Complex World. [http://lst-iipepiiep-unescoorg/cqi-bin/wwwi32exe/?in=epidoc1in/?t2000=013598/\(100\)](http://lst-iipepiiep-unescoorg/cqi-bin/wwwi32exe/?in=epidoc1in/?t2000=013598/(100)). 01/01 2000;19
28. Braun W. The System Archetypes *System.* 01/01 2002;2002:27.
29. Pereira CB, Kanashiro AMK. Falls in older adults: a practical approach. *Arq Neuropsiquiatr.* May 2022;80(5 Suppl 1):313-323. doi:10.1590/0004-282x-anp-2022-s107
30. Xu Q, Ou X, Li J. The risk of falls among the aging population: A systematic review and meta-analysis. *Front Public Health.* 2022;10:902599. doi:10.3389/fpubh.2022.902599
31. M. M-OM. *Osteoporosis in Older Persons: Advances in Pathophysiology and Therapeutic Approaches.* Springer International Publishing Switzerland 2016 11.
32. Fernandes JB, Fernandes SB, Almeida AS, Vareta DA, Miller CA. Older Adults' Perceived Barriers to Participation in a Falls Prevention Strategy. *J Pers Med.* May 23 2021;11(6)doi:10.3390/jpm11060450
33. Vincenzo JL, Patton SK, Lefler LL, McElfish PA, Wei J, Curran GM. A qualitative study of older adults' facilitators, barriers, and cues to action to engage in falls prevention using health belief model

- constructs. *Archives of Gerontology and Geriatrics*. 2022/03/01/ 2022;99:104610. doi:<https://doi.org/10.1016/j.archger.2021.104610>
34. HPB-MOH Clinical Practice Guidelines (1/2015) (2015).
 35. Mahoney JE, Clemson L, Schlotthauer A, et al. Modified Delphi Consensus to Suggest Key Elements of Stepping On Falls Prevention Program. *Front Public Health*. 2017;5:21. doi:10.3389/fpubh.2017.00021
 36. Jones DL, Starcher RW, Eicher JL, Wilcox S. Adoption of a Tai Chi Intervention, Tai Ji Quan: Moving for Better Balance, for Fall Prevention by Rural Faith-Based Organizations, 2013-2014. *Prev Chronic Dis*. Jul 14 2016;13:E92. doi:10.5888/pcd13.160083
 37. Shubert TE, Smith ML, Ory MG, et al. Translation of the otago exercise program for adoption and implementation in the United States. *Front Public Health*. 2014;2:152. doi:10.3389/fpubh.2014.00152
 38. Tchalla AE, Dufour AB, Trivison TG, et al. Patterns, Predictors, and Outcomes of Falls Trajectories in Older Adults: The MOBILIZE Boston Study with 5 Years of Follow-Up. *PLOS ONE*. 2014;9(9):e106363. doi:10.1371/journal.pone.0106363
 39. Faes MC, Reelick MF, Joosten-Weyn Banningh LW, Gier Md, Esselink RA, Olde Rikkert MG. Qualitative study on the impact of falling in frail older persons and family caregivers: Foundations for an intervention to prevent falls. *Aging & Mental Health*. 2010/09/01 2010;14(7):834-842. doi:10.1080/13607861003781825
 40. Xu T, O'Loughlin K, Clemson L, Lannin NA, Dean C, Koh G. Developing a falls prevention program for community-dwelling stroke survivors in Singapore: client and caregiver perspectives. *Disabil Rehabil*. May 2019;41(9):1044-1054. doi:10.1080/09638288.2017.1419293
 41. Mikels JA, Shuster MM, Thai ST, et al. Messages that matter: Age differences in affective responses to framed health messages. *Psychol Aging*. Jun 2016;31(4):409-14. doi:10.1037/pag0000040
 42. Carande-Kulis V, Stevens JA, Florence CS, Beattie BL, Arias I. A cost-benefit analysis of three older adult fall prevention interventions. *J Safety Res*. Feb 2015;52:65-70. doi:10.1016/j.jsr.2014.12.007
 43. Matchar DB, Eom K, Duncan PW, et al. A Cost-Effectiveness Analysis of a Randomized Control Trial of a Tailored, Multifactorial Program to Prevent Falls Among the Community-Dwelling Elderly. *Arch Phys Med Rehabil*. Jan 2019;100(1):1-8. doi:10.1016/j.apmr.2018.07.434

Figures and Tables

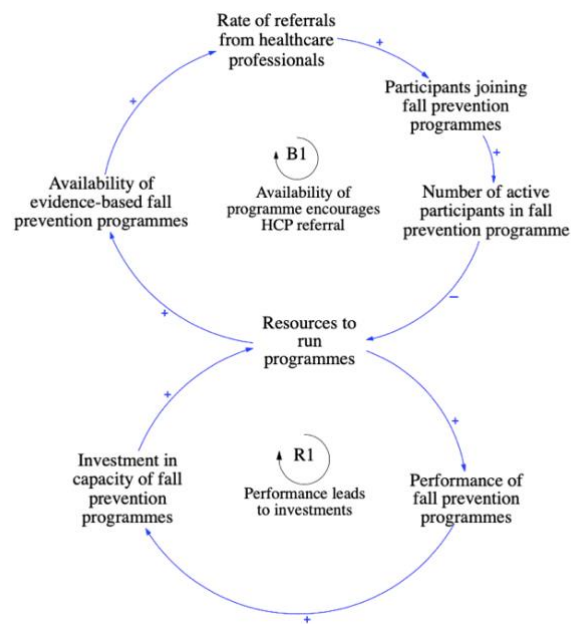


Figure 1 Healthcare provider factors influencing clinicians' referrals

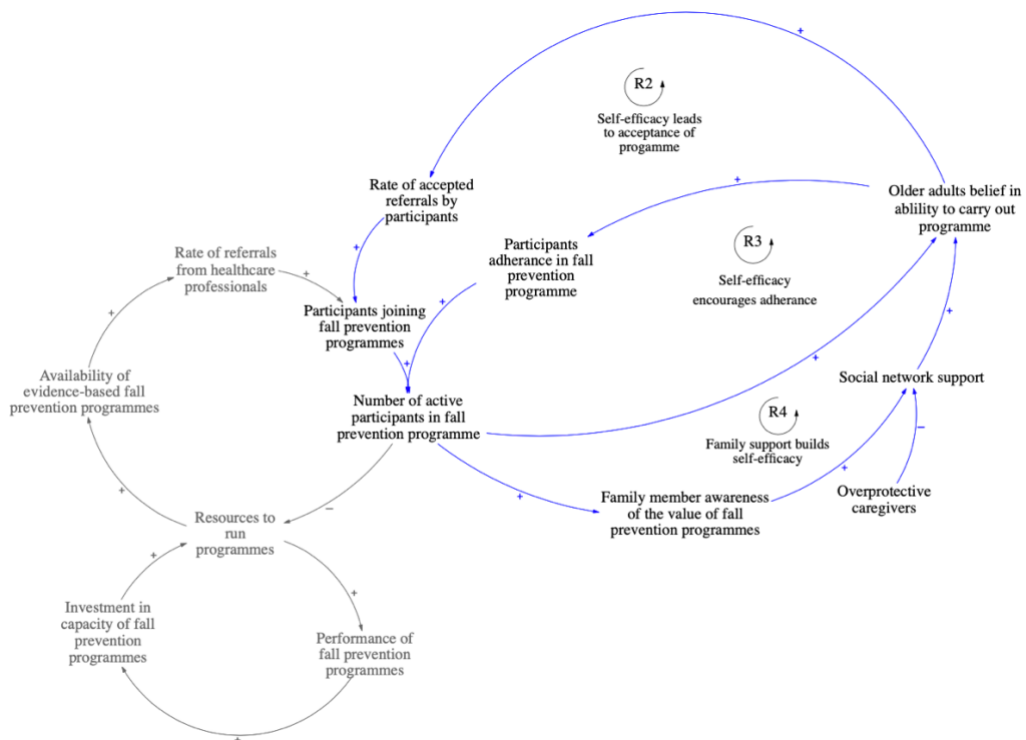


Figure 2 Older adults' self-efficacy in carrying out programmes implicating joining and adhering fall prevention programmes

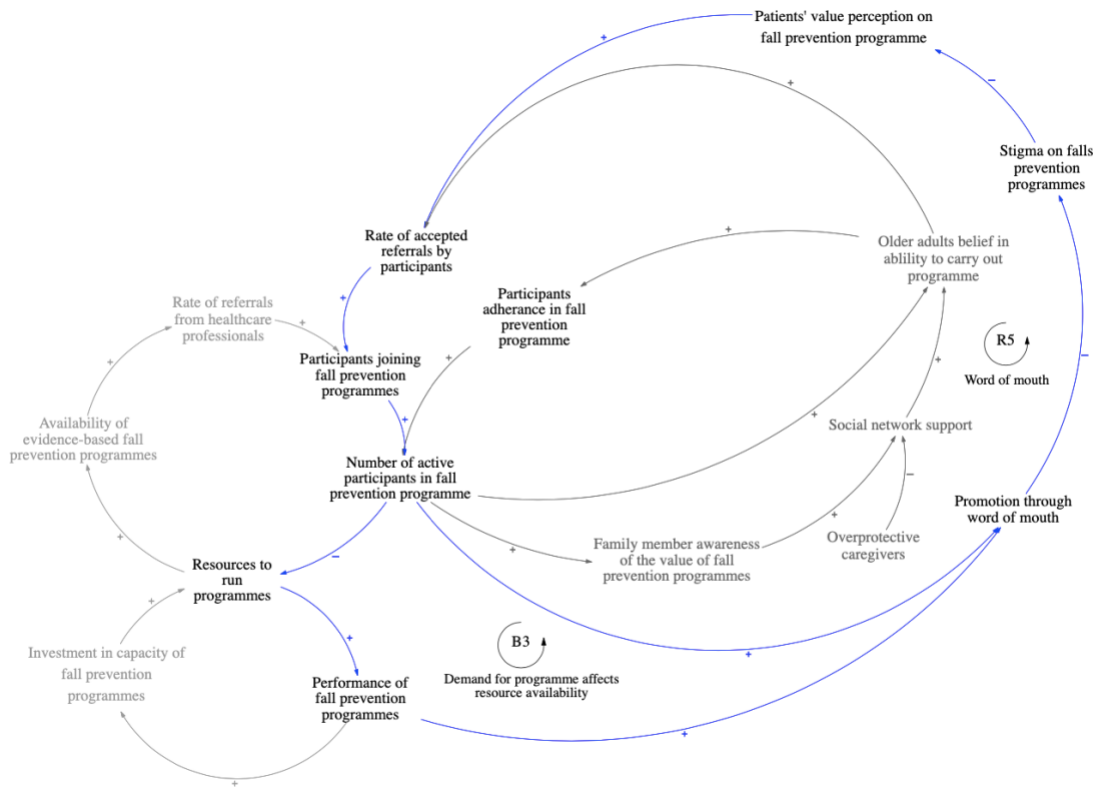


Figure 3 Promotion of fall prevention programmes through word of mouth influences the rate of referrals accepted by participants

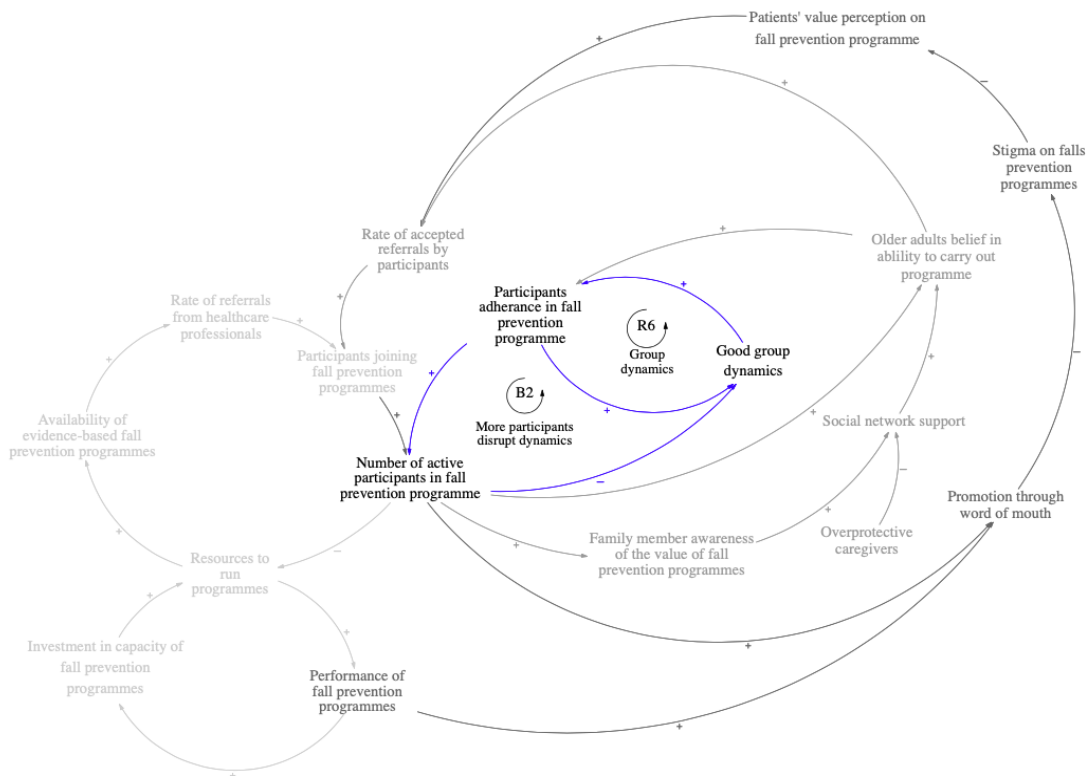


Figure 4 Good group dynamics promotes adherence to fall prevention programmes

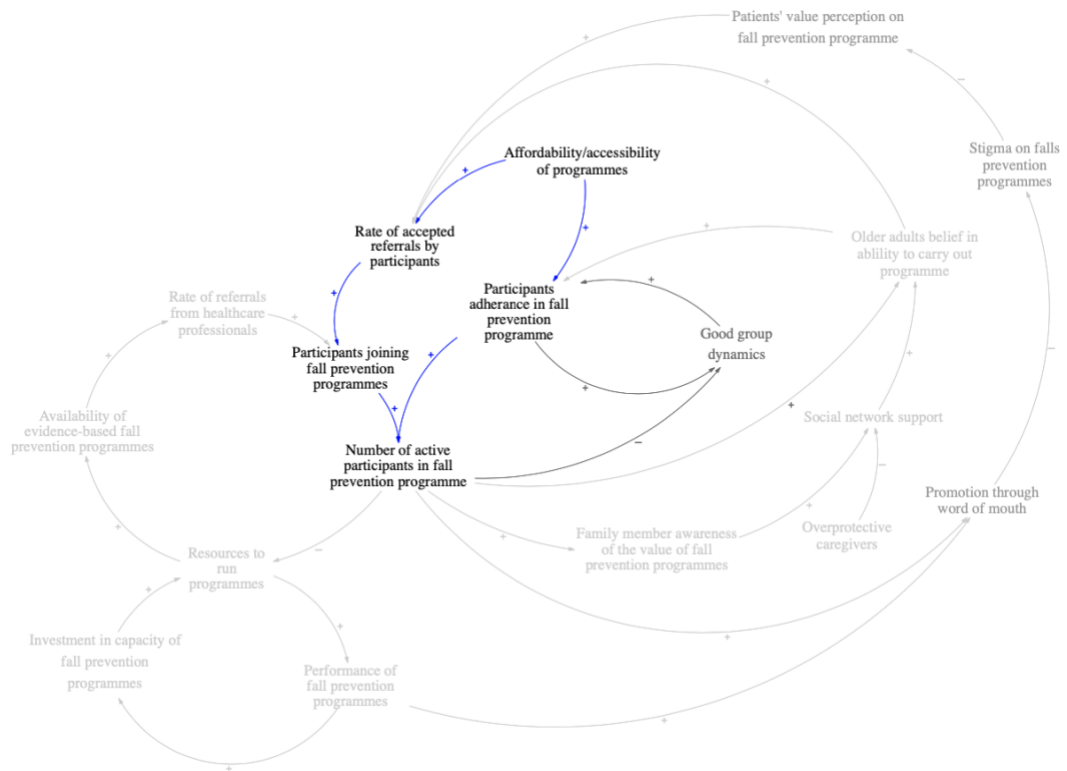


Figure 5 Affordability and accessibility influencing both rates of accepted referrals and long-term adherence to fall prevention programmes

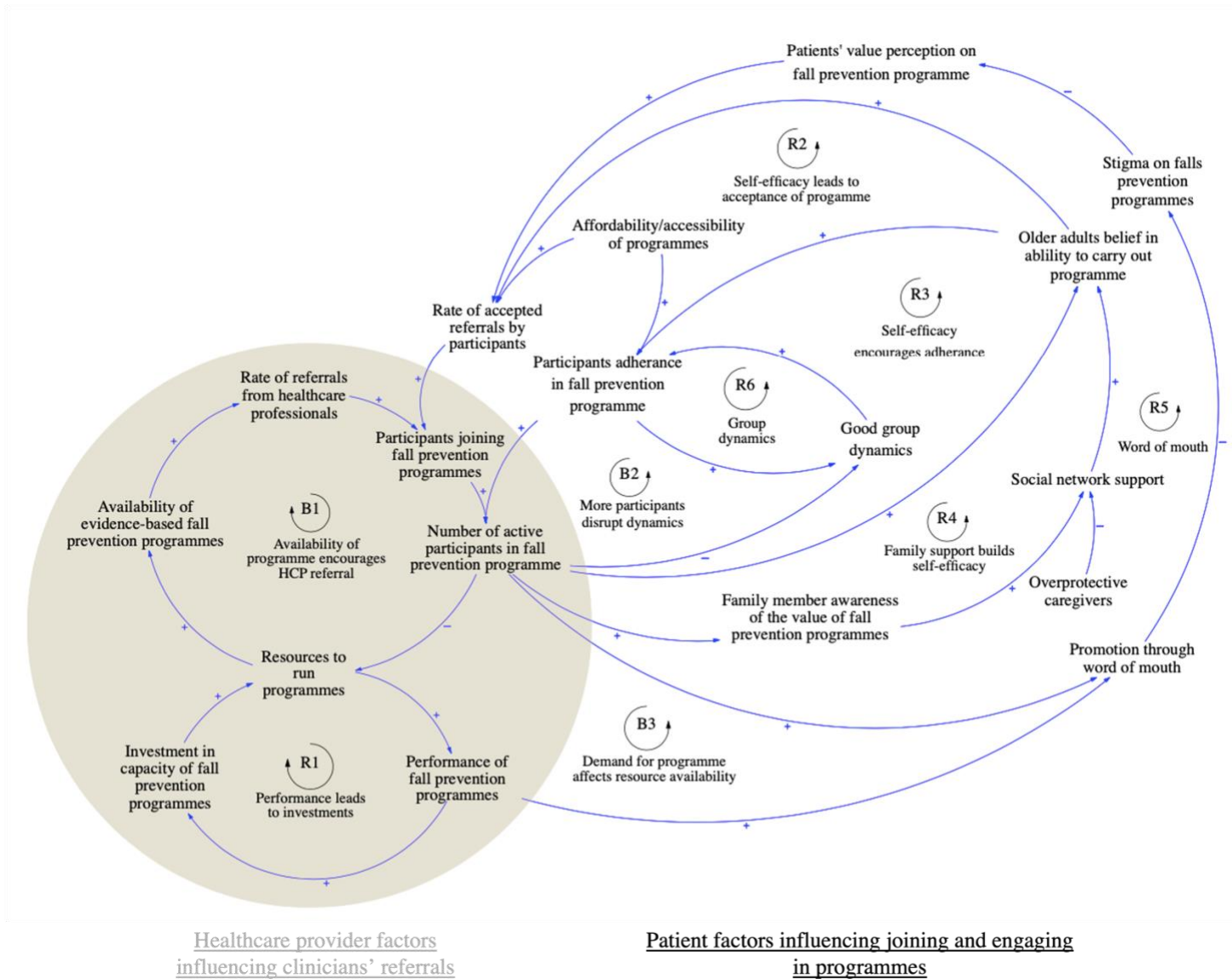


Figure 6 Full causal loop diagram illustrating dynamic relationships between facilitators and barriers influencing the implementation of community-based fall prevention programme

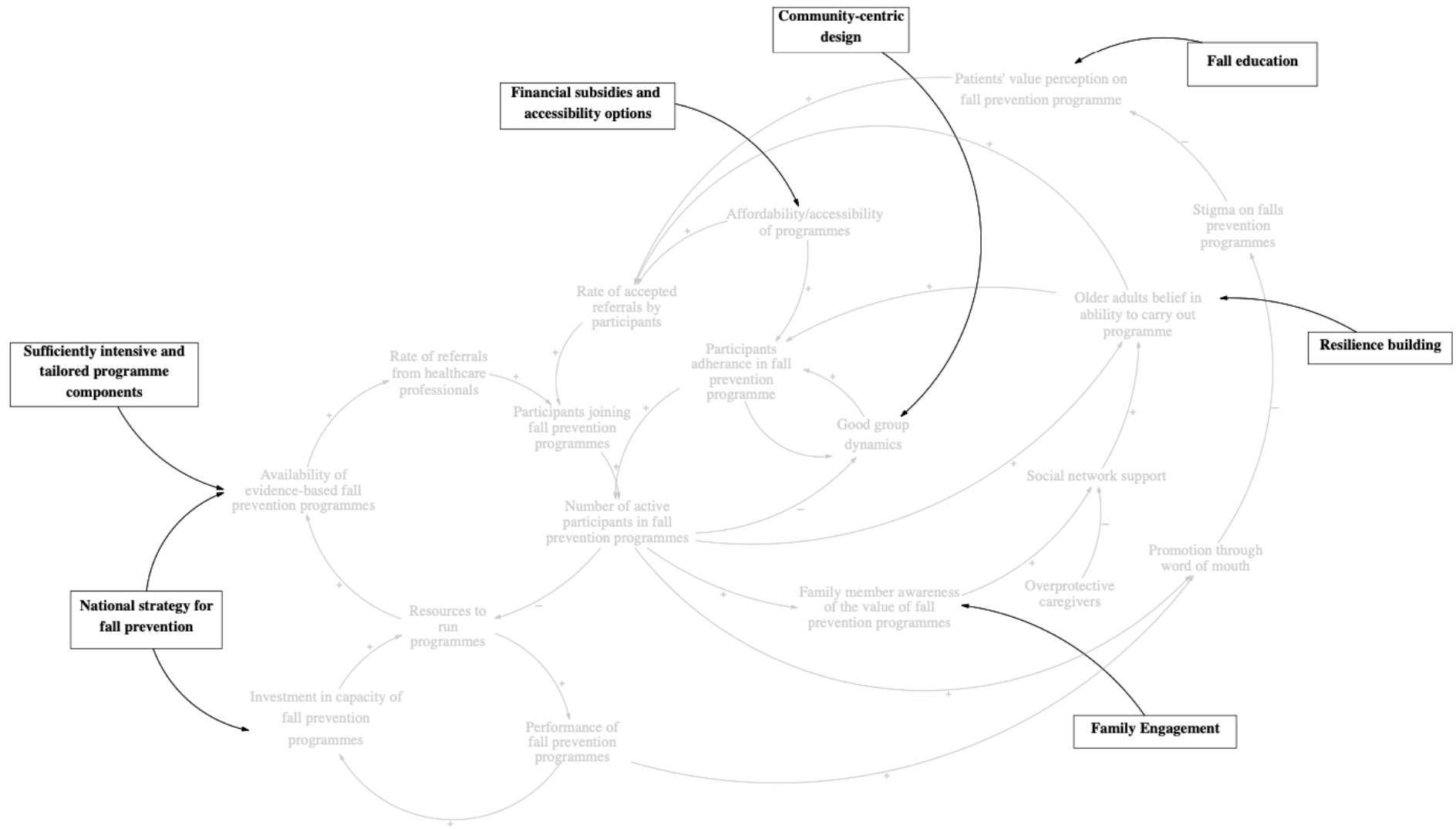


Figure 7 Suggested recommendations from stakeholder discussion targeting key leverage points

Feedback Loops	Description
B1: Availability of programme encourages healthcare professional referral	With greater resources to run programmes, the availability of fall prevention programmes would increase. This would promote the rate of referrals from healthcare professionals leading to an overall increase in the number of participants in the programme. However, resources may be limited with more participants in the programme.
R1: Performance leads to investments	Greater performance of fall prevention programmes encourages investment in the capacity for fall prevention programmes, hence increasing resource availability to run programmes. With more resources, performance of programme will see an increase as well.
R2: Self-efficacy leads to acceptance of programme	Older adults' initial self-belief in carrying out fall prevention programmes encourages participants to accept referrals to join programmes.
R3: Self-efficacy encourages adherence	Older adults' self-belief in carrying out fall prevention programmes promotes adhering to programmes. Being engaged and carrying out programmes reinforces their self-beliefs.
R4: Family support builds self-efficacy for programmes	Family awareness of the importance of fall prevention can increase support for fall prevention programmes. This increases social support for older adults through emotional, functional, and financial support. This can encourage participants to accept referrals and to adhere to programme regimens.
B3: Demand for programme affects resource availability	High performance of fall prevention programmes will be promoted by word of mouth within the community. This can increase the value perception of fall prevention programmes, hence, increasing participant acceptance rates. However, with more participants, this may place a constraint on available resources, which may reduce the performance of programmes.
R5: Word of mouth	Greater active participation in programmes directly affect the promotion of programmes through word of mouth. This can increase older adults' value perception by decreasing the community stigma of fall prevention programmes. Greater value perception increases the rate of accepted referrals from older adults, which can ultimately increase participants joining and engaging in fall prevention programmes.
R6: Group dynamics	Good group dynamics encourages participants to adhere in fall prevention programme. Adherence overtime also maintains and promotes good group dynamics.
B2: More participants disrupt dynamics	Good group dynamics encourage adherence to programmes and increase the number of participants in programmes. However, with more people joining programmes, this may disrupt group dynamics.

Table 1: Identified feedback loops from the concept mode

Domains	Leverage point for intervention	Potential interventions
Programme characteristics	Availability of evidence-based fall prevention programmes	<ul style="list-style-type: none"> • National strategy for fall prevention • Capacity building for greater evidence-based fall prevention programmes • Systematic screening process followed by sufficiently structured, intensive, and customisable programmes in both individual and group settings • Structured and consistent referral pathways • Guided by the national falls playbook
	Group dynamics	<ul style="list-style-type: none"> • Socially conducive design • Enabling environment • Goal setting
Resource allocation and capacity planning	Corporate key performance indicators	<ul style="list-style-type: none"> • Key stakeholders from diverse backgrounds need to restructure current KPIs • Targets should be realistic and patient-centred
Patient factors	Patient attitude and knowledge	<ul style="list-style-type: none"> • Fall education for participants and wider public • Nationwide fall education campaign • Selective messaging approaches to engage different groups in the community
	Older adults' self-efficacy to carry out programmes	<ul style="list-style-type: none"> • Educate participants on value and specific purpose of activities • Resilience-building strategies • Family engagement and outreach
	Family member awareness of the value of prevention programmes	<ul style="list-style-type: none"> • Family engagement and outreach
Affordability and accessibility of programmes	Affordability	<ul style="list-style-type: none"> • Financial subsidies to be made available and accessible for participants
	Accessibility	<ul style="list-style-type: none"> • Transportation services • Facilitators and therapists to be readily available to assist

Table 2: Leverage points for intervention

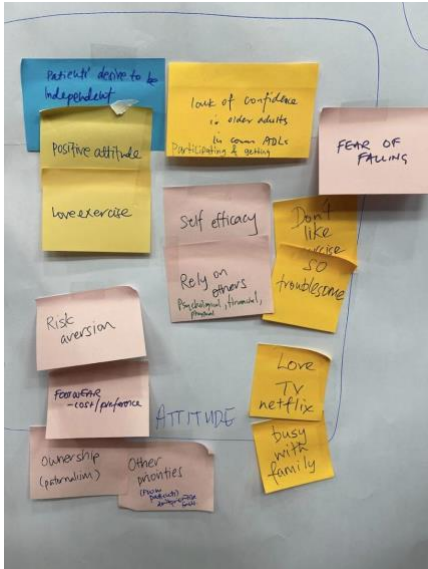
Supplementary Materials

Figures and Illustrations

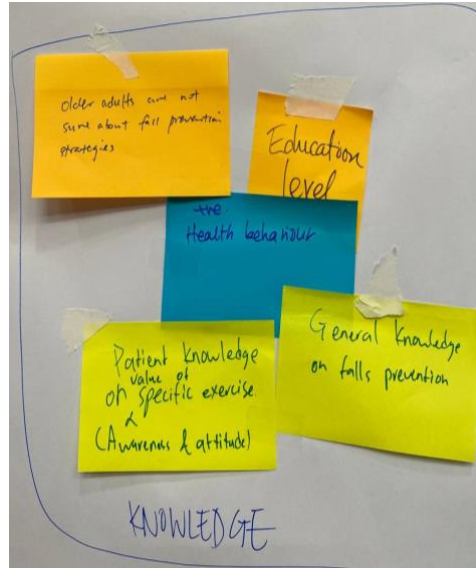


Supplementary Figure 1: Key outcomes prioritised by stakeholders

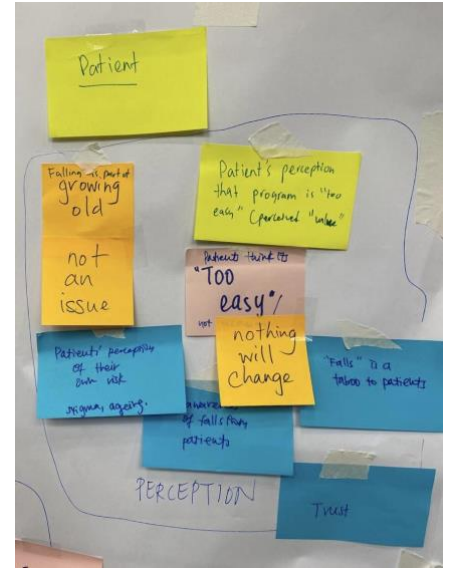
Patient attitude



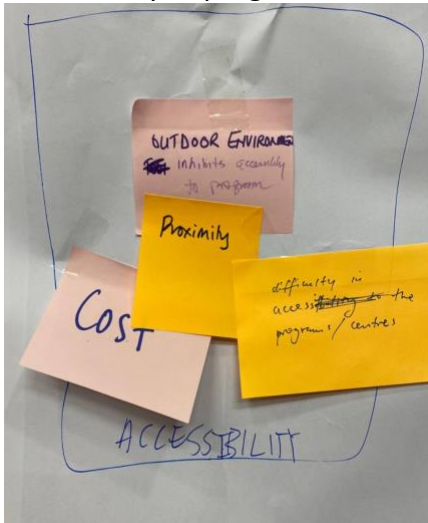
Patient knowledge



Patient perceptions



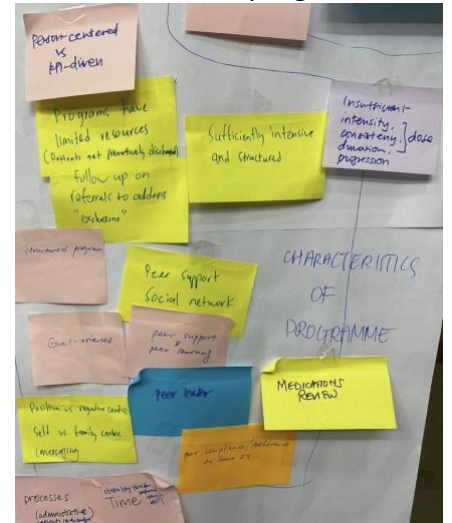
Accessibility of programme



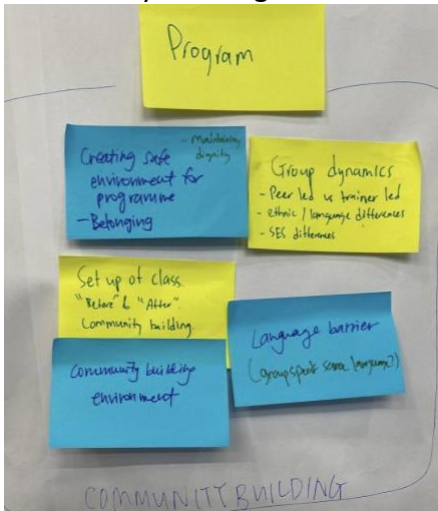
Availability of programme



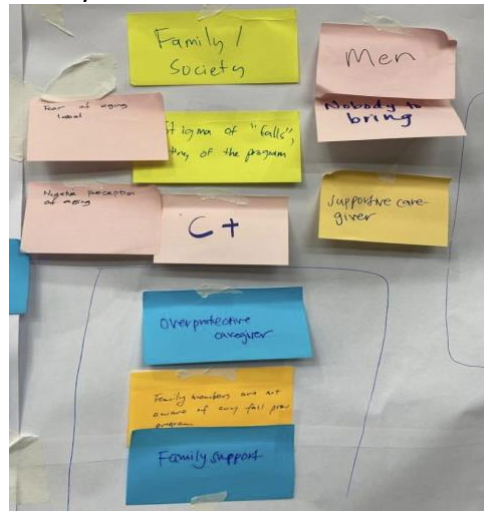
Characteristics of programme



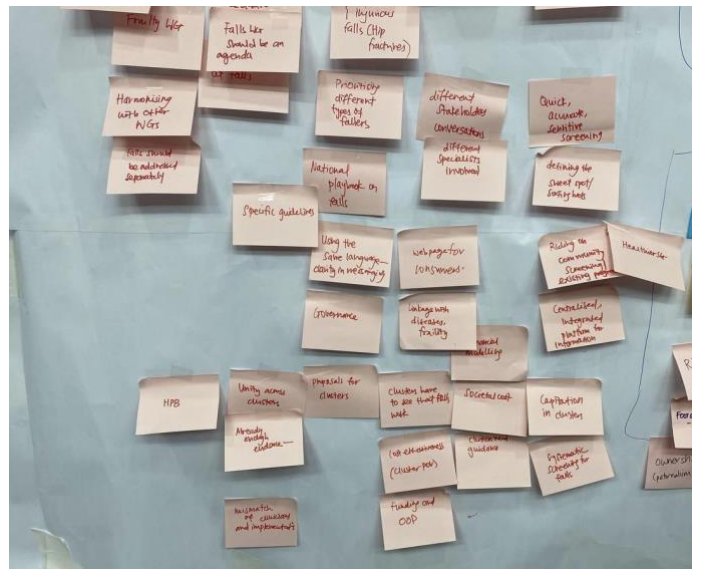
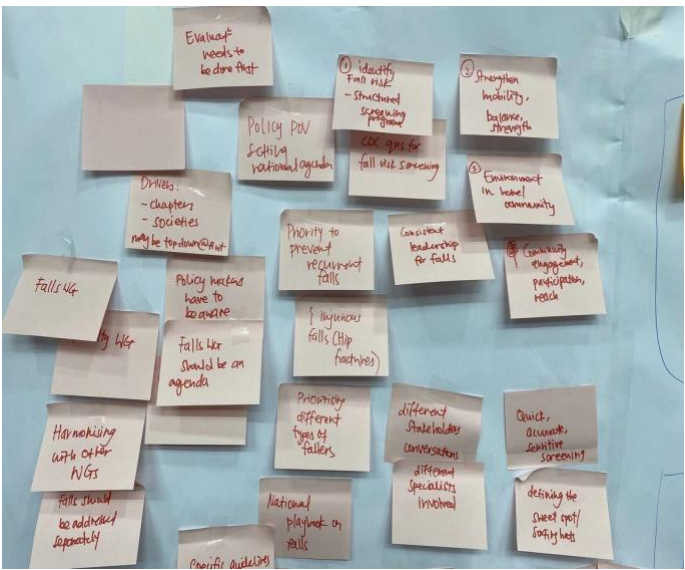
Community-building



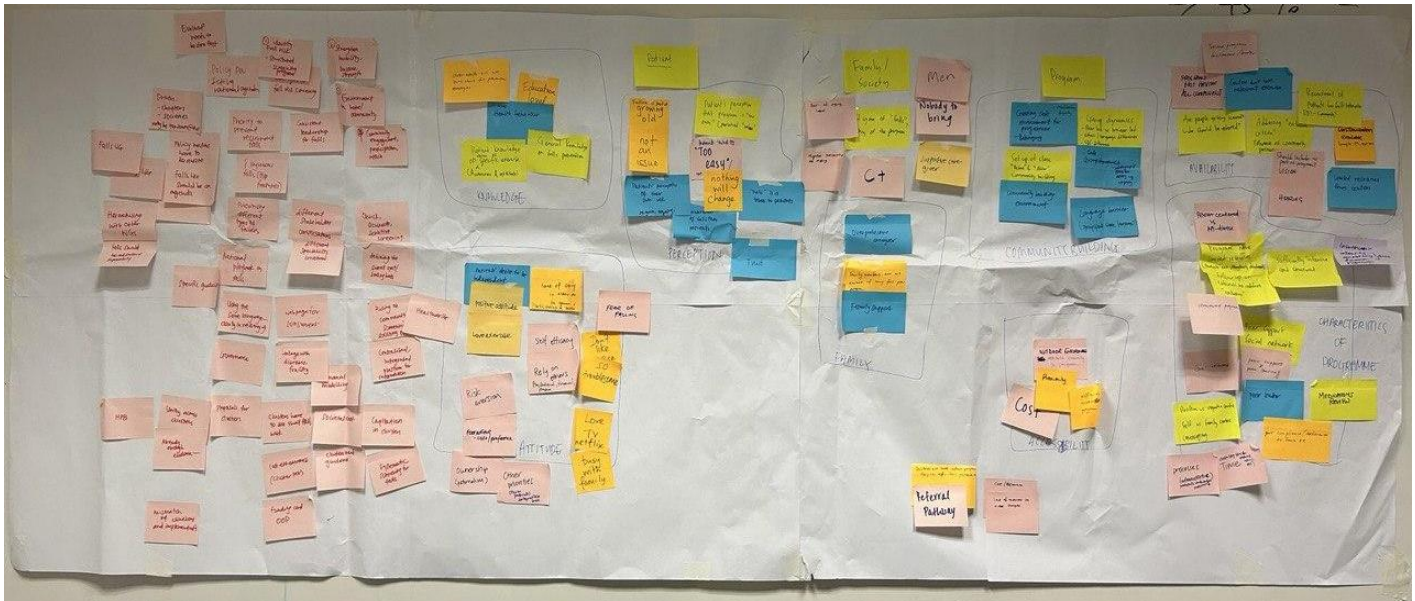
Family and societal norms



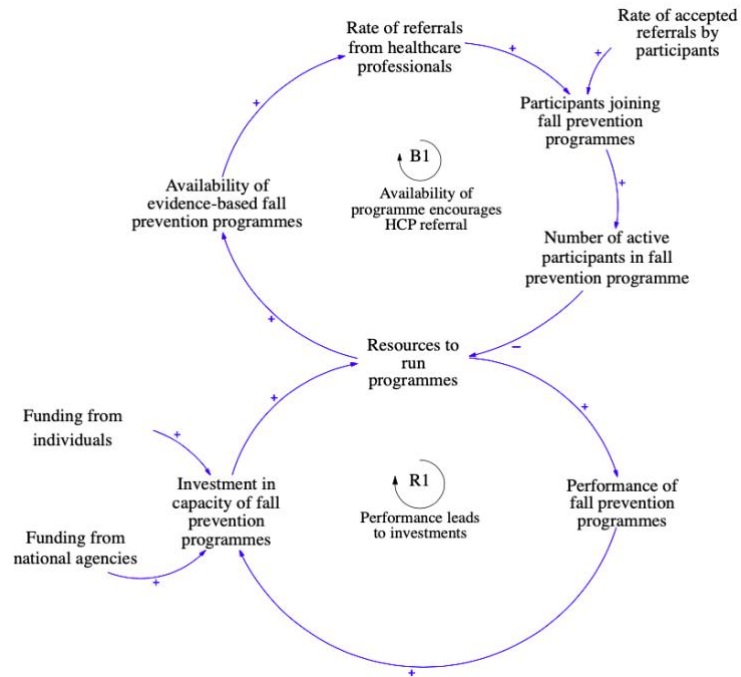
Supplementary Figure 2: Groups categorised after variable elicitation



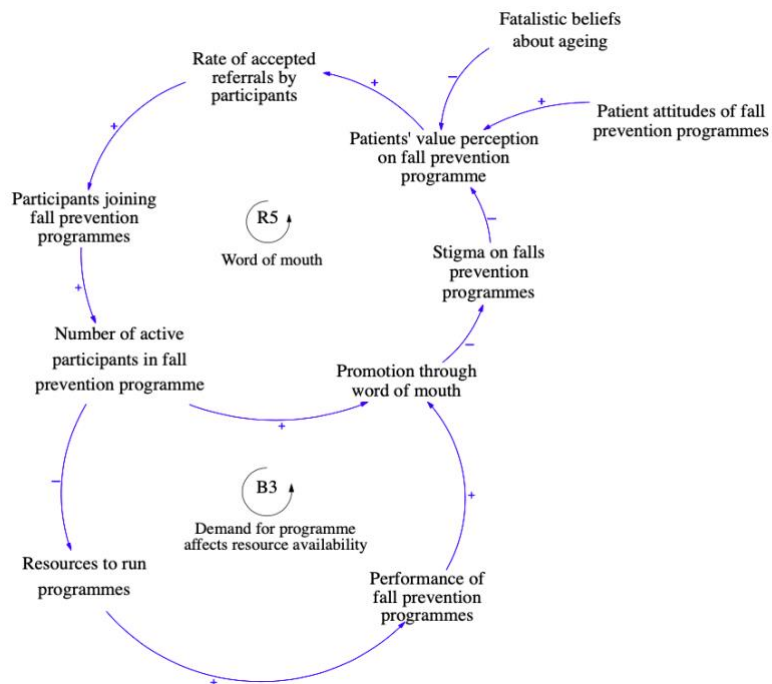
Supplementary Figure 3: Policy recommendations



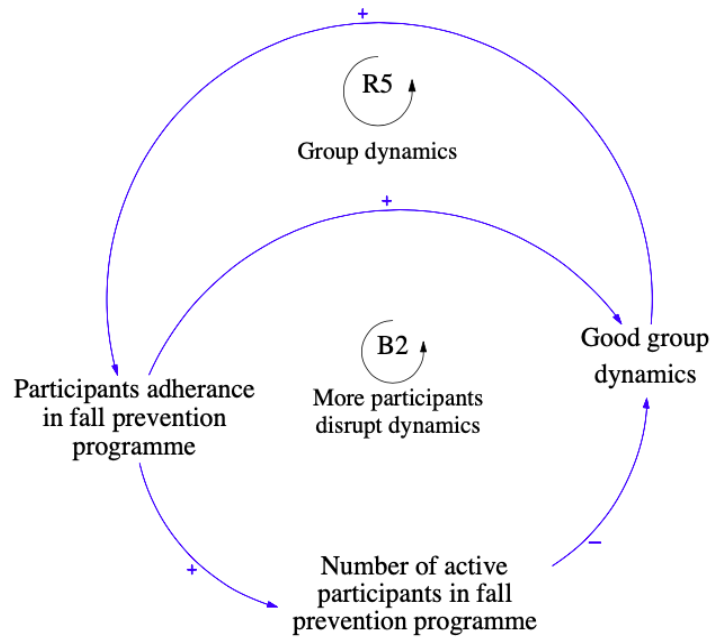
Supplementary Figure 4: Overview of variables for the concept model



Supplementary Figure 5: Resources and performance of programmes – Limits to growth archetype adapted from Braun, 2002



Supplementary Figure 6: Performance of programmes and word of mouth – Limits to growth archetype adapted from Braun, 2002

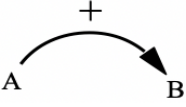

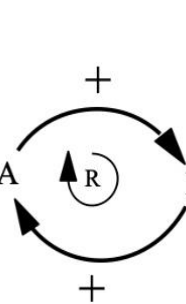
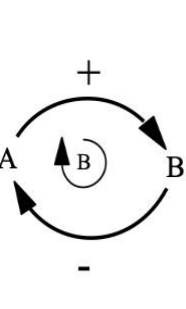


Supplementary Figure 7: Good group dynamics promote adherence to programmes, but more active participants may unintentionally disrupt group dynamics – Fixes the fail archetype adapted by Braun 2002

Tables

Agenda	Activity
Session 1	
Introduction and Overview	<ul style="list-style-type: none"> • Introduction of research team and stakeholders • Background and objectives of the GMB workshop
Persona Creation Icebreaker	<ul style="list-style-type: none"> • Introduction of the patient persona • Stakeholders were asked to share their tension points on fall prevention to create the clinician persona
GMB Exercise 1: Outcome Elicitation	<ul style="list-style-type: none"> • Stakeholders were asked to share key outcomes they were interested in regarding fall prevention and management • Vote to prioritise variables
GMB Exercise 2: Variable Elicitation	<ul style="list-style-type: none"> • Elicit factors • Coloured post-it notes were distributed for writing factors • In a round-robin fashion, each stakeholder was asked to select a variable and describe why and how it is important • Facilitators asked stakeholders to define variables and identify the causal relationship between factors • Variables were clustered on the board and later categorised into groups
Session 2	
GMB Exercise 3: Exploring Policy Options	<ul style="list-style-type: none"> • Stakeholders were asked to explore policy recommendations to target facilitators and barriers identified • Stakeholders identified bottlenecks for possible interventions to improve the implementation of fall prevention programmes
Debriefing session and Close	<ul style="list-style-type: none"> • Insights from workshop were summarised • Shared next steps of the project

Supplementary Table 1: Sequence of activities for GMB

Symbol	Definition
	<p>A positive sign “+” indicates a positive relationship between variables A and B. In this case, an increase in variable A leads to an increase in variable B; or a decrease in variable A leads to a decrease in variable B.</p>
	<p>A negative sign “-” indicates an inverse relationship between variables A and B. In this case, an increase in variable A leads to a decrease in variable B; or a decrease in variable A leads to an increase in variable B.</p>
	<p>“R” denotes that the feedback loop is a reinforcing loop. In a reinforcing loop, an increase in variable A leads to an increase in variable B, which leads to a further increase in variable A. Similarly, a decrease in variable A will also lead to a further decrease in variable A too. The reinforcing feedback loop results in exponential changes, where there may be exponential growth or decay.</p>
	<p>“B” denotes that the feedback loop is a balancing loop. In this balancing loop an increase in variable A leads to an increase in variable B, which finally results in a decrease in variable A. Similarly, a decrease in variable A will also lead to a further decrease in variable A too. Over time, a balancing loop seeks to counteract changes to the system and the feedback loop will reach an equilibrium.</p>

Supplementary Table 2: Symbols in a causal loop diagram