

Translating the Science of Frailty in Singapore: Results from the National Frailty Consensus Discussion

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Introduction

Frailty is an age-related risk state characterised by multisystem deficits with loss of physiologic reserves, which increase the vulnerability of older adults such that even trivial stressor events can lead to a higher risk of negative health-related outcomes.¹ Against the backdrop of population ageing, the prevalence of frailty in community-dwelling older adults in the Asia-Pacific region is expected to increase exponentially from the current reported figures of 3.5% to 27%.² The incremental effect on ambulatory health expenditure approximates an additional 750 Euros per person per year even for people with the very mildest degree of frailty (sometimes called ‘prefrailty’), and doubles to 1500 Euros per person per year for those with varying degrees of clinically apparent frailty.³ Not surprisingly, the burgeoning number of people living with frailty has been described as an emerging public health priority.⁴

Frail patients challenge the usual approach to care due to the complexity of their needs. The encapsulation of physical, cognitive, social, and psychological dimensions within the frailty construct is attractive from the public health perspective, as it allows the complexity of care needs to be a viable indicator of the magnitude of health and social care burden, service utilisation, and ageing well.^{5,6} However, uncertainty persists over existing definitions, concepts and how evidence can be translated into effective and impactful real-world models of care and interventions. Due to inherent challenges and limitations in definition and measurements, frailty is often not incorporated into practice-based settings or used to inform policy.^{5,7,8} This conceptual and measurement challenge compounds contextual and methodological limitations in measuring relevant outcomes within different settings in the healthcare system.⁹ Other challenges in translation to care include the exclusion of representative frail older adults from clinical trials and an evidence base underpinning frailty management that is largely derived from Europe and North America.^{2,10} Meanwhile, frailty research continues to grow in size and

complexity, frustrating attempts to arrive at meaningful consensus over a practical way forward.

In April 2018, the Chapter of Geriatricians, Society of Geriatric Medicine Singapore (SGMS), Geriatric Education & Research Institute (GERI), and Institute of Geriatrics & Ageing (IGA) convened the National Frailty Consensus Discussion. The 1-day discussion was held in conjunction with key stakeholders in the Ministry of Health, Agency for Integrated Care, Regional Health Systems and health practitioners; academic partners; community partners such as foundations, voluntary welfare organisations and social enterprises; and implementation partners. In light of the Asia-Pacific Clinical Practice Guidelines which were released in 2017,² the over-arching purpose was to discuss how the science of frailty can be translated so as to foster alignment in local policy, practice and research in contextualising the clinical practice guidelines to Singapore.

Our objectives were: 1) To describe the current state of evidence and science that can inform our action; 2) To identify gaps in local research and evaluation that can inform the future agenda; and 3) To discuss the implications for community programmes and healthcare services. During the 1-day conference, experts from the areas of practice, policy and research presented on identified key areas followed by facilitated discussion among the various stakeholders. The key findings were consolidated, summarised and agreed upon through an iterative process by the local authors (WSL, CHW, YYD and CL) of this paper, and further refined through inputs of an international expert (KR) who was an author of the Asia Pacific Clinical Practice Guidelines. We outline below the key results of the discussion.

Understanding the Science: Insights from Background Evidence

The hallmark of frailty is the decline in homeostatic reserve and resiliency that increases an individual’s vulnerability to stressors, resulting in increased risk of adverse health outcomes and/or death.¹ Frailty is multidimensional

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and represents a complex interplay between genetic, environmental, ageing, inflammatory and neuroendocrine factors that over time results in impairment of multiple inter-related systems.^{11,12} Notably, frailty is neither an inevitable consequence of ageing nor synonymous with disability or comorbidity.¹³ Frailty, disability and comorbidity can affect individuals independently or coexist in any combination;¹⁴ however, overlap is more frequent and increases with the degree of frailty.¹⁵ Reflecting its complex dynamics,¹⁶ frailty is also potentially reversible, with community studies reporting reversion rates of 13% to 32% to prefrail/non-frail states.^{17,18}

The Comprehensive Geriatric Assessment (CGA) is the recommended “gold standard” to detect and grade frailty, although the resources required are not easily available, particularly in primary care.² Clinical impression through “eyeballing” per se is inadequate, and can result in false-negatives (“under-detection”) and false-positives (“over-detection”). Therefore, frailty should be identified with validated tools,² which can be broadly conceptualised as the physical/phenotypic model¹⁹ and the deficit accumulation model.²⁰ The latter derives a frailty index (FI) from a predetermined list of 30 or more variables. Whilst laborious to collect manually, it has the potential of being computed from the increasingly routine use of electronic health records to risk-stratify the frailty state.²¹ Other validated tools include the FRAIL Scale,²² Clinical Frailty Scale (CFS),²³ Tilburg Frailty Index (TFI)²⁴ and Edmonton Frailty Scale.²⁵ These frailty instruments differ in their domains and predictive abilities and thereby are not interchangeable;²⁶ the setting can also influence their diagnostic performance.²⁷ The choice of frailty instrument should be fit-for-purpose, such that it is simple to use, well validated, and provides a language to appropriately guide goal setting and care planning in the clinical setting.² Frailty identification should not simply result in a “label”,²⁸ but impact management in a meaningful context-appropriate way that is used to make care rational and not to ration care.^{7,29}

The Lifestyle Interventions and Independence for Elders (LIFE) study corroborates the benefits of multimodal physical activity programmes (balance and flexibility, resistance training, and aerobic components) in reducing major mobility disorder in older adults; surprisingly, the effects of multimodal training were highest among those who were frail.³⁰ Evidence supports the benefit of the following interventions: 1) progressive, individualised physical activity programmes that contain a resistance training component;^{31,32} 2) reducing or deprescribing any inappropriate or superfluous medications;^{1,2} 3) screening persons with frailty for causes of fatigue;^{1,33} 4) screening for reversible causes of unintentional weight loss^{2,34} and ensuring adequate protein and caloric intake;^{1,35,36} and 5)

vitamin D supplementation for vitamin D deficiency.^{1,2} Little is known about the successful translation of evidence into real-world implementation.^{7,9} Implementers have to face the challenge of an uncontrolled real-world environment with the heterogeneity of subjects, treatments and settings.³⁷ Beyond efficacy in controlled settings, translational research is required to better understand effectiveness in real-world settings, scalability, sustainability, and dissemination.³⁸

Translating the Science: Insights from Local Evidence

The prevalence of frailty ranges from 5.7% to 6.2% among older adults in Singapore, depending on the population studied and identification tool used.³⁹⁻⁴² While these figures are comparable to those from other countries, it is useful to examine frailty in specific subpopulations defined by ethnicity and disease. For example, the prevalence of frailty was observed to be highest among Indians (10.1% compared with 5.6% and 6.6% among Chinese and Malays, respectively), and about twice the overall prevalence (11.6%) among people with diabetes mellitus.³⁹ This is an interesting finding that merits further research on mechanisms underlying these ethnic differences and their implications on a population-level approach to frailty. Of relevance, a recent scoping review of the extant scientific and grey literature from Singapore focusing on measurement of frailty suggests that its identification is influenced by the tools employed and the constructs they include.⁴³ In the final analysis, the choice of instrument will depend on clinical setting, purpose of assessment, and available resources.²⁹ In line with the Asia-Pacific guidelines,² for older adults identified as being frail, the recommended next steps include comprehensive geriatric assessment or at least clinical assessment of relevant aspects such as medication review;^{44,45} reversible causes of fatigue and unintentional weight loss (if present); and vitamin D status. In addition, clinical guidelines that are context-specific are needed for management of individuals who have been identified as frail and prefrail.^{29,46,47}

Local evidence supports the premise that frailty is reversible. In a randomised controlled trial, physical, nutritional, and cognitive interventional approaches over 6 months were found to be effective in reversing frailty among community-living older persons.⁴⁸ This positive effect persisted across 1 year and was greater when all 3 approaches were combined. Cognitive frailty—defined by the presence of both physical frailty and cognitive impairment in the absence of dementia—conferred 5- to 27-fold increased risk of adverse outcomes such as decreased quality of life, functional disability and mortality compared to robust non-cognitively impaired older adults, as opposed to corresponding risks of 1.5- to 5.5-fold in those with frailty but no cognitive impairment.⁴⁹

Moreover, mild cognitive impairment increased the risk of physical frailty and prefrailty, most uniquely due to low lean muscle mass, slow gait speed, or gait impairment.⁵⁰ This suggests that both frailty and cognitive impairment need to be identified and managed, and further research is required to understand how best to translate these findings to practical clinical approaches. Frailty is also a significant condition encountered in acute care. Among hospitalised older adults, frailty is highly prevalent (50.0%-87.1%) and predicts in-hospital mortality, prolonged length of stay, as well as death, functional decline, and institutionalisation at 1-year.^{27,51} Frailty is also an independent predictor for residual subsyndromal delirium and poorer functional recovery at 12 months postdelirium.⁵² For these reasons, detection of frailty should trigger closer postdischarge monitoring. In the acute setting, frailty can be feasibly assessed using validated instruments such as FI, FRAIL, TFI and CFS, all of which afford short- and longer-term prognostication.^{27,53} Further research to fill the practice gaps in using frailty to guide the management of hospitalised older adults is now needed.

The Science in Action: Applying the Insights

Singapore's response hitherto to the ongoing frailty movement has been both strategic and opportunistic, on the back of a number of parallel developments. At the national level, public healthcare has been reorganised into regional healthcare systems in recent years to achieve the triple aim of improving population health, enhancing experience of care, and reducing per capita cost⁵⁴ by forging a frailty-ready healthcare system across the spectrum, which includes the well healthy ("living well"), well unhealthy ("living with illness"), unwell unhealthy ("living with frailty"), and end-of-life ("dying well").²⁹ On the community front, the Healthy Living Masterplan (2013) envisages healthy living as accessible, natural and effortless for all Singaporeans through an emphasis on the physical and social environments in community settings.⁵⁵ This was followed in 2015 by the \$3 billion national 'Action Plan for Successful Ageing', which included a goal to transform the city via transport and 'Active-Ageing Hubs' into an enabling "city for all ages" for seniors to live and commute independently in their own homes or communities.⁵⁶ In recent years, there has been a surge in the network of programmes, activities and campaigns to promote physical activity and mental well-being amongst community-dwelling older adults through collaborative efforts between the Health Promotion Board and government-linked agencies such as the National Trade Union Congress (NTUC) Health and Sport Singapore.^{57,58}

Complementing these national initiatives are innovations in the delivery of exercise and nutrition in the community via philanthropic, academic and non-profit collaborations,

such as 'Gym Tonic',⁵⁹ Happy Aging Promotion Program for You (HAPPY),⁵⁷ and the Share-a-Pot programme.⁶⁰ Preliminary results from these programmes are encouraging: 1) 'Gym Tonic', a 12-week strength training programme using customised equipment and trained therapists, improved 41% and 55% of frail seniors in nursing homes and senior care centres, respectively to the prefrail state,⁵⁹ and 2) HAPPY, adapting dual-tasking exercises from the Cognicise Programme at the National Centre for Geriatrics and Gerontology (NCGG) in Nagoya, Japan, improved components of fatigue, resistance and illnesses of the FRAIL scale.⁶¹ There remains a gap in evidence regarding the effective translation of these programmes in the real-world setting. Programme evaluation and implementation research will need to incorporate appropriate frameworks and outcome measures for complex interventions to understand the mechanisms and interrelated components, which affect the efficacy, cost-effectiveness, scalability, and sustainability of these programmes.

Summary and Recommendations

Two trends underpin the ongoing transformation of healthcare systems and practice in Singapore, namely the changing needs of an ageing population that portend the epidemiologic transition towards non-communicable chronic diseases with increasingly complex healthcare needs, and a growing shift toward disease prevention and population health. Not surprisingly, policymakers and health service providers—locally and worldwide—have increasingly turned their attention toward the frailty concept to more significantly target the healthcare needs of the ageing population. For instance, the United Kingdom's "GP contract" policy initiative requires general practitioners (GPs) to identify and manage all older patients aged 65 years and older who are moderately to severely frail.⁶² In contrast, many other countries (including Singapore) have yet to systematically incorporate frailty into practice on a wider scale.

Against this backdrop, the National Frailty Consensus Discussion was convened in conjunction with key stakeholders to leverage upon the recently released Asia-Pacific Clinical Practice Guidelines to move forward the agenda of translating the science of frailty in Singapore. In summary, the current body of evidence has established that frailty represents a clinical state that is common, serious, costly and potentially preventable. From the public health perspective, frailty provides a useful construct that can be potentially applied across the spectrum of healthcare from robust, community-dwelling older adults through to end-of-life care. The body of evidence from international and local studies supports the potential of translating frailty and related concepts into real-world models of care and intervention in

a tangible way that may benefit health outcomes for older adults. This evidence base provides the foundation with which to plan and appraise ongoing and future initiatives at the national and ground level. We also identified gaps in local research that pertain largely to frailty epidemiology, identification, and evaluation of innovations and real-world implementation. We propose that these developments be viewed through the lenses of the 4A framework of agenda, ambition, alignment and action (Table 1).⁶³

To adequately respond to the multifaceted challenges posed by population ageing, a comprehensive agenda is required to address the frailty conundrum across its spectrum, ranging from the well healthy (“living well”), well unhealthy (“living with illness”), unwell unhealthy (“living with frailty”) through to end-of-life (“dying well”).²⁹ This approach transcends the ongoing debate about whether frailty is more a predisability at-risk state or a geriatric syndrome.^{9,11} Instead, frailty should be the cornerstone of health and social care systems for population ageing, integrated at multiple levels and supported by a multifactorial systems-based approach to bring together multiple stakeholders in the community, healthcare system, academia and policymaking.^{5,64} While the emphasis on preventative population health approaches is laudable, it is also important not to overlook the pressing needs of the established frail who are negotiating the healthcare system.^{65,66} A recent study using a large English inpatient database reported that frailty accounted for one-fifth of inpatients and almost half of all hospitalisation days,⁶⁷ reiterating the urgency for close attention to this at-risk group to reduce health utilisation

arising from frailty and its complications.⁸ We need to better understand how incorporating frailty tools in clinical practice can help formulate and improve the care plan for shared decision-making,⁶⁸ as well as spur innovations in the areas of admission avoidance,⁶⁹ inpatient collaborative care models such as delirium units, ortho-geriatrics services, and geriatric surgical services;⁷⁰⁻⁷² postdischarge support;²⁹ and transition to end-of-life care.⁷³

This leads to the next point about ambition. Instead of piecemeal and elaborate adhoc programmes that tend to only benefit specific segments of the at-risk population, it is important to consider integrated programmes with a potential for scalability and sustainability, either at the level of public health or integrated care models. This necessitates an alignment of frailty threshold concepts, evaluation measures, and evidence-based interventions among stakeholders, ranging from healthcare practitioners, community partners, policymakers, and academics. Specifically, in the area of frailty identification, consensus on tools for frailty identification and measurement is required, given that new instruments that demarcate frailty into physical, cognitive, psychological, and social dimensions can contribute to further confusion.^{5,74} Alignment in standardisation of measurement is needed for case definition in the community, healthcare system and policy databases, akin to the National Health Service primary care strategy in frailty for older adults aged 65 years and above, which includes standardising a frailty measure (the electronic FI) and creating an ecosystem that supports the identification and guidelines-based management of frailty.⁷⁵

What next in terms of action? A strategic approach is required to translate frailty concepts to design fit-for-purpose health and social services that would genuinely impact the health of older adults.⁶⁴ On the community front, the action has already begun in terms of translating the Asia-Pacific guidelines into evidence-based multicomponent programmes. More can be done to promote the incorporation of resistance training beyond aerobic and balance exercises in physical activity programmes.² Because older adults may find frailty a difficult concept to engage with,⁷⁶ more research is required on how best to frame and communicate the frailty concept for public education and in clinical practice. Recently, there are increasing calls to develop frailty research concurrently with health service research in order to incorporate frailty into meaningful clinical management protocols,⁵ for instance, rapid comprehensive geriatric assessment and intervention by a designated inter-professional team in acute frailty units to optimise functional outcomes, reduce length of stay and reduce readmissions.⁷⁷ In considering uptake by the system, it will be important to distinguish between tools for frailty screening and then the assessment of frailty in those who screen positive. The

Table 1. Summary of Key Points

<ul style="list-style-type: none"> • Frailty represents a clinical state that is common, serious, costly and potentially preventable.
<ul style="list-style-type: none"> • Frailty provides a useful construct that can be applied across the continuum of care from preventative, treatment to end-of-life care.
<ul style="list-style-type: none"> • More local research is required to address gaps in the evidence-base in frailty epidemiology, identification, and evaluation of innovations and real-world implementation.
<ul style="list-style-type: none"> • Key recommendations: <ol style="list-style-type: none"> 1) Comprehensive agenda that addresses the frailty conundrum across its spectrum from the robust/prefrail in the community through to established frail in the healthcare system. 2) Ambition for care models and approaches to be integrated such that impact at the level of public health can be scaled and sustained. 3) Alignment of identification measures, case definitions, and evidence-based interventions for frailty. 4) Multifaceted action, including: <ol style="list-style-type: none"> a. Public education and engagement b. Incorporating frailty into routine clinical care plans c. Enhancing research methodologies, evaluation approaches and outcomes for complex interventions d. Broad-based interdisciplinary expertise

goal is to achieve actionable, feasible, individualised and patient-centred care plans.

Regarding programme evaluation, the exclusive application of randomised controlled trials and related experimental designs may not be the most appropriate for evaluating complex interventions.^{78,79} Paralleling research developments in non-pharmacological interventions for persons with dementia,⁸⁰ understanding the complexity of frailty could benefit from the use of implementation-specific research methods such as pragmatic trials to test interventions embedded within the real-world context.⁸¹ In addition, evaluations that adopt realist approaches to uncover “what works, for whom, under what circumstances, and how?” can help build theory that links context, mechanisms and outcomes of complex multicomponent real-world interventions.^{82,83} Studies should incorporate clinically relevant and meaningful outcomes such as quality of life, cognition, physical function and psychosocial consequences,⁸⁴ and encompass plurality of methods (including the rich diversity of qualitative methods) to answer use-inspired Pasteur’s quadrant research questions.^{37,85} Lastly, as we embark on the next phase of population-wide preventative strategies, we advocate a broad-based interdisciplinary approach that integrates expertise from other fields. For instance, insights from the social and behavioural sciences can be explored to bridge the knowledge-practice gap in healthy living, optimise the behavioural affordance of an enabling environment, and address the low adherence to multicomponent interventions for frailty.⁸⁶⁻⁸⁸ Leveraging upon accessible platforms, analytics, technological advances and marketing expertise of the business and technology sectors to improve population health is another relatively untapped dimension.⁸⁹

Conclusion

In recent years, frailty has emerged as a public health priority for policymakers and practitioners worldwide. Likewise, Singapore needs to respond to the frailty conundrum in the ongoing efforts to transform healthcare to meet the needs of its rapidly ageing population. In this paper, we discussed the current international and local evidence base and the implications for translating the science of frailty in Singapore. The existing evidence for frailty appears promising and suggests that systematic and fit-for-purpose frailty identification that is linked to appropriate follow-up intervention would lead to better health outcomes of frail older adults.^{1,2} Whilst the Asia-Pacific guidelines represent a positive step in recommending clinical practice management of frailty, significant gaps in the evidence base remain regarding the implementation of these guidelines and evaluating outcomes of successful implementation in a real-world environment. There is a need for more comprehensive and coordinated inclusion of frailty into

clinical management protocols and models of care, along with more robust research and evaluation in well designed pragmatic trials which test effectiveness and build theory around complex interventions in the real-world context of Singapore’s healthcare, social and payment systems. Ultimately, these gaps within the evidence base will need to be resolved if frailty were to be established as a “real”, relevant and reachable concept that meaningfully impacts our healthcare and social systems in Singapore.⁵

Acknowledgements

The authors would like to thank the Chapter of Geriatricians; the Society of Geriatric Medicine, Singapore (SGMS); the Institute of Geriatrics and Ageing, Tan Tock Seng Hospital (TTSH) and the Geriatric Education and Research Institute (GERI) for co-hosting the National Consensus Discussion on Frailty at Changi General Hospital (CGH), Singapore. They thank the speakers and the moderators: Dr Mark Chan Peng Chew (TTSH), A/Prof Wong Wei Chin (TTSH), A/Prof Reshma Merchant (National University Hospital), Dr Rahul Malhotra (Duke-NUS Medical School), A/Prof Ng Tze Pin (GERI), Dr Laura Tay (Sengkang General Hospital), Mr Lee Poh Wah (Lien Foundation), and Dr Wong Sweet Fun (Khoo Teck Puat Hospital). They are also thankful for the exercise conversations and demonstrations throughout the meeting led by: Mr Isaiah Chng (ProAge Singapore), Ms Junisha Jamala (CGH), Mr Lutfi Zianalabidin (Sport Singapore), Ms Sharifa Norzila (Active Health, Sport SG), Ms Lee Sin Yi (Singapore Physiotherapy Association), and Mr Hedehiko Shirooka (HAPPY programme). They are also grateful to Dr Melvin Chua (Past President SGMS) and Dr Chew Aik Phon (President, SGMS) for their support in shaping this meeting, and Professor Tan Chor Chuan (Office of Transformation, Ministry of Health) for being present. Finally, they wish to thank Deputy Secretary of Health, Ms Teoh Zsin Woon for her engagement in the discussion and for her resounding support before and after the meeting, especially in the development and delivery of frailty programmes for the elderly in Singapore.

REFERENCES

1. Morley JE, Vellas B, van Kan GA, Anker SD, Bauer JM, Bernabei R, et al. Frailty consensus: a call to action. *J Am Med Dir Assoc* 2013;14:392-7.
2. Dent E, Lien C, Lim WS, Wong WC, Wong CH, Ng TP, et al. The Asia-Pacific clinical practice guidelines for the management of frailty. *J Am Med Dir Assoc* 2017;18:564-75.
3. Sirven N, Rapp T. The cost of frailty in France. *Eur J Health Econ* 2017;18:243-53.
4. Cesari M, Prince M, Thiyagarajan JA, De Carvalho IA, Bernabei R, Chan P, et al. Frailty: an emerging public health priority. *J Am Med Dir Assoc* 2016;17:188-92.
5. Woo J. Challenges of population ageing: putting frailty as a cornerstone of health and social care systems. *Eur Geriatr Med* 2018;9:273-6.
6. Woo J, Leung J, Zhang T. Successful aging and frailty: opposite sides of the same coin? *J Am Med Dir Assoc* 2016;17:797-801.

7. Rodriguez-Manas L, Fried LP. Frailty in the clinical scenario. *Lancet* 2015;385:e7-9.
8. Searle SD, Rockwood K. What proportion of older adults in hospital are frail? *Lancet* 2018;391:1751-2.
9. Sloane PD, Cesari M. Research on frailty: continued progress, continued challenges. *J Am Med Dir Assoc* 2018;19:279-81.
10. Holroyd-Leduc J, Resin J, Ashley L, Barwich D, Elliott J, Huras P, et al. Giving voice to older adults living with frailty and their family caregivers: engagement of older adults living with frailty in research, health care decision making, and in health policy. *Res Involv Engagem* 2016;2:23.
11. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. *Lancet* 2013;381:752-62.
12. Walston JD. Frailty. In: *Geriatrics for specialists*. Springer; 2017. p. 3-12.
13. Wong CH, Weiss D, Sourial N, Karunanathan S, Quail JM, Wolfson C, et al. Frailty and its association with disability and comorbidity in a community-dwelling sample of seniors in Montreal: a cross-sectional study. *Aging Clin Exp Res* 2010;22:54-62.
14. Fried LP, Ferrucci L, Darer J, Williamson JD, Anderson G. Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. *J Gerontol A Biol Sci Med Sci* 2004;59:255-63.
15. Theou O, Rockwood MR, Mitnitski A, Rockwood K. Disability and co-morbidity in relation to frailty: how much do they overlap? *Arch Gerontol Geriatr* 2012;55:e1-8.
16. Mitnitski AB, Rutenberg AD, Farrell S, Rockwood K. Aging, frailty and complex networks. *Biogerontology* 2017;18:443-6.
17. Chong MS, Tay L, Chan M, Lim WS, Ye R, Tan EK, et al. Prospective longitudinal study of frailty transitions in a community-dwelling cohort of older adults with cognitive impairment. *BMC Geriatr* 2015;15:175.
18. Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. *Arch Intern Med* 2006;166:418-23.
19. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 2001;56:M146-56.
20. Mitnitski AB, Mogilner AJ, Rockwood K. Accumulation of deficits as a proxy measure of aging. *ScientificWorldJournal* 2001;1:323-36.
21. Clegg A, Bates C, Young J, Ryan R, Nichols L, Ann Teale E, et al. Development and validation of an electronic frailty index using routine primary care electronic health record data. *Age Ageing* 2016;45:353-60.
22. Morley JE, Malmstrom TK, Miller DK. A simple frailty questionnaire (FRAIL) predicts outcomes in middle aged African Americans. *J Nutr Health Aging* 2012;16:601-8.
23. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, et al. A global clinical measure of fitness and frailty in elderly people. *CMAJ* 2005;173:489-95.
24. Gobbens RJ, van Assen MA, Luijckx KG, Wijnen-Sponselee MT, Schols JM. The Tilburg Frailty Indicator: psychometric properties. *J Am Med Dir Assoc* 2010;11:344-55.
25. Rolfson DB, Majumdar SR, Tsuyuki RT, Tahir A, Rockwood K. Validity and reliability of the Edmonton Frail Scale. *Age Ageing* 2006;35:526-9.
26. Buta BJ, Walston JD, Godino JG, Park M, Kalyani RR, Xue QL, et al. Frailty assessment instruments: systematic characterization of the uses and contexts of highly-cited instruments. *Ageing Res Rev* 2016;26:53-61.
27. Chong E, Ho E, Baldevarona-Llego J, Chan M, Wu L, Tay L, et al. Frailty in hospitalized older adults: comparing different frailty measures in predicting short- and long-term patient outcomes. *J Am Med Dir Assoc* 2018;19:450-7e3.
28. McTighe J. Three key questions on measuring learning. *Educational Leadership* 2018;75:14-20.
29. Lim WS, Wong SF, Leong I, Choo P, Pang WS. Forging a frailty-ready healthcare system to meet population ageing. *Int J Environ Res Public Health* 2017;14:1448.
30. Pahor M, Guralnik JM, Ambrosius WT, Blair S, Bonds DE, Church TS, et al. Effect of structured physical activity on prevention of major mobility disability in older adults: The LIFE study randomized clinical trial. *JAMA* 2018;311:2387-96.
31. Bauman A, Merom D, Bull FC, Buchner DM, Fiatarone Singh MA. Updating the evidence for physical activity: summative reviews of the epidemiological evidence, prevalence, and interventions to promote "active aging". *Gerontologist* 2016;56 Suppl 2:S268-80.
32. Theou O, Stathokostas L, Roland KP, Jakobi JM, Patterson C, Vandervoort AA, et al. The effectiveness of exercise interventions for the management of frailty: a systematic review. *J Aging Res* 2011;2011:569194.
33. Inouye SK, Studenski S, Tinetti ME, Kuchel GA. Geriatric syndromes: clinical, research, and policy implications of a core geriatric concept. *J Am Geriatr Soc* 2007;55:780-91.
34. Morley JE. Undernutrition in older adults. *Fam Pract* 2012;29 Suppl 1:i89-93.
35. Bauer J, Biolo G, Cederholm T, Cesari M, Cruz-Jentoft AJ, Morley JE, et al. Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group. *J Am Med Dir Assoc* 2013;14:542-59.
36. Milne AC, Potter J, Vivanti A, Avenell A. Protein and energy supplementation in elderly people at risk from malnutrition. *Cochrane Database Syst Rev* 2009:CD003288.
37. Lim WS, Ding Y. Evidence-balanced medicine: "real" evidence-based medicine in the elderly. *Ann Acad Med Singapore* 2015;44:1-5.
38. Werner-Seidler A, Perry Y, Christensen H. An Australian example of translating psychological research into practice and policy: where we are and where we need to go. *Front Psychol* 2016;7:200.
39. Merchant RA, Chen MZ, Tan LWL, Lim MY, Ho HK, van Dam RM. Singapore Healthy Older People Everyday (HOPE) Study: prevalence of frailty and associated factors in older adults. *J Am Med Dir Assoc* 2017;18:734.e9-e14.
40. Vaingankar JA, Chong SA, Abdin E, Picco L, Chua BY, Shafie S, et al. Prevalence of frailty and its association with sociodemographic and clinical characteristics, and resource utilization in a population of Singaporean older adults. *Geriatr Gerontol Int* 2017;17:1444-54.
41. Wei K, Nyunt MSZ, Gao Q, Wee SL, Ng TP. Frailty and malnutrition: related and distinct syndrome prevalence and association among community-dwelling older adults: Singapore Longitudinal Ageing Studies. *J Am Med Dir Assoc* 2017;18:1019-28.
42. Ge L, Yap CW, Heng BH. Prevalence of frailty and its association with depressive symptoms among older adults in Singapore. *Aging Ment Health* 2018;1-6.
43. Bautista MA, Malhotra R. Identification and Measurement of Frailty: A Scoping Review of Published Research from Singapore. *Ann Acad Med Singapore* 2018;47:455-91.
44. Lim WS, Low HN, Chan SP, Chen HN, Ding YY, Tan TL. Impact of a pharmacist consult clinic on a hospital-based geriatric outpatient clinic in Singapore. *Ann Acad Med Singapore* 2004;33:220-7.
45. Mamun K, Lien CT, Goh-Tan CY, Ang WS. Polypharmacy and inappropriate medication use in Singapore nursing homes. *Ann Acad Med Singapore* 2004;33:49-52.
46. Chan KM, Pang WS, Ee CH, Ding YY, Choo P. Self-perception of health among elderly community dwellers in Singapore. *Ann Acad Med Singapore* 1998;27:461-7.
47. Joshi VD, Malhotra R, Lim JF, Ostbye T, Wong M. Validity and reliability of the expectations regarding aging (ERA-12) instrument among middle-aged Singaporeans. *Ann Acad Med Singapore* 2010;39:394-8.
48. Ng TP, Feng L, Nyunt MS, Feng L, Niti M, Tan BY, et al. Nutritional, physical, cognitive, and combination interventions and frailty reversal among older adults: a randomized controlled trial. *Am J Med* 2015;128:1225-36.e1.

49. Feng L, Zin Nyunt MS, Gao Q, Yap KB, Ng TP. Cognitive frailty and adverse health outcomes: findings from the Singapore Longitudinal Ageing Studies (SLAS). *J Am Med Dir Assoc* 2017;18:252-8.
50. Nyunt MSZ, Soh CY, Gao Q, Gwee X, Ling ASL, Lim WS, et al. Characterisation of physical frailty and associated physical and functional impairments in mild cognitive impairment. *Front Med (Lausanne)* 2017;4:230.
51. Wu HY, Sahadevan S, Ding YY. Factors associated with functional decline of hospitalised older persons following discharge from an acute geriatric unit. *Ann Acad Med Singapore* 2006;35:17-23.
52. Chew J, Lim WS, Chong MS, Ding YY, Tay L. Impact of frailty and residual subsyndromal delirium on 1-year functional recovery: a prospective cohort study. *Geriatr Gerontol Int* 2017;17:2472-8.
53. Chong E, Ho E, Baldevarona-Llego J, Chan M, Wu L, Tay L. Frailty and risk of adverse outcomes in hospitalized older adults: A comparison of different frailty measures. *J Am Med Dir Assoc* 2017;18:638.e7-11.
54. Berwick DM, Nolan TW, Whittington J. The triple aim: care, health, and cost. *Health Aff (Millwood)* 2008;27:759-69.
55. Ministry of Health, Singapore. Healthy Living Master Plan. Available at: https://www.moh.gov.sg/content/dam/moh_web/Publications/Reports/2014/HLMP/MOH_Healthy%20Living%20Master%20Plan_Inside%20Page_8d.pdf. Accessed on 30 July 2018.
56. Ministry of Health, Singapore. Action Plan for Successful Aging. 2016. Available at: https://www.moh.gov.sg/content/dam/moh_web/SuccessfulAgeing/action-plan.pdf. Accessed on 30 July 2018.
57. Health Promotion Board. New exercise campaign to encourage active living among seniors, including those with reduced mobility. 2017. Available at: <https://www.hpb.gov.sg/article/new-exercise-campaign-to-encourage-active-living-among-seniors-including-those-with-reduced-mobility>. Accessed on 30 July 2018.
58. Activesg. Be a Sport Volunteer. Available at: <https://www.myactivesg.com/whats-on/team-nila-sport-volunteer-drive>. Accessed on 30 July 2018.
59. Gym Tonic. Exercise as medicine. Available at: www.gymtonic.sg. Accessed on 30 July 2018.
60. Wong SF. Building Health Systems to Support Physical Activity & Active Ageing. 12 August 2016. Proceedings of the Asia Pacific Geriatric Conference; Singapore.
61. Straits Times. Happy hour helps seniors delay frailty and disability. 2017. Available at: <https://www.straitstimes.com/singapore/health/happy-hour-helps-seniors-delay-frailty-and-disability>. Accessed on 30 July 2018.
62. Chapman S, Thomas S. Falls and the rise of the GP contract: An EMIS web protocol and template to help identify frail patients. *Br J Community Nurs* 2017;22:554-6.
63. Teoh ZW. 9 April 2018. Proceedings of Translating the Science of Frailty in Singapore: A National Consensus Discussion; Singapore.
64. Woo J. Designing fit for purpose health and social services for ageing populations. *Int J Environ Res Public Health* 2017;14:457.
65. Sahadevan S, Earnest A, Koh YL, Lee KM, Soh CH, Ding YY. Improving the diagnosis related grouping model's ability to explain length of stay of elderly medical inpatients by incorporating function-linked variables. *Ann Acad Med Singapore* 2004;33:614-22.
66. Wong WC, Sahadevan S, Ding YY, Tan HN, Chan SP. Resource consumption in hospitalised, frail older patients. *Ann Acad Med Singapore* 2010;39:830-6.
67. Gilbert T, Neuburger J, Kraindler J, Keeble E, Smith P, Ariti C, et al. Development and validation of a hospital frailty risk score focusing on older people in acute care settings using electronic hospital records: an observational study. *Lancet* 2018;391:1775-82.
68. Theou O, Squires E, Mallery K, Lee JS, Fay S, Goldstein J, et al. What do we know about frailty in the acute care setting? A scoping review. *BMC Geriatr* 2018;18:139.
69. Foo CL, Siu VW, Ang H, Phuah MW, Ooi CK. Risk stratification and rapid geriatric screening in an emergency department - a quasi-randomised controlled trial. *BMC Geriatr* 2014;14:98.
70. Chong MS, Chan MP, Kang J, Han HC, Ding YY, Tan TL. A new model of delirium care in the acute geriatric setting: geriatric monitoring unit. *BMC Geriatr* 2011;11:41.
71. Ramason R, Chong MS, Chan W, Rajamoney GN. Innovations in hip fracture care: a comparison of geriatric fracture centers. *J Am Med Dir Assoc* 2014;15:232-3.
72. Chia CL, Mantoo SK, Tan KY. 'Start to finish trans-institutional transdisciplinary care': a novel approach improves colorectal surgical results in frail elderly patients. *Colorectal Dis* 2016;18:O43-50.
73. Hum AYM, Wu HY, Ali NB, Leong I, Chin JJ, Lee A, et al. The dignity in advanced dementia (diadem) study: developing an integrated geriatric palliative homecare program. *Progress in Palliative Care* 2018;26:65-72.
74. Morley JE. Cognitive frailty: A new geriatric syndrome? *Eur Geriatr Med* 2015;5:408-11.
75. Supporting routine frailty identification and frailty through the GP Contract 2017/2018. Available at: <https://www.england.nhs.uk/publication/supporting-routine-frailty-identification-and-frailty-through-the-gp-contract-20172018/>. Accessed on 30 July 2018.
76. Archibald MM, Ambagtsheer R, Beilby J, Chegade MJ, Gill TK, Visvanathan R, et al. Perspectives of frailty and frailty screening: protocol for a collaborative knowledge translation approach and qualitative study of stakeholder understandings and experiences. *BMC Geriatr* 2017;17:87.
77. Atkins A, Egbe M, Kallat A. Modernising geriatric care: establishing an acute frailty unit. *Future Hospital Journal* 2015;2:s25.
78. Blackwood B, O'halloran P, Porter S. On the problems of mixing RCTs with qualitative research: the case of the MRC framework for the evaluation of complex healthcare interventions. *J Nurs Educ* 2010;15:511-21.
79. Van Belle S, Rifkin S, Marchal B. The challenge of complexity in evaluating health policies and programs: the case of women's participatory groups to improve antenatal outcomes. *BMC Health Serv Res* 2017;17:268.
80. Baier RR, Mitchell SL, Jutkowitz E, Mor V. Identifying and supporting nonpharmacological dementia interventions ready for pragmatic trials: results from an expert workshop. *J Am Med Dir Assoc* 2018;19:560-2.
81. Gibbons M. Mode 2 society and the emergence of context-sensitive science. *Science and Public Policy* 2000;27:159-63.
82. Pawson R. The realist foundations of evidence-based medicine: A review essay. *Evaluation* 2018;24:42-50.
83. Vareilles G, Pommier J, Kane S, Pictet G, Marchal B. Understanding the motivation and performance of community health volunteers involved in the delivery of health programs in Kampala, Uganda: a realist evaluation protocol. *BMJ Open* 2015;5:e006752.
84. Theou O, Searle SD. Using frailty tools as prognostic markers in patients who are acutely ill. *CMAJ* 2018;190:E182-3.
85. Stokes DE. Pasteur's quadrant – basic science and technological innovation. Washington, DC: Brookings Institution Press; 1997.
86. Abbasi J. New strategic plan for behavioral and social sciences research. *JAMA* 2017;317:350.
87. Stolte E, Hopman-Rock M, Aartsen MJ, van Tilburg TG, Chorus A. The theory of planned behavior and physical activity change: outcomes of the Aging Well and Healthily Intervention Program for Older Adults. *J Aging Phys Act* 2017;25:438-45.
88. Yu R, Wang D, Leung J, Lau K, Kwok T, Woo J. Is neighborhood green space associated with less frailty? Evidence from the Mr. and Ms. Os (Hong Kong) study. *J Am Med Dir Assoc* 2018;19:528-34.
89. Stey A, Kanzaria H, Brook R. How disruptive innovation by business and technology firms could improve population health. *JAMA* 2018;320:973-4.