COST-EFFECTIVENESS ANALYSIS OF A MULTIFACTORIAL FALL PREVENTION INTERVENTION VERSUS USUAL HOME CARE FOR COMMUNITY-DWELLING OLDER HOME CARE CLIENTS AT RISK OF FALLING IN CANADA

1.0 INTRODUCTION

Falls among older people is a major health problem as it is the leading cause of their death (Pérula et al., 2012). About one out of every four falls causes physical injuries (Pérula et al., 2012). One-third of people over 65 years living in the community fall at least once per year (Fairhall et al., 2014). Numerous trials and research studies have focused on falls over the years because of the aging population and the growing awareness of the mortality and morbidity associated with it (Gates et al., 2008). Falls are caused mainly by personal and environmental factors (Tinetti et al., 1994); hence they are preventable when strategies are developed to modify these factors. This has led to four fall prevention trials: multiple factors, systems intervention; multiple factors, specific interventions; multiple factors, single intervention and single factor, single intervention trials (Campbell and Robertson, 2006) to reduce falls. Assessing the cost-effectiveness of these interventions is relevant to decision- and policy-makers in allocating scarce resources and attaining value for money.

There is mixed evidence on the cost-effectiveness of most of these interventions in the literature. Isaranuwatchai et al. (2017) used a net benefit framework and OLS regression to examine the cost-effectiveness of multifactorial fall (MF) prevention interventions versus usual care, and they found that MF is not cost-effective. They found that MF is cost-effective for the young-old group when Willingness-to-pay (WTP) ≥ CAD 25 000 and for the old-old group when WTP ≤ CAD 1000 in their subgroup analysis. Jenkyn et al. (2012) also used the incremental cost-effectiveness ratio (ICER) and the net benefit framework to examine the cost-effectiveness of the MF prevention program. They found no evidence of cost-effectiveness of the MF intervention. Rizzo et al. (1996) and Beard et al. (2006) found that fall prevention programs are cost-effective. These studies did not examine the effect of gender on the cost-effectiveness of fall prevention programs, and most of them measured effectiveness with the number of falls. Further studies using different methods, perspectives, and subgroup analysis is required.

This study argues that even though the number of falls is a good measure of effectiveness, it may be essential to explore self-reported health scores. For instance, fall prevention interventions prevent falls and reduce tiredness, stress, and even improve health status by modifying personal and environmental causes of falls. Moreover, a fall may be captured in a self-reported health score, but improved health may not be captured in the number of falls a person experiences. Thus, this study intends to explore self-reported health score as a measure of effectiveness.

Research studies have shown that gender matters in fall prevention programs (Kelsey et al., 2012). Women have a higher risk of falling relative to men because of their greater intake of psychotropic medication and plausible higher weight-to-strength ratio (Campbell and Robertson, 2006). This study, therefore, attempts to add to the literature by exploring the cost-effectiveness of MF interventions taking into consideration gender.

1.1 Research Questions

The study intends to fill the gap in the literature by asking and exploring the questions:

- Is MF prevention intervention cost-effective relative to usual home care (UC) in Canada?
- Does gender affect the cost-effectiveness of the MF intervention relative to UC in Canada?

1.2 Research objective

Generally, the study contributes to the Sustainable Development Goal 3 (8) of achieving universal health coverage without leaving anyone behind as it examines interventions that make essential health care services available to the aged. Specifically, the study examines:

- A cost-effectiveness analysis of MF versus UC for community-dwelling older home care clients (≥75years) "at risk" of falling in Canada.
- The effect of gender on the cost-effectiveness of the intervention versus UC.

The study is divided into introduction, methods and analysis, results, discussion, and conclusion. Introduction includes research questions and objectives. Methods and analysis include the sources of data, study design, and statistical analysis and economic evaluation. Results reports the findings of the study. Discussion explains the findings and conclusion provides a summary of the study.

2.0 METHODS AND ANALYSIS

The study employed the following methods and analysis to achieve its goals.

2.1 Study Design

The clinical trial considered in the study was a randomized control trial (RCT) which included 100 older adults ($\geq$ 75 years) using home support services and were randomized to the MF intervention or UC. The intervention (i.e., MF) was an 8-week multifactorial health program, starting from baseline. The eligibility criteria and details of the MF intervention considered in the study are similar to the Tinetti et al. (1994) article. The MF intervention included but was not limited to hand clenching and raised bed heads and toilet seats, education on the appropriate use of sedatives, environmental changes such as grab bars installation, and balance exercises which were supervised by a nurse or physical therapist.

2.2 Aims and Outcomes

The main aim of the trial used in the study was to determine whether MF is superior to UC in preventing falls of older home care clients. The primary clinical outcome was a self-reported health score (ranging from 0 to 100, with 100 being the best possible health), measured six months after baseline. The secondary outcome of the trial was the estimated cost difference between MF and UC. An economic evaluation, approved by the ethics committees, was planned alongside the RCT conducted in Canada in 2020.

2.3 Variables and Measures

The cost-effectiveness analysis conducted in the study was from the societal perspective. Costs including medications, overhead costs, and out-of-pocket expenses for the health care services were all measured in Canadian dollars. Baseline and follow-up costs and effects were ascertained before randomization and after randomization, respectively. Effectiveness for the MF intervention and UC group in the RCT was measured, asking the participants the following question: Choosing a number from 0 to 100, where 0 is the worst possible health and 100 is the best possible health, how healthy are you?

2.4 Statistical analysis and Economic evaluation

Stata statistical software package (version 14.0; StataCorp LLC, College Station, Texas) was used to conduct the economic analysis. The Chi-square test for dummy variables and Student's t-test (two-tailed) for continuous variables were conducted in the study to compare the characteristics of the MF intervention and UC group. The study built, estimated, and analyzed a net benefit framework for MF versus UC for each participant using (1) the total sample and (2) gender subgroups (i.e., male and female). The analysis using the total sample included all regressors, but the *sex* variable was removed from the subgroup analysis. The net benefit (NB) framework employed in the study was:

$$NB_i=\lambda \, \Delta E - \Delta C=\beta_0 + \beta_1 M_i + \beta_2 X_i + \varepsilon_i \ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where NB represents the dependent variable and denotes the net benefit per person. ΔE and ΔC represent the difference in effectiveness, and the total cost for MF versus UC per person, respectively. λ is the willingness-to-pay (WTP). Six WTP values are used to calculate the Net benefit values for each participant, ranging from 0 to CAD 50,000. Ordinary least-square (OLS) regression is undertaken using equation (1) for each of the six WTP values separately since each participant had a specific NB value for each WTP. The WTP denotes the implicit monetary value that decision-makers are willing to pay to produce a particular health outcome (i.e., health scores; Isaranuwatchai et al., 2017). Effectiveness per person is measured as the self-reported health score (ranging from 0 to 100, with 100 being the best possible health) at six months after baseline. Total cost per person is estimated by multiplying the number of units of service and unit cost. Costs are measured using the Health and Social Services Utilization Inventory (HSSUI) as it is reliable and assesses costs from a societal perspective (Isaranuwatchai et al., 2017). HSSUI includes six direct health care domains: emergency department and specialists, primary care, social care and other health professionals, drug prescriptions and lab services (Isaranuwatchai et al., 2017). M_i represents the main regressor (i.e., MF) or the treatment group. M_i denotes a dummy variable that takes 1 if the participant is in the treatment group and 0 if otherwise. X_i denotes all other independent variables such as age and sex. β_0, β_1, and β_2 are the parameters where β_1 denotes the incremental net benefit (INB) at the various WTP values used in the regression. The MF intervention is deemed cost-effective relative to the usual care if INB is greater than zero (INB>0) and the converse is true. ε is the error term.

3.0 RESULTS

The economic evaluation in the study followed the International Society for Pharmacoeconomics and Outcomes Research guideline for trial-based cost-effectiveness analysis (Ramsey et al., 2005) and their consolidated health economic evaluation reporting standards guideline (Husereau et al., 2013). Table 1 describes and compares the characteristics of the participants between MF intervention and the UC groups for the 100 participants who completed the Six-month follow-up and the *sex* subgroup analysis in the study. Males were 58% and 46% in the intervention and UC group, respectively. Mean age was higher in the UC group relative to the intervention group for both the total sample and the *sex* subgroup.

3.1 *Cost-effectiveness*

Table 2 summarizes the cost-effectiveness results for the total sample and the *sex* subgroup at the various WTP values. The MF intervention was cost-effective with WTP to attain one additional health score ≥ CAD 250 for the total sample. When WTP per unit health score was zero, INB was negative in the total sample. At higher WTP per unit health score values, the INB values increased for both the total sample and *sex* subgroup analysis. For instance, at WTP of CAD 5 000 to attain one additional health score, the INB was CAD 27 487.03 (total sample), CAD 410.12 (male group), and CAD 55 147.25 (female group). When WTP increased to CAD 50 000 per unit health score, the INB increased to CAD 283 597.2 (total sample), CAD 21 414.58 (male group), and CAD 549 242.1 (female group). All INB values were positive for the female subgroup analysis. Thus, the intervention was cost-effective for the female subgroup with WTP to attain one additional health score ≥ CAD 0. INB values were positive (i.e., cost-effective MF intervention) in the men's subgroup analysis only when WTP to attain one additional health score was ≥ CAD 5000.

3.2 *Sensitivity Analysis*

The study accounted for sampling and parameter uncertainty by undertaking a sensitivity analysis captured in the Cost-effectiveness acceptability curve (see Figure 1) and the Cost-effectiveness plane (see Figure 2). The CEAC from bootstrapped net benefits through 1000 replications drawn from the cost and effectiveness at the participant level is presented in Figure 1 as the probability that the MF intervention is cost-effective at various WTP thresholds (i.e., for the total sample).

The probability that the intervention is cost-effective (i.e., for the total sample) ranged from 37% to 96% at the various WTP values, ranging from CAD 0-50 000. An increase of the WTP value from CAD 250 to CAD 2 000 increased the probability that the MF intervention is cost-effective from 55% to 92%. When the WTP per one health score gained is less than CAD 5 000, the probability that the MF intervention is cost-effective is likely to be less than 95%.

4.0 DISCUSSION

In the economic evaluation study, the intervention was cost-effective for the total sample when WTP per health score was ≥ CAD 250. Gender had a significant impact on cost-effectiveness. At a WTP ≥ CAD 0 and WTP ≥ CAD 5 000, the intervention was cost-effective for females and males, respectively. The study concurred with the agreement in the literature that women are more receptive to fall prevention interventions than men (Sandlund et al., 2018) as fear of falling is more common in women than in men (Yu Mei and El Fakiri, 2015). The study adds to the mixed evidence on the cost-effectiveness of fall prevention interventions in the literature (Rizzo et al., 1996; Beard et al., 2006; Jenkyn et al., 2012 and Isaranuwatchai et al., 2017) . The study concurred with Rizzo et al. (1996) and Beard et al. (2006), but it did not concur with Isaranuwatchai et al. (2017), who found that MF intervention was not cost-effective for the total sample, necessitating further inquiry and research, especially for longer time horizons. This is the only research that explored gender subgroup analysis to the extent of my knowledge. If most studies that found no evidence for MF intervention had done gender subgroup analysis, they would have found that the intervention is very cost-effective to females.

This study found that the cost-effectiveness of the MF intervention depends largely on the WTP and decision-makers' decisions. Thus, decision-makers can target a particular group or subgroup and reallocate resources to ensure value for money to implement the intervention. The novelty and strength of the study are that it used self-reported health score to measure effectiveness, while most studies, including Isaranuwatchai et al. (2017), used the number of falls. Thus, a patient in the MF intervention may not fall but feel better from adjusting bed heads and environmental alterations. Falls are more likely to occur among older people, and hence using them as participants in the study was relevant. The net benefit framework employed in the study allowed for analyzing the effect of gender on the cost-effectiveness of the intervention. The study had several limitations. The short time horizon was a limitation. The self-reported health score could possess an inherent report bias where respondents over- or under-estimate their health status. The number of participants involved in the trial was small (n=100). Researchers and decision-makers could explore the specific strategies/activities within the MF intervention that provides relatively greater benefits and leverage on that to improve the cost-effectiveness of the intervention, especially to men.

5.0 **CONCLUSION**

In conclusion, though the intervention is cost-effective (WTP≥ CAD 250), it would depend on gender/sex and decision-makers' WTP. Examining the effect of gender on the cost-effectiveness of the intervention guides decision-makers in reallocating resources to either improve total health or reduce inequality by making the intervention cost-effective to men.

REFERENCES

Beard, J., Rowell, D., Scott, D., Van Beurden, E., Barnett, L., Hughes, K., and Newman, B. (2006). Economic analysis of a community-based falls prevention program. *Public health*, *120*(8), 742-751.

Campbell, A. J. and, and Robertson, M. C. (2006). Implementation of multifactorial interventions. 60–64. https://doi.org/10.1093/ageing/afl089

Fairhall, N. Catherine Sherrington, Stephen R. Lord, Susan E. Kurrle, Colleen Langron Keri Lockdown, Noeline Monaghan, and Christina Aggar, I. D. C. (2014). Effect of a multifactorial , interdisciplinary intervention on risk factors for falls and fall rate in frail older people : a randomised controlled trial. December 2013, 616–622. https://doi.org/10.1093/ageing/aft204

Gates, S., Fisher, J. D., Cooke, M. W., Carter, Y. H., and Lamb, S. E. (2008). Multifactorial assessment and targeted intervention for preventing falls and injuries among older people in community and emergency care settings: systematic review and meta-analysis. *BMJ*, *336*(7636), 130-133.

Husereau, D., Drummond, M., Petrou, S., Carswell, C., Moher, D., Greenberg, D., Augustovski, F., Briggs, A. H., Mauskopf, J., and Loder, E. (2013). Consolidated health economic evaluation reporting standards (CHEERS) statement. *International Journal of Technology Assessment in Health Care*, *29*(2), 117–122. https://doi.org/10.1017/S0266462313000160

Isaranuwatchai, W., Perdrizet, J., Markle-Reid, M., and Hoch, J. S. (2017). Cost-effectiveness analysis of a multifactorial fall prevention intervention in older home care clients at risk for falling. *BMC Geriatrics*, *17*(1), 1–7. https://doi.org/10.1186/s12877-017-0599-9

Jenkyn, K. B., Hoch, J. S., and Speechley, M. (2012). How much are we willing to pay to prevent a fall? Cost-effectiveness of a multifactorial falls prevention program for community-dwelling older adults. *Canadian Journal on Aging*. *31*(2), 121-137.

Kelsey, J. L., Procter-gray, E., Hannan, M. T., and Li, W. (2012). Heterogeneity of Falls Among Older Adults : Implications for Public Health Prevention. 102(11). https://doi.org/10.2105/AJPH.2012.300677

Pérula, L. A., Varas-fabra, F., Rodríguez, V., Ruiz-moral, R., Fernández, A., J., González, J., Pérula, C., J., and Roldán, A., M. (2012). Effectiveness of a Multifactorial Intervention Program to Reduce Falls Incidence Among Community-Living Older Adults : A Randomized

Controlled Trial. *YAPMR*, *93*(10), 1677–1684. https://doi.org/10.1016/j.apmr.2012.03.035

Ramsey, S., Willke, R., Briggs, A., Brown, R., Buxton, M., Chawla, A., Cook, J., Glick, H., Liljas, B., Petitti, D., and Reed, S. (2005). Good research practices for cost-effectiveness analysis alongside clinical trials: The ISPOR RCT-CEA Task Force report. *Value in Health*, *8*(5), 521–533. https://doi.org/10.1111/j.1524-4733.2005.00045.

Rizzo, J. A., Baker, D. I., McAvay, G., and Tinetti, M. E. (1996). The cost-effectiveness of a multifactorial targeted prevention program for falls among community elderly persons. *Medical care*, 954-969.

Sandlund, M., Pohl, P., Ahlgren, C., Skelton, D. A., Melander-wikman, A., Bergvall-kåreborn, B., and Lundin-Olsson, L. (2018). Gender Perspective on Older People ' s Exercise Preferences and Motivators in the Context of Falls Prevention : A Qualitative Study. 2018. https://doi.org/10.1155/2018/6865156

Tinetti, M. E., Baker, D. I., McAvay, G., Claus, E. B., Garrett, P., Gottschalk, M., Koch, M. L., Trainor, K., and Horwitz, R. I. (1994). A multifactorial intervention to reduce the risk of falling among elderly people living in the community. 331(13).

Yu Mei, O., and El Fakiri, F. (2015). Gender differences in risk factors for single and recurrent falls among the community-dwelling elderly. *SAGE Open*, *5*(3).

APPENDIX

Table 1 Characteristics of Participants for the total and by *sex* subgroups.

Participant Characteristics	Total sample, both sexes (n=100)		Male group (n=52)		Female group (n=48)	
	Intervention (n=50)	Usual care (n=50)	Intervention (n=29)	Usual care (n=23)	Intervention (n=21)	Usual care (n=27)
Mean age in years ± SD (approximately)	77 ± 84	80 ± 88	77 ± 83	80 ± 88	76± 85	80 ± 88
Male (%)	58%	46%	100%	100%	0%	0%

Table 2 Incremental net benefits for six willingness-to-pay values to prevent a fall for the total sample and by *sex* subgroups.

WTP (CAD)	Total sample, both sexes (n=100) [a]		MALE GROUP (n=52) [b]		FEMALE GROUP (n=48) [b]	
	INB of intervention (CAD) [95% CI]	P-VALUE	INB of intervention (CAD) [95% CI]	P-VALUE	INB of intervention (CAD) [95% CI]	P-VALUE
0	-969.65 [-7448.185 to 5508.87]	0.767	-1923.717 [-12049.69 to 8202.253]	0.704	247.8321 [-8316.099 to 8811.763]	0.954
250	453.17 [-6448.841 to 7355.199]	0.897	-1807.026 [-12548.07 to 8934.022]	0.737	2992.803 [-6143.379 to 12128.99]	0.513
500	1876.01 [-5776.466 to 9528.49]	0.628	-1690.33 [-13540.52 to 10159.86]	0.776	5737.774 [-4406.058 to 15881.61]	0.261
2000	10413.02 [-4899.476 to 25725.51]	0.180	-990.18 [-24387.44 to 22407.07]	0.933	22207.6 [1842.622 to 42572.58]	0.033
5000	27487.03 [-6482.781 to 61456.84]	0.112	410.117 [-51372.34 to 52192.58]	0.987	55147.25 [9951.58 to 100342.9]	0.018
50000	283597.2 [-41626.29 to 608820.7]	0.087	21414.58 [-474456.9 to 517286]	0.931	549242.1 [116644.4 to 981839.8]	0.014

[a] All six NB models for the total sample were adjusted for age. [b] All six NB regression models for the *sex* subgroup analysis were adjusted for age

MF is cost-effective compared to UC when INB>0. INB=incremental net benefit, MF = multifactorial fall prevention intervention, CI=confidence interval, WTP = willingness to pay.

Figure 1: Cost-effectiveness acceptability curve

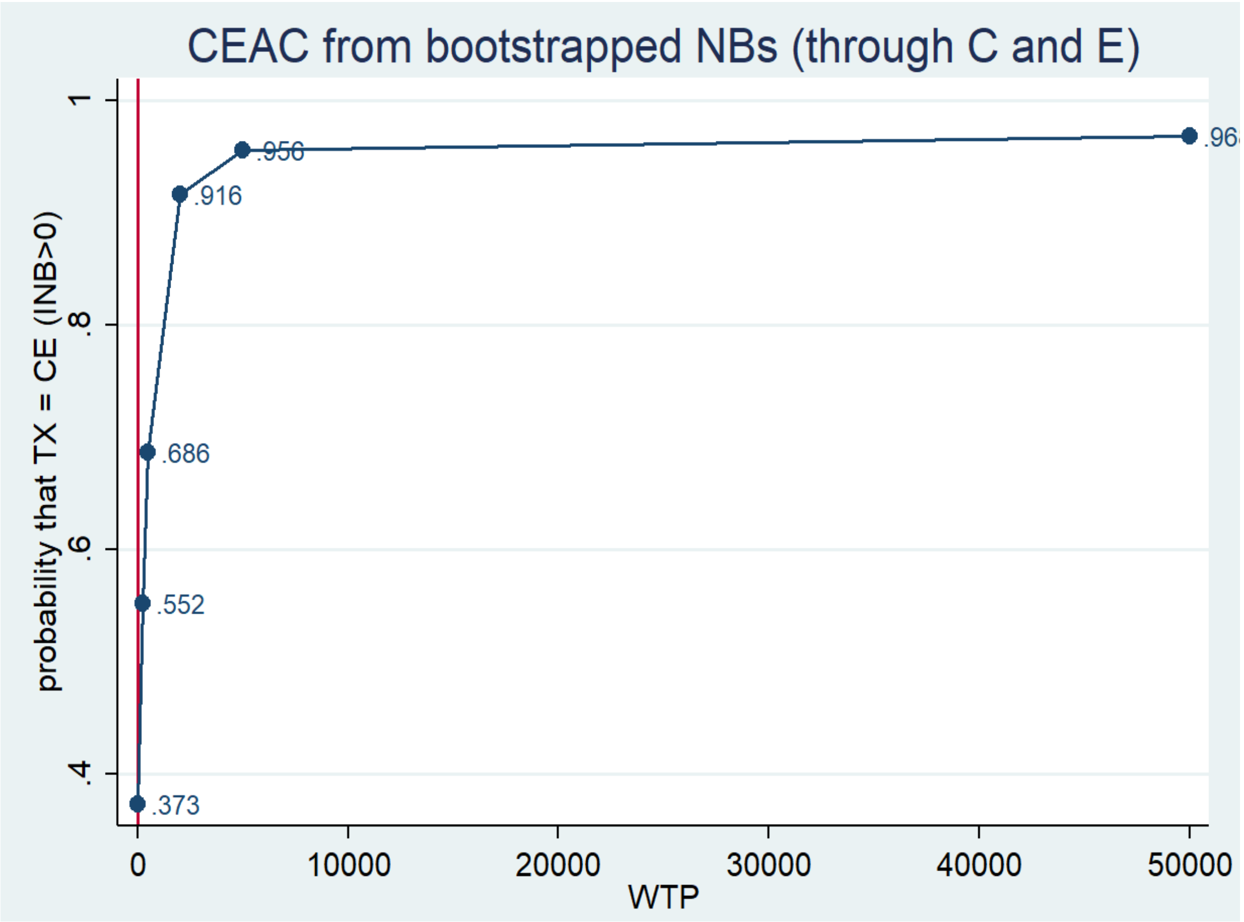

Figure 2: Sneeze Plot