Mediators of the association of limited English health literacy with medication non-adherence among Singaporean elderly

Sumithra Suppiah1, Yi Wen Tan1, Grand H-L Cheng2, Wern Ee Tang3 and Rahul Malhotra1,4

Abstract

Background: In Singapore, English is predominantly used on prescription medication labels (PMLs). However, many older Singaporeans cannot read English, and among those who read English, their English health literacy (EHL) proficiency varies. It is thus pertinent to examine the link between EHL and medication use outcomes in this population. The present research aims to address this question.

Methods: Data from a national survey, on 1,167 home-dwelling elderly on ≥1 prescribed medication was analysed. The validated Health Literacy Test for Singapore was used to determine EHL. Medication non-adherence was self-reported. Path analysis examined the association between limited EHL and medication non-adherence and tested possible mediators.

Results: Limited EHL was associated with medication non-adherence (total effect=0.35; p-value: 0.032), and ‘uncertainty in taking medications correctly due to difficulty in understanding written information on PMLs’ was a significant mediator (indirect effect=0.23, 95% confidence interval (0.12–0.39)).

Conclusions: Elderly people with limited EHL were significantly more likely than those with adequate EHL to report that they were uncertain about taking medications correctly because they had difficulty understanding the information on PMLs and this misunderstanding contributed to medication non-adherence. Interventions focused on incorporating bilingual text and/or pictograms on PMLs may reduce uncertainty in taking medication correctly and improve medication adherence among the elderly.

Keywords

Health literacy, medication non-adherence, prescription medication labels, pharmacy, elderly

Introduction

Medication non-adherence and health literacy

Life expectancy among the elderly is increasing globally, and Singapore is no exception. In 2018, an individual aged 65 and above in Singapore could expect to live another 21 years. While reflective of a public health success, a longer life places the elderly at risk of chronic diseases, which often entail long term drug therapy. The elderly, often at risk of multiple co-morbidities, have a higher risk of polypharmacy, which in turn is associated with a greater likelihood...
of medication non-adherence. Adherence to prescribed medications is critical to ensuring optimal health outcomes, yet the World Health Organization reports that approximately 50% of patients do not adhere to their prescribed pharmacotherapy.

Medication adherence is defined as the extent to which a person’s behaviour is congruent to the prescribed medication regimen from a health provider. Medication non-adherence not only impacts patient health outcomes but also contributes to rising healthcare costs. Studies commonly categorise medication non-adherence into two interacting categories, namely, intentional and unintentional non-adherence. Intentional non-adherence results when the patient decides not to adhere to recommended treatments. This is best understood in terms of a patient’s beliefs and perspectives towards the use of medications. Unintentional non-adherence results when the patient intends to adhere to recommended treatments but is confronted with barriers that result in non-compliance — amongst these would be patients who face difficulties in understanding instructions on prescription medication labels (PMLs), which in turn may be a result of their limited health literacy.

Health literacy is defined as the ‘degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions.’ Limited health literacy is a pervasive problem. In the United States, the Institute of Medicine reports close to 90 million adults who may face difficulties understanding and acting on health-related information. Further, being literate or educated may not necessarily equate to being health literate — even people with adequate education struggle to understand healthcare information. Specific population sub-groups, such as the elderly, are particularly at high risk of limited health literacy.

In recent years, the association between health literacy and medication adherence has been widely studied; however, the resulting evidence is either inconclusive or weak. A recent review examining the impact of health literacy on medication adherence reported that the relationship was weak despite its statistical significance. It has been suggested that health literacy might have a mediated relationship with other medication adherence determinants, which are yet to be explored. Studying mediators could potentially inform interventions aiming to improve medication adherence amongst elderly patients. Our study aimed to investigate three mediating pathways by which limited health literacy, in English, could be associated with medication non-adherence among the elderly in Singapore. Singapore offers a unique setting to explore the relationship between limited EHL and medication non-adherence.

Hypotheses development

Hypothesis 1. Limited English health literacy is associated with medication non-adherence. The Singapore Healthcare System uses English as its primary working language, due to its historic language policy. Written health information in the healthcare sector is predominantly generated in English. PMLs, also known as pharmacy-generated labels, which provide medication-related instructions to patients, are no exception. In such circumstances, individuals in Singapore with limited English health literacy (EHL) are more likely to face problems in navigating and effectively utilising the healthcare system. Translating this to the context of medication taking behaviour, it is hypothesised that limited EHL is associated with medication non-adherence.

Hypothesis 2. ‘Uncertainty in taking medications correctly due to difficulty in understanding written information on PMLs’ mediates the relationship between limited EHL and medication non-adherence. Patients rely on PMLs to understand how to use their medications appropriately. And, in Singapore, the role played by PMLs in informing patients about their prescribed medications is paramount. While patients are often counselled by healthcare providers (pharmacists, pharmacy technicians, physicians, nurses and clinic assistants) on how to use their medications as prescribed, studies from elsewhere show that patients usually do not remember these conversations. Further, in Singapore, patients are often not provided with manufacturer-supplied patient information leaflets (PILs), likely due to more than one reason: providers are not legally required to provide them; and PILs may be discarded when bulk-ordered medications are re-packaged at the pharmacies. Moreover, providers may refrain from providing PILs that detail undesirable effects of the prescribed medications because such details are known to create fear and anxiety and providers are concerned that this may promote intentional non-adherence amongst consumers.

Thus, given the centrality of PMLs — which are predominantly provided in English — in Singapore, it is hypothesised that ‘uncertainty in taking medications correctly due to difficulty in understanding written information on PMLs’ mediates the relationship between limited EHL and medication non-adherence. Other than the contextual basis alluded to above, our hypothesis is also informed by previous studies that report limited English proficiency (a construct that is distinct from, yet closely related to, limited health literacy) to be associated with poorer understanding of PMLs and how this could lead to poor medication management and subsequent medication non-adherence.

Hypothesis 3. Number of prescribed medications resulting from healthcare use mediates the relationship between limited EHL and non-adherence. Several studies have reported on the relationship between limited health literacy and increased healthcare use. Further, a recent study reported an increase of 15.1% in the prevalence of polypharmacy among patients upon hospital discharge relative to hospital admission. Being discharged with a higher number of prescribed medications has been reported to be associated with medication non-adherence and most patients did not understand why they were taking these medications. Taken together, it is anticipated that individuals with limited EHL have increased healthcare utilisation, which in turn is associated with more prescribed medications, and subsequently medication non-adherence.

Hypothesis 4. Number of prescribed medications resulting from number of chronic diseases mediates the relationship between limited EHL and medication non-adherence. Individuals with limited health literacy have been reported to have poorer health outcomes.
and limited knowledge of diseases and self-care strategies. Limited health literacy is a potential barrier to the uptake of preventive interventions for chronic diseases \(^{35}\) and is also linked with poorer uptake of screening programmes. \(^{14}\) Conversely, higher levels of health literacy have been linked to a reduction in chronic disease risk behaviours. \(^{36}\) Thus, we predict that limited health literacy may be associated with more chronic diseases. Furthermore, the presence of multiple chronic diseases, common in the elderly, often necessitates complex pharmacotherapy regimens. \(^{37}\) Polypharmacy is common in the elderly and several studies have identified an association between polypharmacy and medication non-adherence. \(^{43,33,39}\) Together, we posit that individuals with limited EHL are more likely than those with adequate EHL to have more chronic diseases, which can necessitate more prescribed medications, which in turn is associated with medication non-adherence.

**Methods**

**Data source and analytical sample**

Data from Wave 3 of the Panel on Health and Ageing of Singaporean Elderly (PHASE), a nationally representative longitudinal survey of community-dwelling elderly Singapore residents (citizens and permanent residents), was utilised. Details on the sampling approach and design of PHASE are provided elsewhere. \(^{40}\) PHASE was started in 2009 (Wave 1), interviewing (in their preferred language, stratified by age group/gender/ethnicity) a random sample of 4990 Singapore residents aged ≥60 years (or their proxy, if they were unable to respond themselves due to health reasons). Of them, 3103 elderly (or their proxy) participated in Wave 2 in the years 2011–2012. In 2015, 1572 elderly, all aged ≥65 years (or their proxy) were re-interviewed for Wave 3, the only wave with data on prescription medication use of the PHASE participants. PHASE Wave 3 was approved by the institutional review board at the National University of Singapore. Written informed consent was obtained from all participants, in each wave.

Only Wave 3 cross sectional data was used in the present analysis. Elderly who were not taking any prescribed medications (n=270) and those who had a proxy respondent (n=135; adherence was not assessed from the proxy) were sequentially excluded. Thus, the analytical sample comprised 1167 elderly respondents taking ≥1 prescription medication.

**Measurements**

**Predictor:** limited EHL (yes/no). EHL was assessed using the 36-item reading comprehension section of the validated Health Literacy Test for Singapore (HLTS), \(^{31}\) which is an adapted version of the Short-Test of Functional Health Literacy in Adults. It comprises of two prose passages in English, from which a total of 36 words have been selectively deleted, and participants are given a time limit of 7 min to fill in the blanks, choosing from a list of four words for each blank. Each correct choice is scored as 1, resulting in an HLTS score ranging from 0 (lowest) to 36 (highest). As suggested by the HLTS developers, limited EHL was defined as an HLTS score of ≤26. \(^{41}\) Respondents who reported that they were unable to read English were given a choice to respond to the HLTS. Those who did were assigned the score they achieved on the HLTS while those who did not were assigned a score of 0. Respondents who reported being able to read in English were all required to attempt the HLTS.

**Outcome:** medication non-adherence (yes/no). Medication non-adherence was assessed using two questions on the elderly’s medication-taking behaviour: ‘In the last one month, how often did you take your medications as prescribed by the doctor?’ (All the time; Nearly all the time; Most of the time; About half the time; Less than half of the time) \(^{42}\) and ‘At times do you forget to take your prescription medications?’ (Yes; No). \(^{43}\) Studies have found that forgetfulness is one of the key reasons for non-intentional medication adherence among patients. \(^{44,45}\) Participants were classified as adherent only if they answered ‘all the time’ and ‘no’ to the two questions respectively.

**Mediator:** uncertainty in taking medications correctly due to difficulty in understanding written information on PMLs (ordinal: always to never). This was assessed through the participants’ responses to ‘How often are you unsure on how to take your medications correctly because of difficulty understanding written instructions on the medication packet or bottle label?’ \(^{46}\) the response options being Always (score=5); Often; Sometimes; Occasionally; Never (score=1).

**Mediator:** healthcare use (yes/no). Use of three distinct types of healthcare services was assessed, through self-report: doctor visit in past three months; emergency room visit in past six months; and hospitalisation in past six months.

**Mediator:** number of chronic diseases. Self-reported ever-diagnosis, by a doctor, of the following chronic diseases was used to determine the number of chronic diseases: angina/myocardial infarction; other forms of heart disease; cancer; cerebrovascular disease; high blood pressure; diabetes; respiratory illness; renal/kidney/urinary tract ailments; ailments of the liver/gallbladder; joint pain, arthritis, rheumatism or nerve pain; chronic back pain; osteoporosis; glaucoma; Parkinson’s disease; thyroid disorders.

**Mediator:** number of prescription medications. The elderly reported on how many different prescription medications they were taking on a regular basis.

**Covariates.** These included socio-demographic variables (age, gender, ethnicity, highest education level completed, income adequacy and housing type) and cognitive status assessed using the Short Portable Mental Status Questionnaire. \(^{47}\) Adherence to prescribed western medications may be confounded by Traditional Chinese Medicine (TCM) use among the elderly. \(^{48}\) Thus, visit to a TCM practitioner or a traditional healer in the past three months (yes/no) was also included as a covariate.

**Statistical analyses**

Descriptive statistics were used to depict the distribution of the outcome, mediator and covariate variables in the analytical sample, overall and by EHL status. Differences in the
distribution of categorical and continuous variables by EHL status were assessed through the $\chi^2$ test or t-test, respectively, using STATA software, version 14.0 (2015, StataCorp, College Station, Texas, USA).

Path analysis was undertaken using the Mplus version 7.4\textsuperscript{49–51} to examine the total, direct and indirect (mediated) effects of limited EHL on medication non-adherence, controlling for the covariates detailed above. The current sample size was sufficient for the proposed path analysis.\textsuperscript{51,52} Due to the presence of categorical (ordinal and dichotomous) mediator/outcome variables, we adopted the weighted least squares means and variance estimation. Regarding model fit, values <0.90 for comparative fit index (CFI) and Tucker Lewis Index (TLI) suggest model rejection. For root mean-square error of approximation (RMSEA) and weighted root mean square residual (WRMR), values larger than 0.10 and 1.00 indicate a poor model fit. We did not report the $\chi^2$ statistic (significant value suggests that the model does not fit the data well) because it is likely to be significant with a large sample. This similar practice was also demonstrated in another study.\textsuperscript{51} While the total effect reflects the effect of limited EHL on medication non-adherence without accounting for any of the considered mediators, the direct effect reflects the effect after the considered mediators have been accounted for. Indirect effect is the product term of the regression (path) coefficients of the predictor–mediator association and of the mediator–outcome association. When these two coefficients were significant, we computed the indirect effect. Specifically, we applied bootstrapping (2000 samples) to evaluate its significance level. A 95% bias-corrected bootstrap confidence interval (CI95) that excludes zero indicates a significant indirect effect.

Results

The majority of the elderly in the analytical sample were female (59.6%), of Chinese ethnicity (74%), had primary education (35.6%) and lived in four- or five-room flats (56%). More than nine in 10 (90.7%) had limited EHL; even among those who were able to read English (35.2%), 71.6% had limited EHL. Medication non-adherence was significantly higher among elderly with limited versus adequate EHL (31.4% vs. 16.5%; $\chi^2$ test, $p=0.001$). Of the considered mediators, ‘uncertainty in taking medications correctly due to difficulty in understanding written information on PMLs’, ‘hospitalisation in past six months’ and ‘emergency room visits in past 6 months’ were higher for those with limited versus adequate EHL, 16.5% vs. 11.6% ($\chi^2$ test, $p=0.035$). Of the considered mediators, ‘uncertainty in taking medications correctly due to difficulty in understanding written information on PMLs’, ‘hospitalisation in past six months’ and ‘emergency room visits in past 6 months’ were higher for those with limited versus adequate, EHL though the difference was significant for only the first two mediators (Table 1).

Figure 1 illustrates the path analysis findings (the model fit indices – CFI=0.997; TLI=0.972; RMSEA=0.026; WRMR=0.397 – suggested an excellent fit). Limited EHL had a positive association with medication non-adherence (total effect: path coefficient 0.35; $p=0.032$). Only one mediation pathway was significant – limited EHL was positively associated with ‘uncertainty in taking medications correctly due to difficulty in understanding written information on PMLs’ (path coefficient $b=1.25$, $p<0.001$), which was positively linked with medication non-adherence (path coefficient $b=0.19$, $p<0.001$). Bootstrapping results indicated that the indirect effect of limited EHL on medication non-adherence via this mediator was statistically significant (indirect effect: path coefficient 0.23, CI95=(0.12, 0.39)). The direct effect of EHL on medication non-adherence was not significant (path coefficient $b=0.11$ CI95=(−0.21, 0.47)). Overall, ‘uncertainty in taking medications correctly due to difficulty in understanding written information on PMLs’ solely and fully mediated the association between limited EHL and medication non-adherence.

Discussion

The path analysis provided support for two of our four a priori hypotheses. In line with Hypothesis 1, there was a positive association between limited EHL and medication non-adherence and, congruent with Hypothesis 2, this association was fully mediated by ‘uncertainty in taking medications correctly due to difficulty in understanding written information on PMLs’. In context of Hypothesis 3 or 4, while some component paths – higher number of chronic diseases resulting in more prescribed medications, and a positive association between number of prescribed medications and medication non-adherence – of the hypothesised mediation pathways were significant, there was no evidence to support the overall pathways. Uncertainty in taking medications correctly due to difficulty in understanding written information on PMLs explained the relationship between limited EHL and medication non-adherence.

There is a mismatch between the EHL of elderly Singaporeans and what is expected of them in Singapore’s healthcare environment, which primarily functions in English, with nine in 10 elderly Singaporeans having limited EHL. Our finding on the prevalence of limited EHL in Singapore is similar to what was reported by The National Assessment of Adult Literacy (NAAL) conducted in the United States. The NAAL reports 88% of American adults to have limited health literacy skills and over one-third to have difficulty performing common health tasks, such as following directions on PMLs.\textsuperscript{54} In Europe, however, only one in 10 is known to have inadequate health literacy.\textsuperscript{55}

Our findings bring into focus the juxtaposition of limited EHL among the elderly and PMLs, which are predominantly provided in English, in influencing medication non-adherence in Singapore. Improvements to existing PMLs, in ways that allow elderly Singaporeans with limited EHL to gain clarity over their PMLs, is a crucial step towards addressing uncertainty in medication taking and to promote medication non-adherence amongst this cohort. Somewhat related, previous studies have also established the association between lack of patient knowledge of their prescribed medication and medication non-adherence, and highlighted the need for adopting strategies to ensure patients’ knowledge of their prescribed medication thereby reducing medication non-adherence.\textsuperscript{56,57} And, making improvements to existing PMLs is in line with recommendations for health literacy research to focus on the ability of healthcare organisations to manage patients with inadequate health literacy,\textsuperscript{1} rather than putting the onus on the patient.

In the Singapore context, two potential PML improvements are the use of bilingual text (English and one other official language), as a much higher proportion of elderly
Table 1. Distribution of the outcome, mediator and covariate variables, overall and by limited English health literacy status in the analytical sample.

| Variable                                                                 | Overall | Limited English health literacy | p-value |
|--------------------------------------------------------------------------|---------|---------------------------------|---------|
|                                                                          | N=1167  | Yes n=1058 (90.7) | No n=109 (9.3) |       |
|                                                                          | n (%) or mean ±SD | n (%) or mean ±SE |       |
| **Outcome**                                                              |         |                   |       |
| Medication non-adherence                                                 | 350 (30.0) | 332 (31.4) | 18 (16.5) | 0.001 |
| **Mediators**                                                            |         |                   |       |
| Uncertainty in taking medications correctly due to difficulty in         |         |                   | <0.001 |
| understanding written information on PMLs                                |         |                   |       |
| Always                                                                  | 301 (25.8) | 299 (28.3) | 2 (1.8) |       |
| Often                                                                   | 82 (7.0) | 82 (7.8) | 0 (0.0) |       |
| Sometimes                                                                | 161 (13.8) | 160 (15.1) | 1 (0.9) |       |
| Occasionally                                                             | 60 (5.1) | 58 (5.5) | 2 (1.8) |       |
| Never                                                                   | 563 (48.2) | 459 (43.4) | 104 (95.4) |       |
| Doctor visit in past three months                                       | 1029 (88.2) | 933 (88.2) | 96 (88.1) | 0.973 |
| Hospitalisation in past six months                                      | 151 (12.9) | 145 (13.7) | 6 (5.5) |       |
| Emergency room visit in past six months                                 | 124 (10.6) | 116 (11.0) | 8 (7.3) | 0.242 |
| Number of chronic diseases                                              | 2.2±1.3 | 2.2±0.04 | 2.2±0.1 | 0.503 |
| Number of prescription medications<sup>a</sup>                          | 3.1±2.0 | 3.1±0.11 | 3.1±0.2 | 0.326 |
| **Covariates**                                                           |         |                   |       |
| Age, in years                                                           | 76.3±6.8 | 76.7±0.2 | 72.8±0.5 | <0.001 |
| 66–69                                                                   | 224 (19.2) | 185 (17.5) | 39 (35.8) |       |
| 70–74                                                                   | 321 (27.5) | 281 (26.6) | 40 (36.7) |       |
| 75–79                                                                   | 255 (21.9) | 238 (22.5) | 17 (15.6) |       |
| 80–84                                                                   | 209 (17.9) | 200 (18.9) | 9 (8.3) |       |
| 85+                                                                     | 158 (13.5) | 154 (14.6) | 4 (3.7) |       |
| Gender                                                                  |         |                   | <0.001 |
| Female                                                                  | 695 (59.6) | 657 (62.1) | 38 (34.9) |       |
| Ethnicity                                                               |         |                   | 0.002 |
| Chinese                                                                 | 864 (74.0) | 791 (74.8) | 73 (67.0) |       |
| Malay                                                                   | 181 (15.5) | 167 (15.8) | 14 (12.8) |       |
| Indian                                                                  | 107 (9.2) | 86 (8.1) | 21 (19.3) |       |
| Other                                                                   | 15 (1.3) | 14 (1.3) | 1 (0.9) |       |
| Education<sup>b</sup>                                                   |         |                   | <0.001 |
| No formal education                                                     | 397 (34.0) | 395 (37.3) | 3 (2.8) |       |
| Primary                                                                 | 416 (35.7) | 400 (37.8) | 15 (13.8) |       |
| Secondary                                                               | 269 (23.1) | 205 (19.4) | 64 (58.7) |       |
| Above secondary                                                         | 85 (7.3) | 58 (5.5) | 27 (24.8) |       |
| Housing                                                                 |         |                   | <0.001 |
| One- or two-room flat                                                   | 77 (6.6) | 74 (7.0) | 3 (2.8) |       |
| Three-room flat                                                         | 345 (29.6) | 326 (30.8) | 19 (17.4) |       |
| Four- or five-room flat                                                 | 654 (56.0) | 589 (55.7) | 65 (59.6) |       |
| Private                                                                 | 91 (7.8) | 69 (6.5) | 22 (20.2) |       |
| Perceived income adequacy                                               |         |                   | 0.007 |
| Some difficulty or much difficulty meeting expenses                     | 137 (11.7) | 128 (12.1) | 9 (8.3) |       |
| Just enough money, no difficulty                                        | 679 (58.2) | 626 (59.2) | 53 (48.6) |       |
| Enough money, with some left over                                       | 351 (30.1) | 304 (28.7) | 47 (43.1) |       |
| Vision, self-reported                                                   |         |                   | <0.001 |
| Very good                                                               | 100 (8.6) | 79 (7.5) | 21 (19.3) |       |
| Good                                                                    | 668 (57.2) | 605 (57.2) | 63 (57.8) |       |
| Fair                                                                    | 313 (26.8) | 289 (27.3) | 24 (22.0) |       |
| Poor                                                                    | 86 (7.4) | 85 (8.0) | 1 (0.9) |       |
| Traditional Chinese medicine practitioner/traditional healer visit in past three months | 66 (5.7) | 61 (5.8) | 5 (4.6) | 0.612 |
| Cognitive function score<sup>c</sup>                                     | 1.79±1.2 | 1.8±0.04 | 1.7±0.1 | 0.175 |

<sup>a</sup>Sixty-three respondents who were unsure of the number of prescription medications they were taking on a regular basis were excluded for calculation of the mean.

<sup>b</sup>One respondent did not report education level. This missing value was replaced by the mode, which was primary education.

<sup>c</sup>The value represents the number of incorrect responses scored on the 10-item Short Portable Mental Status Questionnaire, corrected for interviewer effect.

PML: prescription medication label.
Figure 1. Path diagram of the association between limited English health literacy and medication non-adherence.

Model fit indices: Comparative fit index = 0.998 (value >0.90 indicates model fit). Root mean square error of approximation = 0.021 (value <0.10 indicates model fit). Weighted root mean square residual = 0.316 (value <1.00 indicates model fit). Solid line arrows represent a path that is statistically significant, and dashed line arrows represent a path that is not statistically significant.

PML instructions are often explained during medication counselling, during which misunderstandings, if any, can be clarified. This is an opportunity to address patients’ uncertainty in medication taking due to difficulty in understanding their PMLs. However, patients with limited health literacy do not generally engage in conversations with their healthcare providers. They tend not to ask questions and therefore any misunderstandings with regard to their PMLs may remain unclarified, giving rise to uncertainty on how to take or use their medications correctly and this could subsequently contribute to medication non-adherence. Thus, pharmacy staff also have an important role in breaking the link between limited EHL and medication non-adherence.

Strengths and limitations

This study has several strengths. First, the study included a large sample, from a national survey of older Singaporeans. Second, participants whose first language was not English were included. Every respondent was given a chance to attempt the HLTS. This reduces the likelihood of underestimating the prevalence of low health literacy in the population being studied, which may happen if respondents who are not native speakers are excluded.

However, limitations also must be taken into account when interpreting the results. First, medication adherence was assessed through self-report. While participants who are reporting non-adherence are most likely truthful, we acknowledge the possibility of bias in such self-reported measures. However, there is no gold standard approach for measuring medication adherence and self-report has been recommended as the type most suitable as it is quick and easy to administer. Finally, while medication non-adherence is a multifaceted concept, the questions used to determine medication non-adherence are unable to distinguish between unintentional or intentional medication non-adherence.

Conclusion

In conclusion, limited EHL is pervasive among the elderly in Singapore, where PMLs are largely in English. Improving existing PMLs through the incorporation of bilingual text and/or pictograms would be beneficial for the elderly. In addition, pharmacy staff should be attentive to the fact that many elderly patients may require additional assistance to understand their medications.

Acknowledgements

The authors would like to thank all research participants and research staff involved in this study.

Authors’ contributions

SS contributed to the study design, data interpretation and the drafting of this manuscript. TYW and GCHL performed statistical analyses and edited the manuscript. TWE edited the manuscript, RM conceptualised the research, guided the analysis and edited the manuscript. All of the authors have made substantive intellectual contributions to the study. All authors have read and approved the final version of the manuscript.
Availability of data and materials
The datasets generated and/or analysed during the current study are available from the corresponding author.

Conflict of interest
The authors have no conflicts of interest to declare.

Ethical approval
Ethical approval for this study was obtained from the National University of Singapore’s institutional review board (NUS-IRB Ref: B-14-235).

Funding
The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study uses data from Wave 3 of the Panel on Health and Ageing of Singaporean Elderly (PHASE), which was funded or supported by the Singapore Ministry of Health’s National Medical Research Council under its Clinician Scientist – Individual Research Grant – New Investigator Grant (NMRC-CNIG-1124-2014) and the Duke-NUS Geriatric Research Fund. This study uses data from Wave 3 of the Panel on Health and Ageing of Singaporean Elderly (PHASE), which was funded or supported by the Singapore Ministry of Health’s National Medical Research Council under its Clinician Scientist – Individual Research Grant – New Investigator Grant (NMRC-CNIG-1124-2014) and the Duke-NUS Geriatric Research Fund.

Informed consent
Written informed consent was obtained from all subjects before the study.

ORCID iDs
Sumithra Suppiah https://orcid.org/0000-0001-5504-0032
Yi Wen Tan https://orcid.org/0000-0002-7716-1043
Grand H-L Cheng https://orcid.org/0000-0001-5783-9534

References
1. Malhotra R, Bautista MAC, Muller AM, et al. The aging of a young nation: Population aging in Singapore. Gerontologist 2019; 59: 401-410.
2. Department of Statistics, Ministry of Trade and Industry, Republic of Singapore. Complete life tables for Singapore resident population, 2017–2018. Singapore: Ministry of Trade & Industry, 2018.
3. Qato DM, Alexander GC, Conti RM, et al. Use of prescription and over-the-counter medications and dietary supplements among older adults in the United States. JAMA 2008; 300: 2867-2878.
4. Pasina L, Brucato AL, Falcone C, et al. Medication non-adherence among elderly patients newly discharged and receiving polypharmacy. Drugs Aging 2014; 31: 283-289.
5. World Health Organization. Adherence to long-term therapies: Evidence for action, http://www.who.int/chp/knowledge/publications/adherence_report/en/ (2003, accessed 13 June 2018).
6. Lehane E and McCarthy G. Intentional and unintentional medication non-adherence: A comprehensive framework for clinical research and practice? A discussion paper. Int J Nurs Stud 2007; 44: 1468-1477.
7. Hugtenburg J, Vervoet M, van Dijk L, et al. Definitions, variants, and causes of nonadherence with medication: A challenge for tailored interventions. Patient Prefer Adherence 2013; 7: 675-682.
8. Clifford S, Barber N and Horne R. Understanding different beliefs held by adherers, unintentional nonadherers, and intentional nonadherers: Application of the necessity–concerns framework. J Psychosom Res 2008; 64: 41-46.
9. Institute of Medicine (US) Committee on Health Literacy, Nielsen-Bohlman L, Panzer AM, et al. Health literacy: A prescription to end confusion. Washington, DC: The National Academies Press, 2004, p.366.
10. Van der Heide I, Wang J, Droomers M, et al. The relationship between health, education, and health literacy: Results from the Dutch Adult Literacy and Life Skills Survey. J Health Commun 2013; 18: 172-184.
11. Kutner M, Greenberg E, Jin Y, et al. The health literacy of America’s adults: Results from the 2003 National Assessment of Adult Literacy. Washington, DC: United States Department of Education; National Center for Education Statistics, 2006, p.60.
12. Geboers B, Brainard JS, Loke YK, et al. The association of health literacy with adherence in older adults, and its role in interventions: A systematic meta-review. BMC Public Health 2015; 15: 903.
13. Quinlan P, Price KO, Magid SK, et al. The relationship among health literacy, health knowledge, and adherence to treatment in patients with rheumatoid arthritis. Int J Surg 2012; 9: 42-49.
14. Berkman ND, Sheridan SL, Donahue KE, et al. Low health literacy and health outcomes: An updated systematic review. Ann Intern Med 2011; 155: 97-107.
15. Cho YL, Lee SYD, Arrozullah AM, et al. Effects of health literacy on health status and health service utilization amongst the elderly. Soc Sci Med 2008; 66: 1809-1816.
16. Cohen MJ, Shaykevich S, Cawthon C, et al. Predictors of medication adherence postdischarge: The impact of patient age, insurance status, and prior adherence. J Hosp Med 2012; 7: 470-475.
17. Fang MC, Machtinger EL, Wang F, et al. Health literacy and anticoagulation-related outcomes among patients taking warfarin. J Gen Intern Med 2006; 21: 841-846.
18. Zhang NJ, Terry A and McHorney CA. Impact of health literacy on medication adherence: A systematic review and meta-analysis. Ann Pharmacother 2014; 48: 741-751.
19. Soones TN, Lin JL, Wolf MS, et al. Pathways linking health literacy, health beliefs, and cognition to medication adherence in older adults with asthma. J Allergy Clin Immunol 2017; 139: 804-809.
20. Dixon LQ. Bilingual education policy in Singapore: An analysis of its sociohistorical roots and current academic outcomes. Int J Biling Educ Biling 2011; 8: 25-47.
21. Bailey SC, Navaratnam P, Black H, et al. Advancing best practices for prescription drug labeling. Ann Pharmacother 2015; 49: 1222-1236.
22. O’Connell MB and Johnson JF. Evaluation of medication knowledge in elderly patients. Ann Pharmacother 2016; 26: 919-921.
23. The Statutes of the Republic of Singapore. The Medicines Act (1987, accessed 13 June 2018).
24. Malhotra R, Bautista MAC, Tan NC, et al. Bilingual text with or without pictograms improves elderly Singaporeans’ understanding of prescription medication labels. Gerontologist 2019; 59: 378-390.
25. Herber OR, Gies V, Schwappach D, et al. Patient information leaflets: Informing or frightening? A focus group study exploring patients’ emotional reactions and subsequent behavior towards package leaflets of commonly prescribed medications in family practices. BMC Fam Pract 2014; 15: 163.
26. Praeka JL, Kripalani S, Seright AL, et al. Identifying and assisting low-literacy patients with medication use: A survey of community pharmacies. *Ann Pharmacother* 2005; 39: 1441-1445.

27. Fernández A, Quan J, Moffet H, et al. Adherence to newly prescribed diabetes medications among insured Latino and White patients with diabetes. *JAMA Intern Med* 2017; 177: 371-379.

28. Davis TC, Wolf MS, Bass PF 3rd, et al. Literacy and misunderstanding prescription drug labels. *Ann Intern Med* 2006; 145: 887-894.

29. Wolf MS, Davis TC, Curtis LM, et al. A patient-centered prescription drug label to promote appropriate medication use and adherence. *J Gen Intern Med* 2016; 31: 1482-1489.

30. Berens E-M, Vogt D, Ganah K, et al. Health literacy and health service use in Germany. *Health Lit Res Pract* 2018; 2: e15-e122.

31. Vandenbosh J, van den Broucke S, Vancorenland S, et al. Health literacy and the use of healthcare services in Belgium. *J Epidemiol Community Health* 2016; 70: 1032-1038.

32. Cartwright LA, Dumenci L, Cassel JB, et al. Health literacy is an independent predictor of cancer patients’ hospitalizations. *Health Lit Res Pract* 2017; 1: e153-e162.

33. Masnoon N, Shakib S, Kalisch-Eliett L, et al. What is polypharmacy? A systematic review of definitions. *BMC Geriatr* 2017; 17: 230.

34. Nobili A, Licata G, Salerno F, et al. Polypharmacy, length of hospital stay, and in-hospital mortality among elderly patients in internal medicine wards. The REPOSI study. *Eur J Clin Pharmacol* 2011; 67: 507-519.

35. Joshi C. Jayasinghe UW, Parker S, et al. Does health literacy affect patients’ receipt of preventative primary care? A multi-level analysis. *BMC Fam Pract* 2014; 15: 171.

36. Taggart J, Williams A, Dennis S, et al. A systematic review of interventions in primary care to improve health literacy for chronic disease behavioral risk factors. *BMC Fam Pract* 2012; 13: 49.

37. Quinn Tj, Kim H-A, Shin J-Y, et al. Prevalence and predictors of polypharmacy among Korean elderly. *PloS One* 2014; 9: e98043.

38. Lyles A, Culver N, Ivester J, et al. Effects of health literacy and polypharmacy on medication adherence. *Consult Pharm* 2013; 28: 793-799.

39. Gellad WF, Grenard JL and Marcum ZA. A systematic review of barriers to medication adherence in the elderly: Looking beyond cost and regimen complexity. *Am J Geriatr Pharmacother* 2011; 9: 11-23.

40. Chan A, Saito Y, Matchar DB, et al. Cohort profile: Panel on Health and Ageing of Singaporean Elderly (PHASE). *Int J Epidemiol* 2019;48(6):1750-1f.

41. Ko Y, Lee JY,C, Toh MPH,S, et al. Development and validation of a general health literacy test in Singapore. *Health Promot Int* 2011; 27: 45-51.

42. Gehi AK. Self-reported medication adherence and cardiovascular events in patients with stable coronary heart disease: The heart and soul study. *Arch Intern Med* 2007; 167: 1798-1803.

43. Rolison DB, Majumdar SR, Tsuyuki RT, et al. Validity and reliability of the Edmonton Frail Scale. *Age Ageing* 2006; 35: 526-529.

44. Khan MU, Shah S and Hameed T. Barriers to and determinants of medication adherence among hypertensive patients attended National Health Service Hospital, Sunderland. *J Pharm Bioallied Sci* 2014; 6: 104-108.

45. Griva K, Davenport A, Harrison M, et al. Non-adherence to Immunosuppressive medications in kidney transplantation: Intent vs. forgetfulness and clinical markers of medication intake. *Ann Behav Med* 2012; 44: 85-93.

46. Chew LD, Bradley KA and Boyko EJ. Brief questions to identify patients with inadequate health literacy. *Fam Med* 2004; 36: 588-594.

47. Pfeiffer E. A short portable mental status questionnaire for the assessment of organic brain deficit in elderly patients. *J Am Geriatr Soc* 1975; 23: 433-441.

48. Kumar K, Greenfield S, Raza K, et al. Understanding adherence-related beliefs about medicine amongst patients of South Asian origin with diabetes and cardiovascular disease patients: A qualitative synthesis. *BMC Endocr Disord* 2016; 16: 24-24.

49. Kelloway EK. Using Mplus for structural equation modeling: A researcher’s guide. Thousand Oaks: SAGE Publications, 2014, p.248.

50. Wang J and Wang X. Structural equation modeling: Applications using Mplus. Hoboken: John Wiley & Sons, 2012, p.478.

51. Geiser C. Data analysis with Mplus. New York: Guilford, 2013, p.305.

52. MacCallum RC, Browne MW and Sugawara HM. Power analysis and determination of sample size for covariance structure modeling. *Psychol Methods* 1996; 1: 130-149.

53. Cheng GH, Malhotra R, Chan A, et al. Weak social networks and restless sleep interrelate through depressed mood among elderly. *Qual Life Res* 2018; 27: 2517-2524.

54. US Department of Health and Human Services. America’s health literacy: Why we need accessible health information. An issue brief from the US Department of Health and Human Services 2008. Accessed 13 June 2018

55. Deakin CD, Shewry E and Gray HH. Public access defibrillation remains out of reach for most victims of out-of-hospital sudden cardiac arrest. *Heart* 2014; 100: 619-623.

56. Cline CM, Bjorck-Linne AK, Israelsson BY, et al. Non-compliance and knowledge of prescribed medication in elderly patients with heart failure. *Eur J Heart Fail* 1999; 1: 145-149.

57. Jin J, Sklar GE, Min Sen Oh V, et al. Factors affecting therapeutic compliance: A review from the patient’s perspective. *Ther Clin Risk Manag* 2008; 4: 269-286.

58. Department of Statistics, Singapore. General household survey. https://www.singstat.gov.sg/publications/ghs/ghs2015con- tent (2015, accessed 13 June 2018).

59. Lam WY and Crespo P. Medication adherence measures: An overview. *Bomed Res Int* 2015; 2015: 1-12.

60. Muluneh B, Deal A, Alexander MD, et al. Patient perspectives on the barriers associated with medication adherence to oral chemotherapy. *J Oncol Pharm Pract* 2016; 24: 98-109.

61. Grenier S, Vaillancourt R, Pynn D, et al. Design and development of culture-specific pictograms for the labelling of medication for first nation communities. *J Commun Healthc* 2013; 4: 238-245.

62. Graham S and Brook J. Do patients understand? *Perin* 2008; 12: 67-69.

63. Paasche-Orlow MK, Parker RM, Gazmararian JA, et al. The prevalence of limited health literacy. *J Gen Intern Med* 2005; 20: 175-184.

64. Roundtable on Health Literacy, Board on Population Health and Public Health Practice, and Institute of Medicine. Health Literacy: Improving health, health systems, and health policy around the world: Workshop summary, Washington, DC: The National Academies Press, 2013, p.234.

65. Garfield S, Clifford S, Eliasson L, et al. Suitability of measures of low-literacy patients with medication use: A survey of community pharmacies. *Ann Pharmacother* 2005; 39: 1441-1445.