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Research Paper

Explaining the causal links between illness management and symptom reduction: Development of an evidence-based patient education strategy

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ABSTRACT

Objective: To determine whether explaining the causal links between illness management and symptom reduction would help younger and older adults learn and apply health information.
Method: Ninety younger and 51 older adults read about a fictitious disease with or without explanations about the cause-and-effects (causal information) of illness management. A knowledge test (applied vs. factual items) was administered immediately and 1-week following the presentation of health booklets. Reading comprehension, working memory and health literacy were assessed as covariate variables.
Results: Younger adults outperformed older individuals on the applied and factual items at both time points. After controlling for covariates, causal information facilitated the comprehension and application of health information for younger but not older adults. Reading comprehension was the best predictor of test performance in the older sample.
Conclusions: Providing an explanation of why illness management is effective for reducing symptomatology can help improve knowledge and application of health information for younger individuals. For older adults, lowering the verbal demands of patient education materials may be a better way to help them learn new health information.
Practice implications: Use of causal information as a teaching strategy in patient education may enhance individuals' ability to learn about and implement self-care strategies.

1. Introduction

A number of systematic reviews have indicated that the delivery of patient education is suboptimal due to lack of evidence-based pedagogy [1–4]. These limitations are particularly concerning for adults age 65 and older because they are the highest users of healthcare services but are more prone to confuse or forget information about illness management than their younger counterparts [5–7]. Having little understanding about an illness condition and its management is associated with poor adherence to recommended self-management behaviors (e.g., dietary changes and exercise) and worse health outcomes [8,9].

Several factors affect the extent to which individuals can understand and apply health information. These include health literacy, education level, reading and numeracy fluency as well as cognitive ability [10]. More specifically, the cognitive ability to temporarily store and manipulate information in memory, termed *working memory,* is a key factor for coherence and integration of incoming information [11]. There is compelling evidence indicating that age-related changes in working memory make it harder for older adults than younger individuals to connect unfamiliar medical concepts and form meaningful interpretations of the given information [12–14]. This age-related difference in how information is cognitively processed in part explains why the learning of health concepts is more demanding for older patients.

According to research in cognitive psychology, the depth at which an individual learns about a concept affects how well the information subsequently can be retrieved [15,16]. Previous studies have attempted to address the varying levels of information processing by manipulating the presentation formats of patient education materials [2,17]. Although strategies such as

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lowering the reading level and using visual aids are important to consider, very few studies have examined how to best explain health information in a way that helps individuals, particularly older adults, form a coherent understanding of the content.

Evidence from the literature on clinical reasoning suggests that increasing individual's knowledge and understanding of causal relationships can help them retain and apply new medical information [18]. Causal information refers to explanations about why an effect occurs or how things work [19,20]. The value of integrating causal information into educational curricula has been demonstrated in the medical teaching context [21–23]. For example, compared to students who received standard information about how to perform a percussive respiratory examination, individuals who received additional causal information about *why* physical sounds occurred during the medical test were better able to interpret the examination results [24]. It has been posited that causal information enhances knowledge acquisition by linking otherwise fragmented pieces of information [25]. It is plausible that similarly integrating this pedagogical feature into patient education programs or material would help individuals better understand *why* self-management of chronic illness is important and *how* health behaviour changes can prevent illness exacerbation.

Currently, it is common practice in patient education to provide information about illness causes, pathophysiology, symptoms and self-management recommendations in a non-integrated fashion [2,3,26]. However, this approach may not be conducive to improving depth of understanding, especially for older adults who struggle to process patient education materials in an integrated fashion[27,28]. Accordingly, the goal of this study was to determine whether providing causal information that explains how elements of a self-management regimen alleviate symptoms of a medical condition improves individuals' understanding of illness management. We used a controlled experimental design to investigate the effects of causal information on younger and older adults' ability to learn and recall novel health information. Applied, rather than factual, knowledge was the main outcome variable of interest because it has implications for self-management adherence [29]. Based on previous findings that working memory, reading comprehension and health literacy affect cognitive processing of health information [14,30,31], these variables were measured as covariates.

It was hypothesized that there would be differences in knowledge performance between older and younger adults. We also predicted that causal information would: 1) enhance the abilities of both younger and older adults to apply and recall health information; and 2) be a significant predictor of the ability to apply medical knowledge after controlling for covariates.

2. Methods

2.1. Participants

The younger participants were 90 undergraduate students recruited from Department of Psychology research participant pool at The University of Western Ontario. Fifty-one community-dwelling older adults, aged 60 years and older, also took part in this study. Recruitment of older adults took place at a community seniors centre, an aging-and-exercise program, and/or through posting of study flyers at grocery stores and malls. The inclusion criteria for both older and younger adults included fluency in English and no prior training in medical professions. Participant characteristics are shown in Table 1. Older adults were offered $20 (CAD). Younger adults completed the study as part of the research requirements of the undergraduate course in which they were enrolled. The study protocol was approved by the University's Non-Medical Research Ethics Board.

2.2. Materials

2.2.1. Health information booklet

The symptoms and self-care recommendations of three metabolic conditions (Urea Cycle Disorder, Biotin Deficiency and Short-chain acyl-CoA Dehydrogenase Deficiency) formed the basis for the learning materials. Consistent with the content of most health education brochures [32–34], the resultant health booklets described the pathophysiology, prevalence, symptoms and self-care management of a fictitious disorder, 'Alphabet Disease'. The first two sections about the triggers and prevalence of the target illness were presented in the same fashion for both learning conditions. The sections about symptoms and self-care management were the tested components. In the causal information condition (experimental group), the health booklet explained self-care management in the context of the disease pathophysiology. That is, the text explained what patients are required to do to manage a condition and how this management approach is necessary for symptom improvement. For participants in the control group, information about symptoms and self-care behaviors was not explicitly linked. See Fig. 1 for sample excerpts of the two booklet conditions.

Table 1
Participant characteristics.

	Younger Adults			Older Adults		
	Control (n = 45)	Intervention (n = 45)	p-value[a]	Control (n = 26)	Intervention (n = 25)	p-value[a]
M(SD)						
Age	19.60 (4.09)	18.54 (1.28)	0.11	72.19 (7.41)	69.83 (6.47)	0.24
Years of education	13.30 (2.01)	13.04 (0.89)	0.45	14.00 (2.34)	14.58 (3.48)	0.50
Working memory	6.70 (2.25)	7.24 (2.39)	0.28	5.68 (1.93)	6.52 (2.58)	0.20
Reading comprehension	5.20 (1.53)	5.87 (1.38)	0.30	4.19 (2.04)	4.96 (2.25)	0.21
Health literacy	6.82 (0.45)	6.62 (.57)	0.08	6.48 (1.15)	6.64 (0.91)	0.59
(%)						
Female	71.10	65.90	0.65	57.70	64.00	0.65
Non-white ethnicity	42.20	44.40	0.83	19.20	8.00	0.24
With partner	4.40	4.40	1.00	61.50	60.00	0.91
>60,000 Household income	64.50	77.80	0.40	15.00	33.33	0.17
Has a diagnosis of a chronic illness	6.70	9.10	0.67	57.70	62.50	0.73

Note: n = group sample size; M = mean; SD = standard deviation; *ns* = non-significant, $p < 0.05$.
[a] p-value compares control and experimental conditions.

Sample Causal Information

Presented on one page:

How Can I Manage the Symptoms and Complications of Alphabet Disease?

Feeling Tired (fatigued)

What to do: Consume 3-4 glasses of **high carbohydrate drinks** each day

Why: Alphabet disease makes it difficult for your body to produce essential fats and carbohydrates that give you energy. Consuming high carbohydrate drinks will supply you with the energy you need.

Sample Non-Causal Information

Presented on separate pages:

What is Alphabet Disease?	What are the Symptoms and Complications?	How Can I Manage My Alphabet Disease?
Alphabet disease occurs when your liver has difficulty breaking down Alphabetin into vitamin ABC. Your body needs vitamin ABC to metabolize proteins, keep your immune system strong and produce fats and carbohydrates. As a result, individuals with Alphabet disease have a build up of proteins and not enough fats and carbohydrates.	• **Feeling tired (fatigued)** (...)	**High Carbohydrate Drinks** Consume 3-4 glasses of natural juices and energy drinks each day

Fig. 1. This figure shows an example of how the learning material was presented in a causal (experimental condition) and non-causal (control condition) way. The dotted line represents information that was shown on a separate page in the booklet.

2.2.2. Comprehension and retention of health information

A 25-item multiple-choice Health Knowledge Questionnaire (HKQ) was created to test participants' factual and applied understanding and retention of information about Alphabet Disease. The HKQ contained 10 *factual* items on content that was presented in the same format for both booklet conditions (e.g., "Who is more at risk for developing Alphabet Disease?"). The remaining 15 *applied* items tested knowledge of self-management, strategies, which were explained differently for the two conditions. The applied items required patients to make inferences

Sample Applied Item:

What should someone with Alphabet Disease do when they are feeling tired?

a. Rest
b. Take vitamin ABC supplements
c**. Drink fruit juice**
d. All of the above

Sample Factual Item:

Who is more at risk for developing Alphabet Disease?

a. Women
b. Men
c. Men and women are equally affected
d. I don't know

Fig. 2. This figure shows an example of one applied and one factual item. The correct answers, which are not presented to participants, are shown in bold-face text.

about how to apply self-management strategies based on the information they had read (e.g., "If someone with Alphabet Disease forgets to take their vitamin ABC supplements, what should they watch out for?"). These items were included to examine a deeper and more actionable understanding of the material than the factual items. All factual and applied items included four response choices and a point was given for each correctly answered item. The total number of correct responses was tallied for the entire HKQ, and then separately for the two item sets to measure applied and factual knowledge. The HKQ was administered immediately after presentation of the health booklets to gauge participant comprehension of the information. Participants also completed the HKQ after a 1-week delay as a measure of retention of health information. See Fig. 2 for sample items.

2.2.3. Reading comprehension

Two passages from the Nelson-Denny Reading Test (FORM H) [35] were used to assess participants' reading comprehension. The test required participants to read narrative passages and answer 10 multiple-choice items, each with 5 answer choices. The number of correct responses was summed for the total score, which ranged from 0 (no correct answers) to 10 (all answers were correct).

2.2.4. Health literacy

The Rapid Estimate of Adult Literacy in Medicine-Short Form (REALM-SF) [36] is a seven-item word recognition task used to assess participant health literacy. Scores range from 0 (no words pronounced correctly) to 7 (all words pronounced correctly). The REALM-SF is a widely used measure for assessing health literacy [37] and is highly correlated with the 66-item REALM instrument ($r = 0.94$; [36]). It has been shown to be a valid and reliable measure [38].

2.2.5. Working memory

The Backward Digit Span task from the Weschler Adult Intelligence Scale-IV (WAIS-IV) [39] was used to assess working memory. This task required participants to recall a progressively longer series of digits in a backward order. A higher number of correct trials recalled reflect a larger working memory capacity.

2.3. Procedure

Participants were randomly assigned to one of two booklet conditions. The study was completed individually or in groups of up to three individuals, in two sessions held one week apart. Testing for younger adults took place in the Categorization Lab at The University of Western Ontario. Older participants completed the study at either a senior's community center or in a research office. After providing informed consent, participants were asked to read and study the health information booklet to the best of their abilities. They were told that the material would not be shown again during testing and that they could take as much time as they needed to learn the information. Following the methodological approach used in a study of a similar intervention [24], the HKQ was administered immediately after participants returned the booklet (Time 1), and after 1-week delay (Time 2). The administration of the remaining battery of cognitive measures took place during either the first or second testing session, depending on the participant flow. Younger adults took between 10 to 15 min to read the booklet whereas older adults took between 20 and 30 min to review the material.

2.4. Statistical analyses

Statistical analyses were carried out using PSAW 23.0 software package [40]. Demographic differences between the experimental and control groups were assessed by chi-square and independent *t*-tests analyses. Pearson-moment correlations were conducted to examine the associations between booklet condition **(0 = non-causal; 1 = causal),** demographic characteristics, covariates and knowledge performance on applied and factual items at Time 1 and Time 2. Pairwise comparisons were used to determine age-related

Table 2
Bivariate correlations between predictor and outcome variables.

		Age	Years of education	Booklet condition	Reading comprehension	Health literacy	Working memory
Older Adults							
Age			−0.05	−0.17	0.06	0.19	0.06
Years of education				0.10	0.35*	.37**	0.18
Booklet condition (0 = control; 1 = experimental)					0.18	0.08	0.19
Reading comprehension						0.26	0.17
Health literacy							0.15
Time 1	HKQ Applied	−0.02	0.23	0.24	0.35*	**0.28***	0.23
	HKQ Factual	−0.11	0.24	0.07	0.20	**0.35***	**0.33***
Time 2	HKQ Applied	0.00	−0.01	0.22	**0.62****	0.00	0.05
	HKQ Factual	0.04	**0.31***	0.10	**0.65****	0.21	0.12
Younger Adults							
Age			**0.73****	−0.17	0.033	0.05	0.01
Years of education				−0.08	−0.12	−0.11	−0.14
Booklet condition					0.20	−0.19	0.12
Reading comprehension						**0.49****	−0.14
Health literacy							−0.06
Time 1	HKQ Applied	−0.04	−0.07	**0.57*****	**0.25***	0.04	0.19
	HKQ Factual	0.04	−0.02	0.06	**0.24***	0.12	0.11
Time 2	HKQ Applied	0.04	−0.01	**0.22***	**0.21***	0.11	0.13
	HKQ Factual	0.00	0.02	0.00	0.13	0.14	0.01

Note. $^{*}p < 0.05$, $^{**}p < 0.01$; HKQ = Health Knowledge Quiz.

differences in knowledge performance across time and item type. The impact of booklet condition on knowledge performance was analyzed separately for each age group using $2 \times 2 \times 2$ mixed factorial ANOVAs with Bonferroni correction. Booklet condition (experimental/control) was entered as the between subjects factor, and the within-subject factors comprised of time (Time 1/Time 2) and item type (Factual/Applied). Finally, multivariate analysis of covariance (MANCOVA) using Pillai's trace was conducted for each age group to determine the effects of booklet condition on applied knowledge performance at Time 1 and 2 after controlling for covariates. Box's Test was used to examine the assumption of equality of covariance matrices. Multicollinearity was tested using Pearson-moment correlation, where a coefficient above 0.7 suggests that pairs of variables were collinear [41].

3. Results

3.1. Sample characteristics

There were no differences in demographic characteristics, working memory, health literacy and reading comprehension between the control and experimental conditions for both younger and older adult age groups (Table 1).

3.2. Correlations between predictor, covariate and outcome variables

Table 2 shows the bivariate correlations between predictor, covariate, and outcome variables. Years of education were positively correlated with reading comprehension, and health literacy among older adults. For younger adults, higher levels of reading comprehension were associated with better health literacy. Furthermore, several covariate variables were associated with performance on the knowledge questionnaire (Table 2). Among older adults, health literacy, working memory and reading comprehension were positively correlated with acquisition of health knowledge at immediate recall (Time 1). Reading comprehension and years of education was highly correlated with HKQ scores at Time 2. Older adults' age and booklet condition did not affect performance. In contrast, for younger adults, booklet condition and reading comprehension were positively associated with test performance on applied items at both time points (Table 2).

3.3. Younger vs. older adults

Table 3 shows the mean proportion correct on applied and factual items across age group and time. Younger adults outperformed older adults on the applied items at both Time 1 $t(139) = -9.23$, $p < 0.001$) and at Time 2 ($t(139) = -8.79$, $p < 0.001$). Similarly, performance on factual items was higher for younger adults than the older age group at both Time 1 ($t(67.29) = -7.09$, $p < 0.001$) and Time 2 ($t(139) = -8.60$, p $0.001 < 0.001$).

Table 3
Mean proportion correct on Health Knowledge Quiz at time 1 and time 2.

	Item Type	Group	Time1 *M (SD)*	Time 2 *M (SD)*	*n*
Younger Adults	Applied	Control	0.66 (0.16)	0.66 (0.19)	45
		Experimental	0.86 (0.11)	0.75 (0.23)	45
	Factual	Control	0.88 (0.11)	0.81 (0.11)	45
		Experimental	0.89 (0.11)	0.81 (0.275	45
Older Adults	Applied	Control	0.47 (0.11)	0.35 (0.19)	26
		Experimental	0.54 (0.17)	0.43 (0.17)	25
	Factual	Control	0.65 (0.21)	0.46 (0.24)	26
		Experimental	0.68 (0.20)	0.50 (0.21)	25

Note: *M* = mean; *SD* = standard deviation; *n* = group sample size.

3.4. Performance of younger adults

Among younger adults (Table 3), results of a 2 (time) × 2 (item type) × 2 (booklet condition) ANOVA showed higher HKQ performances at Time 1 ($F(1, 88 = 12.52$, $p = 0.001$, $\eta^2 = 0.13$), for the factual items ($F(1, 88) = 94.93$, $p < 0.001$, $\eta^2 = .52$), and for the experimental condition $F(1, 88 = 6.60$, $p = 0.012$, $\eta^2 = 0.07$). A significant item x booklet interaction showed that both the experimental and control groups did equally well on factual items but participants who received causal information scored significantly higher on applied items than the control group, $F(1, 88) = 36.33$, $p < 0.001$. The effect size for this group difference was large, ($\mathbf{r^2 = 0.32}$).

There was a significant three-way interaction of booklet condition x item x time, $F(1, 88) = 10.89$, $p < 0.001$, $\eta^2 = 0.110$. Pairwise *t*-tests were conducted for each booklet condition to determine the effects of time on the proportion of correct applied and factual items. The experimental group showed a decrease in proportion of correct applied ($t(44) = 3.39$, $p = 0.001$) and factual items ($t(44) = 2.37$, $p = 0.022$) between Time 1 and Time 2. For the control group, there was a decline in performance for factual ($t(44) = 3.36$, $p = 0.002$) but not applied items ($t(44) = 0.22$, $p = 0.827$) at Time 2. However, the proportion of correct applied items was still significantly higher for the experimental than the control group at Time 2, $t(88) = -2.12$, $p = 0.037$, $r^2 = 0.05$.

Moreover, the effect of causal information on applied knowledge was significant after accounting for covariates, V = 0.33, $F(2, 83) = 20.21$, p $0.001 < 0.001$. The group marginal means are displayed in Fig. 3. Follow-up univariate ANOVA tests revealed that provision of causal information led to better performance on applied items only at Time 1 but not at Time 2, $F(1, 84) = 35.95$, p $0.001 < 0.001$. Working memory, reading comprehension and health literacy were not associated with applied knowledge performance in younger adults. For this age group, the bivariate correlation between Time 1 and Time 2 performance on HKQ applied items was 0.59 (p $0.001 < 0.001$).

3.5. Performance of older adults

With regards to older adults (Table 3), there was a significant interaction of item type x time, such that the passage of time compromised the recall of applied items, $F(1, 49) = 8.60$, $p = 0.005$, $\eta^2 = 0.15$. Performance was significantly better during Time 1 than Time 2 and for factual compared to applied items, $F(1, 49) = 29.87$, $p < 0.001$, $\eta^2 = 0.38$, $F(1,49) = 40.53$, $p < 0.001$, $\eta^2 = 0.45$, respectively. Contrary to our predictions, there was no effect of booklet condition, suggesting that causal information did not facilitate acquisition of information for older adults, $F(1,49) = 1.97$, $p = 0.167$. Results of a MANCOVA (Fig. 4) showed no effect of booklet condition on older adults' Time 1 and 2 applied item scores after controlling for covariates of reading comprehension, health literacy and working memory, V = 0.118, $F(2, 44) = 0.69$, $p = 0.51$. Reading comprehension predicted Time 2, but not Time 1, performance on applied items ($F(1, 45) = 22.84$, p $0.001 < 0.001$). Working memory and health literacy were not associated with applied knowledge at either time points. The bivariate correlation between Time 1 and Time 2 performance on the applied items was 0.497 (p $0.001 < 0.001$).

4. Discussion and conclusion

4.1. Discussion

The present study examined whether explicitly explaining the link between recommended self-management behaviour and reduction in illness-related symptoms would enhance the uptake of novel health information. This study is among the first to

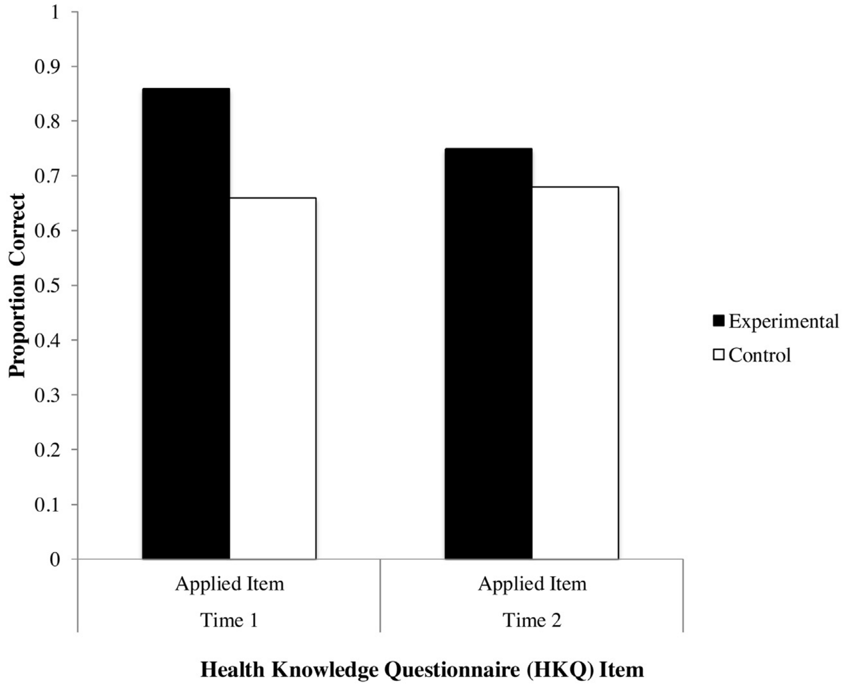

Fig. 3. Bar graph illustrating younger adults' ($n = 90$) estimated marginal mean scores for applied items on the Health Knowledge Questionnaire after accounting for working memory, health literacy and reading comprehension. The estimated marginal means are displayed for each booklet condition and time point.

manipulate how information can be delivered to highlight the cause-and-effect of self-management on illness pathophysiology. Our broad goal was to address the gaps in the literature regarding effective teaching strategies that can address individuals' depth of learning process among younger and older adults.

Our results showed that performance on a test of novel health information was significantly enhanced for younger adults who received patient education booklets explaining the cause and effects of illness self- management. Specifically, the provision of causal information led to higher accuracy on applied items, which

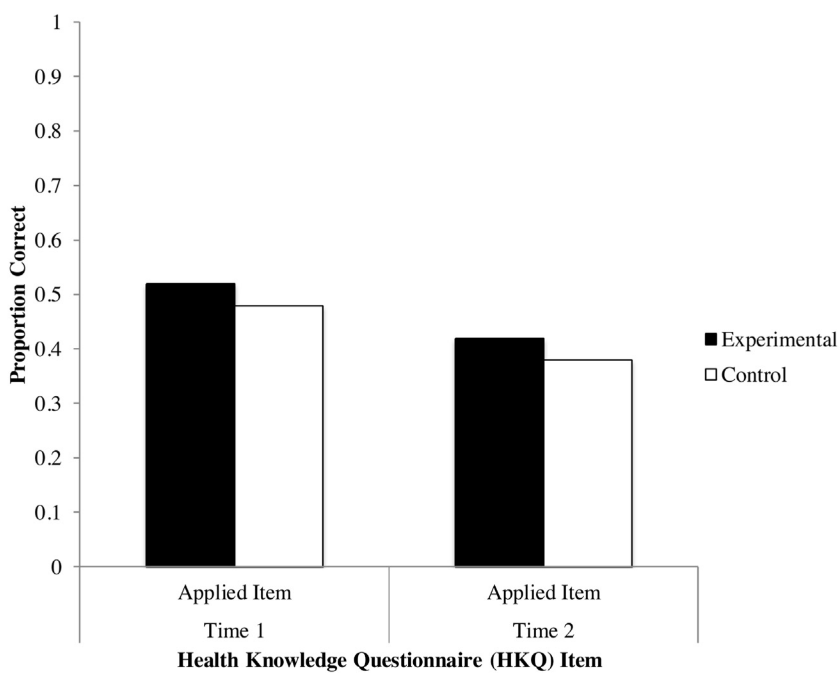

Fig. 4. Bar graph illustrating older adults' ($n = 51$) estimated marginal mean scores for applied items on the Health Knowledge Questionnaire after accounting for working memory, health literacy and reading comprehension. The estimated marginal means are displayed for each booklet condition and time point.

were questions that required participants to make decisions about how to manage a hypothetical symptom flare-up. Younger adults who received causal information answered approximately 85.6% of these applied items correctly compared to 66.4% in the control condition. For items that required participants to recall verbatim factual information, both the experimental (88.9%) and control (87.6%) groups achieved similar levels of accuracy. This suggests that causal information benefitted health users' acquisition of knowledge by enabling them to apply this information to problem-solve different situations. Although the provision of causal information enhanced younger adults' applied knowledge after controlling for health literacy, working memory and reading comprehension for younger adults, this strategy did not improve application of the information after a one-week delay. Hence, causal information appears to help with the consolidation of unfamiliar health information but necessarily with the retrieval of the content.

The present findings are consistent with previous reports that incorporating basic sciences in medical curricula in a way that emphasize causal connections in medical exams, helps to improve the diagnostic skills of inexperienced trainees [18,42]. Our results extend past research in showing that causal information could be a promising teaching strategy for patient education interventions. Our data therefore support the notion that causal information facilitates connections between individual health concepts, which in turn help form a coherent cognitive representation of the information [25]. However, contrary to our predictions and in contrast to the results with younger adults, there were no significant differences in proportion of correct applied items between elderly individuals in the experimental (54.0%) and control (47.0%) groups. Rather, reading comprehension was the best predictor of older adults' recall of medical information.

Furthermore, older adults' knowledge test performance was markedly lower than that of their younger counterparts. We found that younger adults answered approximately 78.9% of the HKQ items correctly across both time points, while older adults only achieved 50.7% accuracy. This study, along with others [43–45], indicate that older adults are less able to understand and retain health information than younger individuals. Previous research has mostly focused on the effects of working memory on age-related differences in knowledge acquisition [11]. However, our findings suggest that one of the main barriers to comprehension of medical information among the older age group may be related to cognitive changes in reading comprehension. As such, there is a need to re-evaluate patient education strategies for the older patients in order to accommodate for cognitive declines in verbal ability [5,46].

Several methodological limitations may affect the interpretation of the study's findings. First, the intended novelty of the health booklets may have inadvertently interfered with any potential benefits of causal information for older adults. Past research has shown that older adults are more resistant to adopting new accurate medical information that disconfirms previous beliefs [30,47–49]. Second, the design of the health information booklets and knowledge test may advantage individuals with higher reading comprehension. Presenting causal information in a non-written format may increase its utility in patient education. Third, the relatively smaller sample size of older adults may have limited the power to detect experimental effects. As shown in Table 2, the effect sizes (Pearson *r*) of causal information on HKQ applied scores at Time 2 were similar between younger and older adults but was only statistically significant for the former group. Future studies should re-examine the effects of causal information among a larger sample of older adults.

Finally, it is difficult to gauge the intrinsic motivation for participants to learn the health information. Patients in clinics, unlike research participants, may be more inclined to learn about their actual diagnosis and therefore, may be more sensitive to the presentation of health information. Although there were several disadvantages to using education material about an artificial disease, implementing a controlled experimental design allowed for the singular effects of an educational strategy to be evaluated.

Overall, results from this study suggest that causal information can improve the comprehension of novel health information for younger but not older adults. It is possible that causal information may improve the delivery of patient education for older adults if this strategy were to be used in combination with efforts to reduce the verbal complexity of healthcare information. For example, providing face-to-face education sessions in addition to written-information alone, and reducing the reading level of text information may counter deficits in reading comprehension among older adults [50,51]. In this study, participants were required to memorize the health information. However, this would not be the case in a clinical context where patients could refer to the given educational material at will. Without the cognitive load associated with memorizing the information, the benefit of using causal information to help older adults learn medical information may be more pronounced.

4.2. Conclusion

This experimental study suggests that making it clear for patients why and how recommended lifestyle changes will reduce their symptoms may enhance their acquisition and use of healthcare knowledge. However, older adults may require more instructional aids, such as reduced reading level, before they can benefit from the provision of causal information. Therefore, there is merit to further explore the effects of providing causal information in a patient education context. Future patient education interventions should consider both presentation formats *and* how health information is explained to patients.

4.3. Practice implications

Providing explanations for *why* patients should follow illness management strategies, rather than prescribing *what* they should do, is aligned with a patient-centred approach. The integration of causal information in patient education programs can help increase individuals' ability use health information, which has implications for self-management adherence. Future research should determine the effects of providing causal information in actual health care settings with regards to improving patient knowledge and uptake of self-management strategies. This translation of experimental findings from cognitive psychology into clinical practice would contribute to the need for evidence-based care in patient education. Moreover, development of education materials that focuses on patients' learning processes has the potential to be a cost-saving strategy for patient education implementation. The regard for patients as capable learners in the medical setting brings us closer to building provider-patient partnerships in chronic disease management.

Conflict of interest

The authors declare no conflict of interest.

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