Medication Adherence in New Zealand Older Adults: Effects of an External Cognitive Support

June Greyvenstein and Nikolaos Kazantzis
Massey University, New Zealand

Nancy A. Pachana
The University of Queensland, Australia

Pharmacotherapy is the most frequently used treatment modality among the older adult population. Consequently, medication adherence represents an important treatment consideration. The present study was conducted to assess the extent of medication adherence in the New Zealand sample, and evaluate the effectiveness of an external cognitive support in a sample of 50 community-dwelling older adults (M = 70.70, Mdn = 72.00, SD = 8.12). A randomised controlled trial to compare the usual medication practice with a medication calendar was conducted. The present sample had high levels of medication adherence, with high adherence measured on an adherence ratio 97% (range 82% to 109%), and low rate of medication errors (19 errors). There were no significant differences in medication adherence between intervention and control groups (ps > .05). However, consistent with prior research, there was some evidence to suggest that female participants were less compliant and made more errors than male participants. Further research on larger more representative older adult samples is warranted.

Pharmacotherapy is the most frequently used treatment modality among older adults (Cooper, 1990). Older adults consume approximately 30% of all prescription medications in the United States (AARP, 1999) and 34% of this group take three or more prescriptions (Chrischilles, Segar, & Wallace, 1992). Thus, medication adherence is an important treatment consideration in an older cohort.

The definition of medication adherence coined by Haynes (1979) is commonly cited in the literature, namely that it is the extent to which a person's medication taking behaviour coincides with medical advice. Failing to present prescriptions to a pharmacy is one common form of nonadherence, and it has been estimated that in the United States about 20% of prescriptions are not filled (Berg, Dischler, Wagner, Raia, & Palmer-Shevlin, 1993). Many studies indicate that a large proportion of nonadherence is the result of taking less medication than is prescribed (e.g., Kruse et al., 1992; Park, Morrell, Frieske, & Kincaid, 1992; Salzman, 1995). There is also evidence to suggest that 40% of older adults surveyed stopped taking prescription medications sooner than prescribed (Salzman, 1995). Similar compliance rates have been observed for older adults wearing medical alert bracelets (i.e., 57.5% in Devor, Wang, Renvall, Feigal, & Ramsdell, 1994).

Address for correspondence: Nancy A. Pachana, School of Psychology, The University of Queensland, Australia. E-mail: n.pachana@psy.uq.edu.au

The large quantity of research into medication adherence has produced a correspondingly large range of findings. Adherence levels cited in the literature vary markedly, ranging from 10% (e.g., Monane, Bohn, Gurwitz, Glynn & Avorn, 1994) to 97% (e.g., Atwood et al., 1996), although the consensus is that, on average, about half to two thirds of patients are compliant (Wright, 1993). Average adherence levels among elderly patients do not appear to differ significantly from those of younger adults (e.g., Wandless & Davie, 1977). Nevertheless, although older adults may generally not make more drug errors than younger adults, the adverse consequences of nonadherence may be more severe and less easily detected or resolved (Green, Mullen, & Stanbrook, 1986).

While medication nonadherence is found across all age groups, the consequences for older patients tend to be more serious than those for younger patients. Adverse results may include suffering prolonged illness, undergoing unnecessary medical procedures, being hospitalised or having to move from an independent living situation to a residential care facility. Absence from work, emergency care, hospitalisation and in some cases death, may also result from medication nonadherence (Perri, Martin, & Pritchard, 1995). Physicians may alter prescriptions, or send the patient for further and unnecessary diagnostic procedures, not realising that the lack of success in treatment is due to nonadherence rather than inappropriate prescribing. Older adults have an increased sensitivity to drugs as a result of age-related physiological changes (Richardson, 1986), combined with the often long term and substantive consumption of drugs (polypharmacy) in chronic and multiple medical disorders.

Medication under-adherence may also lead to the hoarding of unused and possibly unidentifiable tablets, an unsatisfactory and potentially dangerous situation. Saved tablets may be used at a later stage, perhaps subsequent to their 'use-by' date, or shared with others. In fact, 43% of Buckalew and Buckalew's (1995) census-based sample confessed to having used other people's medication; 5% gave away unused medications to others.

A variety of factors contribute to medication nonadherence in older adults. The costs of medication (Chubon, Schulz, Lingle, & Coster-Schulz, 1994), quality of doctor–patient communication (Bula et al., 1995), negative medication beliefs (Leventhal, Leventhal, & Cameron, 2001), and the absence of symptoms for which the medication is being used (Leventhal, Leventhal, & Schaefer, 1992) may lead to nonadherence. Cognitive declines that accompany normal aging may also affect adherence by impeding older adults' ability to perform desirable health behaviors (Park, 2000). Declines in working memory can make it difficult to manage multiple medical demands (Park et al., 1992). Furthermore, declines in the ability to comprehend a physician's instructions (Halter, 1999; Morrell, Park, & Poon, 1989) and declines in prospective memory for remembering to perform health behaviors at their appropriate time are also associated with nonadherence (Einstein & McDaniel, 1990). There has been substantial research on medical information processing to indicate that older adults may have more difficulty than younger adults in comprehending, remembering, and following physician instructions (Brown & Park, 2002; Halter, 1999; Park & Kidder, 1996; Park, Willis, Morrow, Diehl, & Gaines, 1994; Salzman, 1995).

Interventions for Medication Non-Adherence

There has been considerable research attempting to improve medication adherence in older adults. Studies have shown that improved communication between doctor and patient leads in increased adherence (e.g., Bula et al., 1995). While some medication organisers can detract from adherence, there is emerging evidence to support the use of instructional charts and organisers to improve adherence (Park et al., 1992).

The utility of a range of memory aids including voice mail recording, dose counters, alarms and medication calendars or charts has also been investigated. For instance, in a simulated study, Leirer, Morrow, Tanke, and Pariante (1991) successfully reduced nonadherence to a mere 2.1% for a complex medication schedule, by using a recorded telephone reminder. In a study by Perri et al. (1995), which compared prescription refill data 3 months before and after the introduction of dose counters contained within prescription medication bottle caps, adherence was improved in the intervention group by 5%.

The use of such devices has often proved efficacious in older populations. In fact, a recent review of the literature indicates that strategies such as a telephone reminder or electronic reminder proved more effective than more cost-effective strategies such as a medication calendar (van Eijken Tsang, Wensing, de Smet, & Grol, 2003). However, often the downfall of such aids is either the complexity of programming the device, or their cost. Simpler techniques such as memory aids which require little cognitive input on the part of the patient, such as medication reminder calendars or charts, may be of most assistance to older adults on a complex medication regimen, or to those who are cognitively impaired and thus require support to comply with their medication regimen (e.g., Southam & Dunbar, 1986).

Aims of the Present Study

The present study was designed to determine whether external cognitive aids that require little or no training could facilitate adherence to a medication regimen. Forgetfulness is one of the myriad of variables implicated in medication nonadherence and has been cited as the most common cause of missing medication, or *errors of omission*, among older adults (e.g., Park et al., 1992). Due to the expectation that the mild memory deficits, which are the usual concomitants of normal aging, may sometimes cause older adults to forget to take their medication, this study investigated whether the provision of a memory cue, in the form of an individualised 'medication calendar' enhanced adherence with prescription drug regimens involving multiple drugs. For the purposes of this study, polypharmacy was operationally defined as taking three or more different prescribed medications per day, as in the studies by Gray, Mahoney and Blough (2001). Adherence was operationally defined as taking between 90% and 110% of prescribed medication. Lorenc and Branthwaite (1993) state that this is the range 'normally accepted as compliant' (p. 487).

The present study was designed to establish the average medication adherence rate in a sample of community dwelling older adults taking multiple medications. An intervention was also planned, wherein a treatment subsample within the study was provided with an individualised medication reminder calendar designed to improve medication adherence. The calendar was designed to result in less medication errors rather than control who took their medications as per usual. The calendar was expected to reduce errors of omission by serving as a memory prompt, and reduce taking more medication than prescribed, or *errors of commission*, through self-monitoring ingested medication.

Method

Participants

Fifty community-dwelling older adults living in the greater Auckland area of New Zealand participated in the present study. All were aged 55 years or older and ingesting three or more different prescription medications daily. No other exclusion criteria were used. Although 65 years and older is the age grouping most commonly used to define older adults (Davidson & Neale, 1994), the present study deviated from the conventional age criterion in the hope of appealing to Maori adults, who, on average, live for about 5 years less than New Zealand Europeans and are under-represented in the older age groups (Statistics New Zealand, 1998). Two participants withdrew from the study due to illness.

Procedure

Participants were recruited through invitations from their general medical practitioners (GPs), as is accepted practice in medication adherence research (e.g., Atwood et al., 1996; Maddox, Levi & Thompson, 1994). In the first instance, we distributed 'Registration of Interest' forms and cover letters inviting a random sample of 732 Auckland GPs to participate. Practitioners were also asked to estimate the number of patients to whom they were willing to forward information sheets. An initial positive response was received from 153 GPs (21% response rate), but only 18 GPs (2.5% response rate) actually participated in the main study. Despite the low response, these 18 practitioners estimated that 170 information sheets could be distributed to patients. Consequently, the target of a minimum sample size of 50 patient participants did not seem to be an unreasonable expectation. Older adults were also recruited through 'word of mouth', and 21 participants joined the study in this way.

The final sample of 50 participants were randomly assigned to intervention ($N = 20$) or control conditions ($N = 30$). The unequal division into groups was the result of a decision to limit the number of participants with medication calendars to 20, due to the cost involved in the monitoring of medications taken. The resultant sample size was similar to prior medication adherence research (e.g., Kendrick & Bayne, 1982; Park et al., 1992).

Prescription information was used to compile the medication reminder calendars for those participants who had been randomly allocated to the intervention condition. For self-referred participants, prescription medication information was taken directly from pharmacists' labels on medication containers.

Appointments to see participants in their homes were arranged subsequent to the receipt of details of their current prescription medication from their GP. At this initial visit, a brief summary of the study's purpose and method was presented, and any questions by participants were answered. Participants were informed whether they were in the experimental or control group, and it was emphasised that this allocation was by chance alone. Participants were then requested to produce all their medication, including refills not yet opened, in order for it to be counted.

Prior to the actual drug inventory, dosages and other information provided upon container labels (e.g., the number of tablets provided, date dispensed, number of repeats remaining, etc.) were carefully noted. Medication calendars were checked with the participant to ensure their correctness and completeness, and their purpose explained. Participants were requested to keep their calendars in a place where they would serve as a visual reminder to take their medication, and to make a tick in the appropriate place on the calendar once this had been done, in order to self monitor their medication taking behaviour.

The pill count was conducted using a pharmacist's counting tray, disposable rubber gloves and a clean plastic knife. Its accuracy was verified by a research assistant, who was always present. Various medications (e.g., insulin administered by self injection) were not included in drug inventories, most commonly due to their unsuitability for counting purposes. Approximately 7 weeks later, a final drug inventory was conducted.

Measurement of Medication Adherence

Two methods were employed in the present study to assess medication adherence, namely an overall adherence ratio and a total error rate. The adherence ratio for a particular medication was established by calculating the number of pills taken by the participant, dividing this by the number of pills that should have been ingested according to the GP's prescription and multiplying the result by 100 (Lorenc & Branthwaite, 1993). This procedure was repeated for all prescribed medications.

Overall adherence ratios were then calculated by combining individual medication ratios and dividing by the total number of medications prescribed, as has been done in prior research (e.g., Botelho & Dudrak, 1992; Rich et al., 1996). The drawback of an adherence ratio is that where a participant takes too much of one medication, and too little of another, these errors will balance each other out and produce an adherence ratio of 100%. For this reason, an additional measure of adherence was calculated, namely total error rate, calculated by adding up the number of medication mistakes made (Wandless & Davie, 1977). For instance, each tablet that had not been ingested as prescribed was counted as one mistake. Total errors were subdivided into errors of omission, operationally defined as taking fewer tablets than had been prescribed, and errors of commission, operationally defined as taking more tablets than had been prescribed.

Materials

Materials used in the present study included a drug inventory form, the medication calendar, and a brief sociodemographic questionnaire. A pharmacist's pill counting tray was used to conduct medication inventories.

The primary function of the medication calendar was to serve as a memory prompt, and as such, it was printed on brightly coloured paper to increase its prominence. Apart from its purpose as a memory cue, the calendar also provided information about medication (what to take, how much to take and when to take it) and allowed for self monitoring by providing a check-off space to tick after each dose had been taken. A large font (size 14) was used to make it easy to read. The calendar was printed on thin cardboard with a page for each week, attached to a brightly coloured clip board, with a pencil and re-usable adhesive provided for those participants who wished to secure it to a wall, cupboard door or refrigerator.

Results

Sample Characteristics

Participants were aged between 55 and 84 years (M = 70.70, Mdn = 72.00, SD = 8.12). Of the male participants, 15 (83%) were retired, as were 25 (78%) of the female participants. It is also noteworthy that almost half (48%) had tertiary qualifications. The sample was evenly divided in terms of living arrangements, with half living alone and half living with their spouse. Of those living alone, three lived in 'granny flats' attached to the home of a relative. More males than females were married (72%, 38%, respectively) and more females than males were living alone (62%, 28%, respectively). Further demographic information is presented in Table 1.

Medication Use

On average, participants were prescribed five different drug types prescribed on a daily basis by their GPs (*Mdn* = 4.50, *SD* = 1.87, range of 2 to 10). This translated into participants ingesting an average of seven tablets or capsules daily (*Mdn* = 6.00, *SD* = 4.01, 2 to 19). A wide range of drugs was prescribed for sample members by their general practitioners, with 23 participants (46%) being prescribed aspirin in some form or another (e.g., Solprin, Cartia, Aspro). Anti-hypertensive drugs also predominated, with the diuretics Bendrofluazide and Frusid being prescribed to 19 participants (38%).

TABLE 1

Demographic Characteristics of Study Participants

		n	%
Gender	Male	18	36
	Female	32	64
Ethnicity	New Zealand European	42	84
	British	2	4
	Maori	1	2
	South African	4	8
	Dutch	1	2
Employment status	Retired	40	8
	Full-time	4	8
	Part-time	4	8
	Sickness benefits	2	4
Income (annual)	Below $15,000	31	62
	$15,000–$24,999	7	14
	$25,000–$34,999	3	6
	$35,000 or more	9	18
Education Level	No formal school qualification	11	22
	Proficiency examination	3	6
	School certificate	5	10
	Sixth form certificate	5	10
	Bursary	2	4
	Trade certificate or diploma	13	26
	Undergraduate degree	6	12
	Postgraduate degree	5	10

Note: (*N* = 50)

Only a few psycho-active drugs were prescribed, with just four participants (8%) taking sleeping pills (i.e., Halcion or Imovane) and nine (18%) taking anti-depressants (e.g., Aurorix, Nortriptyline, Dothiepin HCI).

Effects of Intervention on Medication Adherence

The average overall adherence ratio for the sample (that is, experimental and control groups combined) was 97% (M = 97.06, Mdn = 98.50, SD = 4.98) and ranged from a minimum of 82% to a maximum of 109%. On average, participants made 19 errors in the interval between pill counts (Mdn = 13.00, SD = 18.42). The total number of errors made ranged from a minimum of zero to a maximum of 77. The majority (79%) of the errors made were errors of omission (M = 14.56, Mdn = 7.50, SD = 16.94) while 21% were errors of commission (M = 4.40, Mdn = 1.00, SD = 7.47). The number of errors of omission and commission ranged from zero to 75 and 31 respectively. Only one participant made no errors, while three made no errors of omission and 19 made no errors of commission.

Adherence Ratio

The average adherence ratio of the participants in the experimental group (N = 20) was 98% (Mdn = 98.50, SD = 3.81, range 90% to 104%). The average adherence ratio of the participants in the control group (N = 30) was 97% (Mdn = 98.50, SD = 5.68), ranging from 82% to 109%. A Mann Whitney U test, a nonparametric alternative to the t-test, established that the adherence difference between the control and experimental groups was not significant, $t(48) = 286.00$, $p = .78$, indicating that the provision of an individualised medication calendar did not result in a significantly increased average adherence ratio.

Total Error Rate

There were no group differences in mean error rate, both the experimental and control group made an average of 19 errors (Mdn = 14.00, SD = 16.41, and Mdn = 11.50, SD = 19.91 respectively). The number of errors ranged from 1 to 50 for the experimental group and from 0 to 77 for the control group. Thus, the provision of an individualised medication calendar did not lead to the expected decrease in total errors made. Further, the groups did not differ significantly when compared according to mean number of errors of omission and commission.

It was suspected that the use of the adherence ratio (number of doses taken, divided by the number of prescribed doses, multiplied by 100) to compare the performance of the experimental and control group may have artificially inflated the average level of adherence. Adherence ratio is only a true measure of adherence in a group where all errors are errors of omission. In the present study, 11 participants had adherence ratios exceeding 100%, due to the inclusion of errors of commission. Without these participants, the average adherence rate drops from 97% to 95.5%. This, however, did not alter the finding that the medication calendar did not improve adherence rates in the experimental versus control group.

Relationship Between Sample Characteristics and Medication Adherence

Exploratory bivariate analyses for demographic and socioeconomic factors were conducted. There was no significant relationship between age and any of the adherence measures, nor between living arrangements and any of the adherence measures. However, a Mann Whitney *U* test indicated a gender difference in adherence ratio score; $t(48) = 150.50$, $p < .001$, with women in this sample more likely to demonstrate nonadherence. At this stage in the analysis, there were no gender differences in numbers or types of errors made. As only one participant identified ethnicity other than European (New Zealand or 'other'), relationships between ethnicity and adherence measures or other independent variables were not examined.

As far as the interrelationship between education and adherence measures was concerned, only errors of commission were weakly and inversely related to education, ($r = -.33$, $p = .018$). On average, education accounted for about 11% of the variance in errors of commission in this sample, with less well educated participants tending to make more errors of commission than better educated participants. Similarly, only errors of commission were moderately and inversely related to income ($r_s = -.42$, $p = .003$), with income accounting for about 18% of the variance in errors of commission, and with participants receiving lower annual incomes tending to make more errors of commission than participants receiving higher annual incomes. As far as employment status was concerned, again, errors of commission was the only adherence measure to be significantly related ($r = -.33$, $p = .021$). The data showed that more errors of commission were made by participants in this sample who were retired or receiving a sickness benefit, than by those in full or part time employment. Further analyses were conducted to establish relationships between demographic and socioeconomic variables (see Table 2).

The significant bivariate correlations in Table 2 indicate that, on average, older participants in the sample received lower incomes and were more likely to be retired. Those on lower incomes were more likely to be retired or on a sickness benefit rather than employed. The higher the level of education, the more likely it was that a participant was employed and the higher their income was likely to be.

Prediction of Medication Adherence

Due to these associations between independent variables, multiple linear regression (standard or 'all in') was employed in order to assess whether any of the

TABLE 2

Intercorrelations Between Sample Characteristics and Independent Variables

	1	2	3	4	5	6	7
1. Age	—						
2. Gender	.06	—					
3. No. of daily tablets	−.32*(1)	−.21	—				
4. Income	−.41**(2)	.11	.18	—			
5. Employment	.39**(2)	.24	.05	−.54**(2)	—		
6. Education	−.08	.49	−.15	.40**(2)	−.31*(2)	—	
7. Living situation	−.10	−.33*(3)	.01	.20	.25	.31	—

Note: 1 = Pearson's *r*, 2 = Spearman's *r*, 3 = Cramer's *V*.
*$p < .05$ level
**$p < .01$ level

significantly related demographic and socioeconomic variables were independent predictors of adherence.

Adherence Ratio

The adjusted R^2 was significantly different from zero, adjusted $R^2 = .173$, $F(5, 44) = 2.05$, $p = -.02$. Thus, the model accounted for about 17% of the variance in adherence ratio score, with this relationship unlikely to be due to chance. Regression coefficients for the independent variables are set out in Table 3. Gender was the only independent variable contained in this model to contribute significantly to the prediction of adherence ratio score, consistent with the previously established bivariate gender difference. The gender difference in adherence ratio score of about four indicated that, on average in this sample, women tended to be more noncompliant than men.

Total Error Rate

The adjusted R^2 was significantly different from zero, adjusted $R^2 = .243$, $F(5, 44) = 4.15$, $p = .004$. This model accounted for about 24% of the variance in total error rate, with this relationship highly unlikely to be due to chance. Regression coefficients for the independent variables are set out in Table 4. Only two out of the five independent variables contained in this model contributed significantly to the

TABLE 3

Regression Co-efficients for Multivariate Model Using Compliance Deviation Score as the Dependent Variable

Variable	*B*	*SEB*	β
Age	0.12	0.08	.24
Gender	4.00	1.21	.46*
No. of daily tablets	8.15	0.15	.08
Income	0.28	0.58	.08
Education	0.60	0.31	.30

Note: *$p < .01$ level

TABLE 4

Regression Coefficients for Multivariate Model Using Total Error Rate as the Dependent Variable

Variable	*B*	*SEB*	μ
Age	0.40	0.34	.18
Gender	12.53	5.10	.33*
No. of daily tablets	2.73	0.63	.59**
Income	0.30	2.43	.02
Education	1.38	1.30	.16

Note: *$p < .05$ level
**$p < .01$ level

prediction of total error rate. These were gender and number of daily tablets, with the latter responsible for the greatest amount of variance, on average, in total medication errors made. The results indicated that for every one standard deviation increase in number of daily tablets, there was a .59 standard deviation increase in error rate, on average, which was highly unlikely to be due to chance. This finding is consistent with the previously established significant bivariate correlation between number of daily tablets and total errors made ($r = .45$). The gender difference in total error rate of about 12.5 indicated that, on average and in this sample, women tended to make more medication errors than men. This finding is inconsistent with preliminary analyses, where a Mann Whitney *U* test indicated no gender differences in numbers of errors made.

Errors of Omission

The adjusted R^2 was significantly different from zero (adjusted $R^2 = .133$, $F(5, 44) = 2.51$, $p = .044$). Thus the model accounted for about 13% of the variance in errors of omission, with this relationship unlikely to be due to chance. As before, only two out of the five independent variables contributed significantly to the prediction of errors of omission, namely gender and number of daily tablets. This result is inconsistent with preliminary analyses, where a Mann Whitney *U* test indicated no gender differences in numbers of errors made and there was no significant bivariate correlation between number of daily tablets and errors of omission.

Errors of Commission

The adjusted R^2 was significantly different from zero, adjusted $R^2 = .376$, $F(5,44) = 6.90$, $p < 01$. Thus, the model accounted for about 38% of the variance in errors of commission, with this relationship highly unlikely to be due to chance. Again, only two out of the five independent variables contributed significantly to the prediction of errors of commission, with number of daily tablets reaching significance, as in

TABLE 5

Regression Coefficients for Multivariate Model using Errors of Omission and Errors of Commission as Dependent Variables

Dependent Variable	Variable	*B*	*SEB*	β
Errors of Omission	Age	.54	.33	.26
	Gender	10.52	5.02	.30*
	No of daily tablets	1.76	.62	.42**
	Income	2.33	2.40	.16
	Education	1.84	1.28	.23
Errors of Commission	Age	−.15	.12	-.16
	Gender	2.01	1.88	.13
	No of daily tablets	.97	.23	.52**
	Income	−2.03	.90	−.32
	Education	−.46	.48	−.13

Note: $^*p < 0.05$ level
$^{**}p < 0.01$ levelM

all of the previous models and consistent with the significant bivariate correlation ($r = .53$). However, gender failed to produce a significant effect, whereas there was a significant effect for income. This is consistent with the previously significant bivariate correlation between income and errors of commission ($r_s = -.42$). Regression coefficients for the independent variables for both models are set out in Table 5.

Discussion

It was anticipated that, with the advent of blister packaging and sophisticated medication organisers, and the increased awareness of the problems resulting from nonadherence, average overall medication adherence rates among participants would be higher than the 50% to 66% commonly cited in the literature. In fact, the mean adherence rate of the participants in the present study (97%) was substantially higher than that found in many past studies. Comparison with other studies is made difficult by the wide range of operational definitions of adherence. Nevertheless, when compared with similar studies that also defined adherence according to the average percentage of prescribed doses of medication taken by their participants (e.g. Ware, Holford, Davison, & Harris, 1991), the average adherence rate in the present study seems high. Application of the definition of adherence adopted for present purposes, namely taking 90% to 110% of prescribed medication (Lorenc & Branthwaite, 1993), only three participants may be defined as noncompliant (taking 82%, 83% and 88% of their medication respectively). As far as error rate is concerned, and in keeping with the findings of previous studies (e.g., Kruse et al., 1992; Park et al., 1992; Salzman, 1995) the present study found most medication errors (79%) to be errors of omission.

The present study anticipated that those individuals in the sample who were provided with an external cognitive support (i.e., individualised medication reminder calendar) would, on average, achieve higher rates of adherence with medication regimens and make fewer medication errors than controls. This hypothesis was not supported, and groups did not differ according to either average adherence ratios or error rates. This result contradicts prior research, such as Park and colleagues (1992) that found the use of external cognitive aids significantly reduced errors of omission in community dwelling participants over age 71. Consistent with the present study, however, Park and colleagues found no improvement in those aged 70 years or younger. Consequently, one reason for the failure to find an effect could be the difference in sample age; while the mean age in the present sample was 71 years, the mean age in Park et al.'s sample was 78 years.

The most probable explanation for both the high average rate of medication adherence, and the lack of difference between experimental and control groups is the fact that the sample were self-selected volunteers. The participants in the present study were all fully informed about the nature of the study prior to consenting to participate. Epstein and Cluss (1982) suggest that volunteers may be different in motivational or other characteristics, making them more likely to comply with their medication than others who are not willing to participate. They suggest that as a result, in many studies medication adherence is likely to have been overstated.

A further possibility for the lack of difference between experimental and control groups is low statistical power. Given that statistical power represents the probability of detecting an effect, as statistical power decreases the likelihood of obtaining a null result increases (Cohen, 1988). If the effect size for the medication intervention was small in magnitude, then it is likely that the study was underpowered to detect an effect at the conventional .05 level. The above mentioned difficulties in recruiting participants, and financial restraints, meant that the sample size was not a large as would have been preferred.

Relationship Between Sample Characteristics and Adherence

Due to the inconsistencies in previous research, the present study aimed to investigate the relationship between adherence rates and demographic and socioeconomic factors, particularly gender, age, ethnicity, education, income and living arrangements. Gender was the only one of the demographic variables to be significantly related to the medication adherence ratio and error rates in the present study. On average, female participants were less compliant and made more errors than male participants. This result has been obtained in other studies (e.g., Col, Fanale, & Kronholm, 1990; Daniels, Rene, & Daniels, 1994). Interestingly, when total medication error rate was broken down into errors of omission and commission, the gender effect failed to reach significance. Thus, while women appeared to make more errors of omission than men in this sample, there was no gender difference for errors of commission. This is difficult to explain, given that there was no significant relationship between gender and amount of medication taken; however, this is in keeping with the research literature, where inconsistent findings according to gender and adherence are prevalent.

As far as the relationship between income and nonadherence is concerned, previous research has established a link between low socioeconomic status and nonadherence (e.g., Bame, Peterson, & Wray, 1993). It is noteworthy that the present study established an inverse relationship between income and errors of commission, but not errors of omission or total errors made. This finding suggests that persons of lower socioeconomic status tend to over-comply with medication. As indicated in Table 4, income was related to both education level and employment status in the present sample. Gray et al. (2001) established an association between low education and medication over-adherence in a sample of 147 older participants, although this univariate effect failed to reach significance in a multivariate model. The finding of the present study may be the result of lower socioeconomic participants, with relatively high educational attainment, when uncertain about whether or not they had taken their medication, preferring to err on the side of caution. It is also possible that these participants may not understand that over-medication is potentially as hazardous for their health as under-medication.

Analysis of the demographic characteristics of the present sample indicates that in some respects, these characteristics do differ from those of the general population of older adults in New Zealand, most notably in terms of education. For example, 48% of sample participants have a tertiary qualification, compared with about 11% of the New Zealand population aged 15 years and over (Statistics New Zealand, 2001). Several studies have implicated education as a factor promoting medication adherence (e.g., Daniels et al., 1994; Leistyna & Macaulay, 1966) and volunteering for research projects (Maine, Rodriguez & Brown, 1988). Further, participants in the present study were not as disabled as the general population of older adults in New Zealand, about a quarter of whom suffer from vision or hearing deficits, and over a third of whom suffer from a physical disability of some sort (Statistics New Zealand, 1998). Only one participant in the present study was visually impaired to the extent that she required the researcher to read the questionnaires to her, and interestingly her adherence ratio was 91%, with no more errors than the average.

Difficulty with the Pill Counting Procedure

Pill counting proved to be a potentially inaccurate medication adherence measure. While it is unlikely that the actual counting process was subject to error, as the researcher's count was always checked by a research assistant, it was not uncommon for participants to remember at the second pill count that they had 'spares', sometimes dating back before the first pill count. In addition, the amount of daily medication taken by the participant occasionally bore little resemblance to the amount indicated by the GP, or fluctuated during the course of the study. In such instances, or in other cases of confusion, it was necessary to drop the suspect drug from the inventory. Thus, adherence figures are likely to have been inflated somewhat.

As anticipated, in the calculation of the adherence ratio, errors of omission often cancelled out errors of commission, perhaps where similar looking pills had been confused. Thus, the high overall adherence ratio (97%) for participants in the present study may disguise numerous drug taking mistakes. This is supported by the total error rate, where on average each participant made 19 errors and the maximum number of errors made by a participant during the interval between pill counts reached as high as 77.

Conclusion

The present study found adherence rates to be substantially higher than those quoted in the research literature. Despite the cited concerns about the self-selection in the convenience sample used, these findings are reassuring, particularly considering New Zealand's aging population and the limited resources available in the health sector. The present study indicates that sample participants are neither wasting health resources nor putting their own health at risk. Given the nature of the sample used as well as the low numbers of participants, a similar study conducted on a larger, research on more representative samples of older adults is warranted.

Acknowledgments

This study was supported in part by a grant from the School of Psychology, Massey University. The authors thank Judith Russell for comments on a previous version of this manuscript.

References

Atwood, J.R., Giordano, L., Vargas, P., Blackwell, G.G., Earnest, D.L., Meyskens, F., et al. (1996). Adherence enhancers in pill-related clinical trials: A health behaviour in cancer prevention model-based approach. *Patient Education and Counseling, 28*, 15–23.

AARP Administration on Aging. (1999). *A profile of older Americans, 1999*. Washington, DC: AARP.

Bame, S.I., Petersen, N., & Wray, N.P. (1993). Variations in hemodialysis patient compliance according to demographic characteristics. *Social Science and Medicine, 37*(8), 1035–1043.

Berg, J.S., Dischler, J., Wagner, D.J., Raia, J.J., & Palmer-Shevlin, N. (1993). Medication compliance: A healthcare problem. *The Annals of Pharmacotherapy, 27*(9), s2–s19.

Botelho, R.J., & Dudrak, R. (1992). Home assessment of adherence to long-term medication in the elderly. *The Journal of Family Practice*, *35*(1), 61–65.

Brown, S.C., & Park, D.C. (2002). Roles of age and familiarity in learning health information. *Educational Gerontology*, *28*(8), 695–710.

Buckalew, L.W., & Buckalew, N.M. (1995). Survey of the nature and prevalence of patients' non-compliance and implications for intervention. *Psychological Reports*, *76*, 315–321.

Büla, C., Alessi, C.A., Aronow, H.V., Yubas, K., Gold, M.& Niesenbaum, R., et al. (1995). Community physicians' cooperation with a program of in-home comprehensive geriatric assessment. *Journal of the American Geriatrics Society*, *43*(9), 1016–1020.

Chrischilles, E.A., Segar, E.T., & Wallace, R.B. (1992). Self reported adverse drug reactions and related resource use: A study of community-dwelling persons 65 years of age and older. *Annals of Internal Medicine*, *117*, 634–640.

Chubon, S.J., Schulz, R.M., Lingle, E.W., & Coster-Schulz, M.A. (1994). Too many medications, too little money: How do patients cope? *Public Health Nursing*, *11*(6), 412–415.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Col, N., Fanale, J.E., & Kronholm, P. (1990). The role of medication non-compliance and adverse drug reactions in hospitalisations of the elderly. *Archives of Internal Medicine*, *150*, 841–845.

Cooper, J.W. (1990). Drug related problems in the elderly at all levels of care. *Journal of Geriatric Drug Therapy*, *4*(3), 79–83.

Daniels, D.E., Rene, A.A., & Daniels, V.R. (1994). Race: An explanation of patient compliance — fact or fiction? *Journal of the National Medical Association*, *86*(1), 20–25.

Davison, G.C., & Neale, J.N. (1994). *Abnormal Psychology* (6th ed.). New York: John Wiley & Sons.

Devor, M., Wang, A., Renvall, M., Feigal, D., & Ramsdell, J. (1994). Compliance with social and safety recommendations in an outpatient comprehensive geriatric assessment program. *Journal of Gerontology*, 49(4), M168–M173.

Einstein, G.O., & McDaniel, M.A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*,*16*(4), 717–726.

Epstein, L.H., & Cluss, P.A. (1982). A behavioural medicine perspective on adherence to long term medical regimens. *Journal of Consulting and Clinical Psychology*, *50*(6), 950–971.

Gray, S.L., Mahoney, J.E., & Blough, D.K. (2001). Medication adherence in elderly patients receiving home health services following hospital discharge. *Annals of Pharmacotherapy*, *35*(5), 539–545.

Green, L.W., Mullen, P.D., & Stanbrook, G.L. (1986). Programs to reduce drug errors in the elderly: Direct and indirect evidence from patient education. *Journal of Geriatric Drug Therapy*, *1*(1), 3–18.

Halter, J.B. (1999). The challenge of communicating health information to elderly patients: A view from geriatric medicine. In D.C. Park, R.W. Morrell, & K.Shifren (Eds.), *Processing of medical information in aging patients: Cognitive and human factors perspectives* (pp. 23–28). Mahwah, NJ: Lawrence Erlbaum Associates.

Haynes, R.R. (1979). Introduction. In R.B. Haynes, D.W. Taylor, & D.L. Sackett (Eds.), *Compliance in health care*. Baltimore: Johns Hopkins University Press.

Kendrick, R., & Bayne, J.R.D. (1982). Compliance with prescribed medication by elderly patients. *Canadian Medical Association Journal*, *15*, 127–128.

Kruse, W., Koch-Gwinner, P., Nikolaus, T., Oster, P., Schlierf, G., & Weber, E. (1992). Measurement of drug compliance by continuous electronic monitoring: A pilot study in elderly patients discharged from hospital. *Journal of the American Geriatrics Society*, 40, 1151–1155.

Leventhal, H., Leventhal, E.A., & Cameron, L. (2001). Representations, procedures, and affect in illness self-regulation: A perceptual-cognitive model. In A. Baum, T.A. Revenson, & J.E. Singer (Eds.), *Handbook of health psychology* (pp. 19–47). Mahwah, NJ: Lawrence Erlbaum Associates.

Leventhal, H., Leventhal, E.A., & Schaefer, P.M. (1992). Vigilant coping and health behavior. In M.G. Ory, R.P. Abeles, & P.D. Lipman (Eds.), *Aging, health, and behavior* (pp. 109–140). Thousand Oaks, CA: Sage.

Leirer, V.O., Morrow, D.G., Tanke, E.D., & Pariante, G.M. (1991). Elders' non-adherence: Its assessment and medication reminding by voice mail. *The Gerontologist, 31*(4), 514–520.

Leistyna, J.A., & Macaulay, J.C. (1966). Therapy of streptococcal infections. Do pediatric patients receive prescribed oral medication? *American Journal of Diseases of Children, 111*(1), 22–26.

Lorenc, L., & Branthwaite, A. (1993). Are older adults less compliant with prescribed medication than younger adults? *British Journal of Clinical Psychology, 32*, 485–492.

Maddox, J.C., Levi, M., & Thompson, C. (1994). The compliance with antidepressants in general practice. *Journal of Psychopharmacology, 8*(1), 48–53.

Maine, L.L., Rodriguez, R., & Brown, J. (1988). Geriatric drug testing — Who will volunteer? A descriptive survey. *Journal of Geriatric Drug Therapy, 2*(4), 63–65.

Monane, M., Bohn, R.L., Gurwitz, J.H., Glynn, R.J., & Avorn, J. (1994). Noncompliance with congestive heart failure therapy in the elderly. *Archives of Internal Medicine, 154*, 433–437.

Morrell, R.W., Park, D.C., & Poon, L.W. (1989). Quality of instructions on prescription drug labels: Effects on memory and comprehension in young and old adults. *Gerontologist, 29*(3), 345–354.

Park, D.C. (2000) Medication adherence: Is and why is older wiser? *Journal of the American Geriatric Society, 48*, 458–459.

Park, D.C., & Kidder, D.P. (1996). Prospective memory and medication adherence. In M. Brandimonte, G.O. Einstein, & M.A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 369–390). Mahwah, NJ: Lawrence Erlbaum Associates.

Park, D.C., Morrell, R.W., Frieske, D., & Kincaid, D. (1992). Medication adherence behaviours in older adults: Effects of external cognitive supports. *Psychology and Aging, 7*(2), 252–256.

Park, D.C., Willis, S.L., Morrow, D., Diehl, M., & Gaines, C. (1994). Cognitive function and medication usage in older adults. *Journal of Applied Gerontology, 13*, 39–57.

Perri, M., Martin, B.C., & Pritchard, F.L. (1995). Improving medication compliance: A practical intervention. *Journal of Pharmacy Technology, 11*, 167–172.

Rich, M.W., Baldus Gray, D., Beckham, V., Wittenberg, C., & Luther, P. (1996). Effect of a multidisciplinary intervention on medication compliance in elderly patients with congestive heart failure. *American Journal of Medicine, 101*(3), 270–276.

Richardson, J.L. (1986). Perspectives on compliance with drug regimens among the elderly. *Journal of Compliance in Health Care, 1*, 33–46.

Salzman, C. (1995). Medication compliance in the elderly. *Journal of Clinical Psychiatry, 56*(1), 18–22.

Southam, M.A., & Dunbar, J.M. (1986). Facilitating patient compliance with medical interventions. In K. Holroyd & T. Creer (Eds.), *Self management of chronic disease*. New York: Academic Press.

Statistics New Zealand (1998). *65 Plus*. Wellington, New Zealand: Author.

Statistics New Zealand (2001). *2001 Census: Education*. Wellington, New Zealand: Author.

Van Eijken, M., Tsang, S., Wensing, M., de Smet, P., & Grol, R. (2003). Interventions to improve medication compliance in older patients living in the community: A systematic review of the literature. *Drugs & Aging, 20*(3), 229–240.

Wandless, I., & Davie, J.W. (1977). Can drug compliance in the elderly be improved? *British Medical Journal, 1*, 359–361.

Ware, G.J., Holford, N.H.G., Davison, J.G., & Harris, R.G. (1991). Unit dose calendar packaging and elderly patient compliance. *New Zealand Medical Journal, 101*, 495–497.

Wright, E.C. (1993). Non-compliance: Or how many aunts has Matilda? *The Lancet, 342*(8876), 909–913.