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In-Home Drug Storage by Older Adults

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ABSTRACT

Globally, in-home drug-storage compliance is often unsatisfactory, especially among older adults, and can lead to negative health outcomes. This study used a cross-sectional and descriptive design to examine in-home drug-storage compliance among older adults. Convenience sampling was used to recruit 117 older adults in Hong Kong. An in-home drug-storage checklist was used to assess the in-home drug-storage environments (light, temperature, and humidity) and drug-storage methods (drug safety, packaging, information, and expiration) of each older adult. The findings showed that Hong Kong older adults' overall compliance rate in drug storage was 87.25%, and their compliance rate for drug-storage methods (84.59%) was lower than that for drug-storage environments (97.02%). Older adults who were of advanced age, who were less educated or who lived alone demonstrated lower in-home drug-storage compliance. This indicates the need to revise existing health-education strategies to encourage in-home drug-storage compliance. Healthcare professionals should assess older adults' drug-storage compliance to identify less compliant subgroups and deliver specific drug-storage support as required. Family members should also be involved in this process.

1. Introduction

In-home drug storage is a common practice around the world [11,14,21,23,27,31]. In Hong Kong, three-quarters of the population store drugs at home [4]. In-home drugs are prescribed by physicians or purchased from dispensaries [30], and typically include analgesics, antibiotics, and cold remedies [1,17]. People often store drugs for continuous use and may keep discontinued drugs at home for emergency use [4]. Older adults are subject to risks from poly-

pharmacy and multiple co-morbidities, and are also at risk of suffering from adverse drug reactions as result of taking drugs that have been improperly stored at home [11,14]. Currently, the global population is aging; the number of people aged 65 or more is projected to rise from 703 million in 2019 to 1.5 billion in 2050 [32]. Thus, older adults' in-home drug-storage compliance will be of increasing significance.

Improper in-home drug-storage has many negative

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consequences^[8,10], such as the risk of poisoning. Good drug-storage has two components: a proper drug-storage environment and a proper drug-storage method. Proper in-home drug-storage environment has appropriate levels of light, temperature, and humidity, as these factors can influence drug safety and effectiveness^[7,17,37]. Proper in-home drug-storage methods involve storing drugs in a safe place, keeping the original packaging and drug information, and discarding expired drugs^[10,18]. Improper drug-storage methods include putting drugs in the wrong packaging or keeping expired drugs, which can result in accidental poisoning and toxicity. Ultimately, improper drug-storage practice threatens patient safety, and may increase healthcare costs^[13,16]. Similarly, it has also been noted that improperly stored drugs harm the health of users^[11,14,17]. Therefore, complying with in-home drug-storage standards is crucial^[18].

Although studies have highlighted the importance of proper in-home drug storage, they have found that compliance is often poor. Studies have found that only half of older adults, for instance, complied with in-home drug-storage standards in the Netherlands (51.2%) and Nepal (51.3%)^[27,33]. More than half of adults in United Kingdom (63.8%) and Brazil (52.9%) stored drugs in the kitchen, where the temperature is unsuitably high^[22,26]; another study found that many adults in Qatar kept drugs in the bathroom (19%), which is unsuitably humid^[13]. Adults appear to be best at complying with appropriate light conditions for drug storage, by keeping drugs away from sunlight (89.1%)^[22]. However, another study found that approximately three quarters (76.4%) of older adults consistently stored drugs in the proper environment, in terms of temperature, light and humidity^[34]. Vlieland found that older adults correctly stored less than half (46.8%) of drugs that required refrigeration but did not investigate their drug-storage practices with respect to light and humidity^[34]. There is an incomplete understanding of older adults' drug-storage environment practice.

With respect to older adults' drug-storage methods, 90.6% of older adults in the Netherlands stored unexpired drugs at home^[34], and this figure was even higher in Nepal (99.5%)^[27]. Vlieland found that most older adults kept the intact primary packaging (95.3%), stored drugs with their leaflets or instructions (71.2%) and kept drugs labels intact for drug identification (97.1%)^[34]. The reasons for these practices are still unknown as they have not been discussed in previous studies. In addition, another study showed that only one quarter of adults kept drugs away from children^[22]; however, this practice has not been explored among older adults. Knowledge of older adults' in-home drug-storage practice remains incomplete.

Studies have suggested that in-home drug-storage practice is related to personal characteristics. Educational level is positively correlated with drug-storage compliance; the prevalence of keeping expired drugs at home is four times higher in households with the lowest levels of education than in households with university-educated members^[17]. However, another study found that even those with a graduate level of education often failed to comply with drug-storage standards^[27]. Gender is associated with drug-storage compliance: Brazilian women are more likely to comply with drug-storage standards than men^[22], whereas another study found that Chinese women had poor drug-storage practices^[20]. Living with children is associated with higher drug-storage compliance, as households are more concerned to hide drugs from children^[22]. One study highlighted that older adults living alone had particular difficulties with drug-storage problems due to a lack of social and family supports^[20]. These previous findings regarding the associations between personal characteristics and drug-storage compliance remain incomplete, particularly for older adults.

Most of the literature has focused on adults; studies that focus specifically on older adults' in-home drug-storage are rare. Previous studies have also focused on different cultural backgrounds, generating inconsistent findings, and current knowledge is inadequate for explaining local contexts. This study therefore attempted to address the current insufficient understanding of in-home drug-storage compliance among older adults. We assessed the compliance rate in terms of the drug-storage environment and drug-storage methods, compared the differences in compliance rates between older adults with different personal characteristics and examined the correlation between compliance rates and different personal characteristics.

2. Methods

2.1 Design, Setting, and Sample

Our research adopted a cross-sectional and descriptive approach. It was conducted in Hong Kong. Convenience sampling was used to recruit participants through the researchers' social networks. The criteria for selection were that subjects must (1) be aged 65 or above, (2) self-manage in-home oral drugs, (3) have normal cognitive function and have passed the Mini-mental State Examination (MMSE), and (4) understand and speak Cantonese (a common dialect in Hong Kong). Subjects who (1) lived in a hospital, residential care home, or outdoors, or (2) suffered from psychiatric or neurological disorders were excluded from this study.

2.2 Measures

An in-home drug-storage checklist was used to measure in-home drug-storage compliance. The checklist was developed on the basis of international guidelines on drug storage^[10,18], and the items were conceptualized and categorized into groups. The checklist comprised 17 items in two parts. Part one measured the drug-storage environment, with respect to light (1 item), temperature (1 item), and humidity (1 item), while part two measured drug-storage methods, with respect to drug safety (3 items), drug packaging (4 items), drug information (2 items), and expiration of drugs (2 items). The content validity of the checklist was assured by conducting an expert review. A panel of four experts, consisting of one pharmacist, one community nurse and two academics in nursing research, was invited to assess the content validity. The finalized checklist obtained a Content Validity Index (CVI) of 0.94, suggesting high validity^[25]. Inter-rater reliability was estimated by Krippendorff's alpha coefficient, which had a value of 1.0, indicating the highest level of agreement^[15]. The total number of drugs stored and the number of drugs stored properly were recorded. Each item was then rated by calculating the compliance rate in terms of the percentage of drugs stored properly (the number of drugs stored properly divided by the total number of drugs stored). Compliance rates for each subscale (drug-storage environment and method) and overall compliance were calculated.

2.3 Data Collection Procedure

Home visits were conducted from December 2019 to January 2020. Researchers explained the purpose and procedures of the study to the participants and obtained their consent prior to data collection. Data on individual characteristics, comprising age, gender, educational level, living status, financial status and utilization of community health care services and community centers were collected. Researchers used the in-home drug-storage checklist to assess compliance with in-home drug storage standards. The compliance rates for individual items, subscales and overall performance were then calculated by the researchers.

2.4 Data Analysis

The Statistical Package for the Social Sciences version 22 was used for data analysis. Descriptive statistics were obtained using frequencies and percentages for categorical variables (gender, living status, receiving community health-care services and visiting community centers) and ordinal variables (educational level and financial status); the mean, range, standard deviation, and scores were used for continuous variables (age, overall compliance rate and compliance

rates for drug-storage environment and method).

Non-parametric statistics were used because the sample was not normally distributed. Spearman's rho test was conducted to examine the correlation between an individual's personal characteristics (age, educational level and financial status) and compliance rate (drug-storage environment, drug-storage method, and both). The Mann-Whitney U test was used to assess differences in compliance rates (drug-storage environment, drug-storage methods, and overall drug storage) between older adults in different groups (gender, living status, receiving community healthcare services and visiting community centers). A *p* value of <0.05 was considered statistically significant.

2.5 Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee of The Open University of Hong Kong prior to data collection. Each participant was given an information sheet explaining the purpose of study. All of the participants were voluntary and anonymous. Consent was obtained from each participant. Information collected from this study was used exclusively for the purposes of this study. All data were kept confidential and secure. Personal information was disposed of by shredding documents and deleting the digital data after completion of the study.

3. Results

3.1 Participants' Characteristics

Table 1 displays the personal characteristics of the participants. A total of 117 participants were recruited and their average age was 72.6 [standard deviation (SD) = 7.2]. More than half were female (55.6%). Almost half (46.2%) had received primary education. Over two thirds (76.9%) were living with others. More than four-fifths earned less than HK\$8,000 per month (82.1%). Most did not receive community healthcare services (93.2%) and did not visit community centers (81.2%).

Table 1. Personal characteristics of participants (N = 117)

| Personal characteristics | <i>M</i> ± <i>SD</i> (Range) | <i>n</i> (%) |
|--------------------------|------------------------------|--------------|
| Age | 72.6 ± 7.2 (65-93) | |
| | 65-74 | 82 (70.1) |
| | 75-84 | 21 (17.9) |
| | 85+ | 14 (12.0) |
| Gender | Male | 52 (44.4) |
| | Female | 65 (55.6) |
| Educational level | Below primary | 30 (25.6) |
| | Primary | 54 (46.2) |
| | Above primary | 33 (28.2) |

| | | |
|------------------------------------------|--------------------|------------|
| Living Status | Alone | 27 (23.1) |
| | Living with others | 90 (76.9) |
| Financial status (Monthly income in HKD) | < \$4,000 | 49 (41.9) |
| | \$4,000-\$7,999 | 47 (40.2) |
| | \$8,000-\$11,999 | 11 (9.4) |
| | ≥\$12,000 | 10 (8.5) |
| Receiving community healthcare services | Yes | 8 (6.8) |
| | No | 109 (93.2) |
| Visiting community centers | Yes | 22 (18.8) |
| | No | 95 (81.2) |

3.2 Compliance Rates for Drug-storage Environment and Drug-storage Methods

The mean overall compliance rate for drug storage was 87.25%. The mean compliance rate for drug-storage environment (97.02%) was higher than that for drug-storage methods (84.59%) (Table 2). For drug-storage environment, mean compliance rates were similarly high for keeping drugs away from sunlight (99.48% ± 2.47%), at the recommended temperature (92.53% ± 24.49%), and in a dry environment (99.06% ± 9.28%). The compliance rate for keeping drugs at the recommended temperature ranged from 0% to 100%, and was highly dispersed with the largest SD (= 24.49), compared to that for protecting drugs from sunlight (SD = 2.47) and from humidity (SD = 9.28). Another dimension was compliance with drug-storage methods, i.e, drug safety, drug package, drug information and expiration of drugs. In terms of drug safety, the mean compliance rate was relatively high for storing drugs individually (94.00% ± 18.56%), but was lower for separating drugs from food (87.52% ± 31.84%) and for keeping drugs in a locked cabinet and out of reach of children (58.14% ± 48.26%). For drug packaging, mean compliance rates were as follows: storing drugs in intact packaging (95.12% ± 12.32%), storing drugs in sealed or zipped packages (89.09% ± 23.34%), storing drugs in primary packaging (85.08% ± 25.16%), and storing drugs with leaflets or instructions (80.89% ± 26.94%). For drug information, the mean compliance rate for storing drugs with labels present (86.79% ± 23.82%) was slightly higher than that for storing drugs with labels having clear information of the drug name, dosage, frequency, expiry date and patient name (81.42% ± 27.07%). For expiration of drugs, the mean compliance rate for storing drugs with identifiable expiry dates (92.13% ± 16.96%) was considerably higher than that for keeping unexpired drugs (80.28% ± 21.74%).

Table 2. Compliance rates for drug-storage environment and methods (N = 117)

| Items | Compliance rate | | | |
|------------------------------------------------------------------------------------------------------------------------|-----------------|-------|----------|----------|
| | Mean | SD | Range | |
| | | | Mini-mum | Maxi-mum |
| Drug-storage environment | | | | |
| Light | | | | |
| 1.1 Drugs were stored away from direct sunlight | 99.48 | 2.47 | 80.00 | 100.00 |
| Temperature | | | | |
| 2.1 Drugs were stored at room temperature (15-25 °C) or refrigerated (2-8 °C) | 92.53 | 24.49 | 0.00 | 100.00 |
| Humidity | | | | |
| 3.1 Drugs were kept in a dry environment with humidity less than 65% | 99.06 | 9.28 | 0.00 | 100.00 |
| <i>Subscale for drug-storage environment</i> | 97.02 | 8.85 | 60.00 | 100.00 |
| Drug-storage methods | | | | |
| Drug safety | | | | |
| 4.1 Drugs were kept in a locked cabinet and out of reach of children | 58.14 | 48.26 | 0.00 | 100.00 |
| 4.2 Drugs were stored individually | 94.00 | 18.56 | 0.00 | 100.00 |
| 4.3 Drugs were separated from food | 87.52 | 31.84 | 0.00 | 100.00 |
| Drug packaging | | | | |
| 5.1 Drugs were stored in intact packaging | 95.12 | 12.32 | 33.33 | 100.00 |
| 5.2 Drugs had sealed or zipped packaging | 89.09 | 23.34 | 0.00 | 100.00 |
| 5.3 Drugs were stored with leaflets or instructions | 80.89 | 26.94 | 0.00 | 100.00 |
| 5.4 Drugs were stored in primary packaging | 85.08 | 25.16 | 0.00 | 100.00 |
| Drug information | | | | |
| 6.1 Drug labels were present | 86.79 | 23.82 | 0.00 | 100.00 |
| 6.2 Clear information was visible on drug labels, including drug name, dosage, frequency, expiry date and patient name | 81.42 | 27.07 | 0.00 | 100.00 |
| Expiration of drugs | | | | |
| 7.1 Presence of expiry date on drug packaging | 92.13 | 16.96 | 0.00 | 100.00 |
| 7.2 Drugs had not expired | 80.28 | 21.74 | 0.00 | 100.00 |
| <i>Subscale for drug-storage methods</i> | 84.59 | 13.69 | 27.27 | 100.00 |
| <i>Overall drug storage</i> | 87.25 | 11.14 | 42.86 | 100.00 |

Overall mean in-home drug-storage compliance was 87.25%; mean compliance rates for individual dimensions were below 100%. The mean compliance rate for the drug-storage environment was clearly higher than that for drug-storage methods. For each dimension, the mean compliance rate varied among the participants: the mean compliance rate for keeping drugs at the recommended temperature was particularly variable, and the mean compliance rate for keeping drugs in safe locations was consistently low.

3.3 Correlations between Older Adults' Personal Characteristics and In-home Drug-storage Compliance

Table 3 shows the correlations between older adults' personal characteristics and their mean compliance rates with respect to drug-storage environment, drug-storage methods and overall drug storage. There were weak negative correlations between age and drug-storage environment ($r_s = -0.213, p = 0.021$), drug-storage methods ($r_s = -0.187, p = 0.044$) and overall drug storage ($r = -0.190, p = 0.041$). In addition, there were moderate positive correlations between educational level and drug-storage methods ($r_s = 0.306, p = 0.001$) and overall drug storage ($r_s = 0.310, p = 0.001$). No correlations were found between financial status and drug-storage compliance.

Table 4 shows the mean differences in drug-storage compliance rates between older adults grouped by personal characteristics. There was a statistically significant difference in compliance with drug-storage methods ($p = 0.046$) between participants of different genders. Male older adults showed higher compliance in drug-storage methods than female older adults. However, there was no significant

difference in compliance with drug-storage environment and overall drug storage between participants of different genders. Furthermore, there was a statistically significant difference in compliance with drug-storage environment ($p = 0.048$) between older adults with different living statuses: older adults who lived with others showed better drug-storage environment compliance. However, there was no significant difference in compliance with drug-storage methods and overall drug storage between older adults with different living statuses. Moreover, there was no significant difference in drug-storage compliance between participants with different experiences of receiving community health-care services and visiting community centers.

Table 3. Correlations between personal characteristics and compliance rates for drug-storage environment, drug-storage methods and overall drug storage ($N = 117$)

| Personal characteristics | Compliance rate | | | | | | |
|--------------------------|--------------------------|--------|----------------------|--------|---------|--------|--------|
| | Drug-storage environment | | Drug-storage methods | | Overall | | |
| | r_s | p | r_s | p | r_s | p | |
| Age | 65-74 | -0.213 | 0.021* | -0.187 | 0.044* | -0.190 | 0.041* |
| | 75-84 | | | | | | |
| | 85+ | | | | | | |
| Educational level | Below primary | 0.167 | 0.072 | 0.306 | 0.001* | 0.310 | 0.001* |
| | Primary | | | | | | |
| | Above primary | | | | | | |
| Financial status | < \$4,000 | -0.014 | 0.881 | 0.093 | 0.317 | 0.061 | 0.514 |
| | \$4,000-\$7,999 | | | | | | |
| | \$8,000-\$11,999 | | | | | | |
| | ≥\$12,000 | | | | | | |

Note:
* $p < 0.05$

Table 4. Mean differences between personal characteristics and compliance rates for drug-storage environment, drug-storage methods and overall drug storage ($N = 117$)

| Personal characteristics | | Compliance rate | | | | | | | | |
|-----------------------------------------|--------------------|--------------------------|--------|--------|----------------------|--------|--------|---------|--------|-------|
| | | Drug-storage environment | | | Drug-storage methods | | | Overall | | |
| | | Mean | U | p | Mean | U | p | Mean | U | p |
| Gender | Male | 58.49 | 1716.5 | 0.821 | 66.00 | 1326.0 | 0.046* | 65.84 | 1334.5 | 0.51 |
| | Female | 59.41 | | | 53.40 | | | 53.53 | | |
| Living status | Living alone | 51.72 | 1411.5 | 0.048* | 55.81 | 1301.0 | 0.577 | 54.69 | 1331.5 | 0.451 |
| | Living with others | 61.18 | | | 59.96 | | | 60.29 | | |
| Receiving community healthcare services | Yes | 45.69 | 542.5 | 0.073 | 53.19 | 482.5 | 0.615 | 50.06 | 507.5 | 0.44 |
| | No | 59.98 | | | 59.43 | | | 59.66 | | |
| Visiting community centers | Yes | 57.95 | 1068.0 | 0.803 | 57.86 | 1070.0 | 0.861 | 56.84 | 1092.5 | 0.74 |
| | No | 59.24 | | | 66.00 | | | 59.50 | | |

Note:
* $p < 0.05$

To conclude, older adults' age, gender, educational level and living status were associated with their drug-storage compliance, whereas their financial status and experiences of receiving community healthcare services and visiting community centers were not.

4. Discussion

This study provided insights into the in-home drug-storage compliance of older adults. Its main finding was that older adults failed to comply with in-home drug-storage in terms of drug-storage environment and methods, especially those of advanced age, who had lower educational levels or who lived alone.

4.1 Compliance with Drug-storage Environment among Older Adults

Older adults in this study kept almost all drugs away from direct sunlight (99.48%) and in a dry environment (99.06%), but less frequently complied with keeping drugs at the recommended temperature (92.53%). They may have had a better understanding of appropriate conditions for drugs in terms of light and humidity than in terms of temperature, leading them to hide drugs from sunlight and store drugs in dry, well-ventilated places. Akin to Dutch older adults who failed to freeze more than half (53.2%) of drugs in accordance with instructions^[34], Hong Kong older adults were also less compliant concerning storage temperature. Further, compliance rates with drug-storage temperature varied greatly; given that some of them exhibited extremely low compliance rates and should be targeted for education on correct drug-storage temperature procedures. Drug-storage location is an important criterion of proper drug storage, as locations such as kitchens and washrooms/bathrooms have unstable temperature and humidity^[22,26]. This problem can be better addressed by future studies that record where older adults store drugs.

4.2 Compliance with Drug-storage Methods among Older Adults

Older adults' mean compliance rate for keeping drugs in locked cabinets and out of reach of children (58.14%) was the lowest among drug safety items, indicating that there was insufficient awareness of this issue. Although older adults stored most drugs with labels (86.79%), not all these labels had clear information on self-medication (81.42%), which poses a health risk. A study has found that 76% of adults used in-home stored drugs without medical consultation^[23], which indicates that patients solely depended on the information on the label for self-administration. It is therefore essential to increase older

adults' awareness of the necessity of keeping the original drug labels, which provide clear information on self-medication, to avoid incorrect drug intake.

Studies have found that the prevalence of keeping in-home drugs past their expiry date was 8% in Portugal^[6], 18.5% in Turkey^[1], and 27% in the United States^[3], while among the older adults in this study, 19.72% had expired in-home drugs. Older adults in Hong Kong might be unaware of the dangers of keeping expired drugs, especially large quantities of drugs, at home. Expired drugs are dangerous, as they are associated with adverse drug reactions due to self-medication^[2], but 23% of Irish respondents reported taking expired drugs^[35]. Therefore, it is crucial to check drug expiry dates and discard expired drugs.

The older adults in this study mostly complied with storing drugs in intact packaging (95.12%); similarly, a Dutch study found that 95.3% of older adults stored drugs in intact packaging^[34]. However, older adults in this study less frequently stored drugs in sealed or zipped packaging (89.09%) and might forget to seal it due to decreased memory capacity^[27]. A study from the Netherlands has further found that older adults had difficulty sealing drug packaging completely, due to age-related physical limitations^[24]. Thus, manufacturers or dispensers should use age-friendly drug packaging that does not require extensive fine motor skills to manipulate. Most importantly, older adults should double-check drug packaging is closed after sealing.

Older adults in this study also did not store all drugs in primary packaging (85.08%), which means that they might neglect primary packaging and re-organize drugs into secondary containers. This is dangerous, because essential drug information on primary packaging might be missed and lead to incorrect self-administration. In addition, chemical reactions may occur between the secondary container and drug^[10,36]. It is therefore vital to increase older adults' awareness of the importance of primary packaging and instruct them to inform healthcare professionals about any broken primary packages.

Finally, older adults often failed to store drugs with accompanying leaflets or instructions (80.89%). Drug instructions are mainly printed in English in a very small font, and with terminology that might be unintelligible to older adults, and thus may be neglected. Studies have emphasized that drug information should be expressed in clear words, in a language appropriate to the target group^[10,29]. Thus, for the older Hong Kong population, drug information should be written in Chinese, printed in a large font, and use simple language.

4.3 Overall Drug-storage Compliance among Older Adults

This study showed that older adults did not comply with all of the drug-storage instructions, and the mean compliance rate for drug-storage methods was even lower (87.25%) than that for drug-storage environment (97.02%). As more than half of the participants engaged in self-medication without medical consultation, which could lead to dangerous medication use and undesired consequences^[23,24], non-compliance with good in-home drug-storage practice should be addressed.

4.4 Association between Personal Characteristics and Drug-storage Compliance among Older Adults

4.4.1 Age

Drug-storage compliance was lower among adults of advanced age in this study. The prevalence of visual and cognitive impairment and difficulties with self-care increases with age^[28,34], which might explain why older adults were unable to fully understand drug-storage instructions. We suggest that adults of advanced age, especially those with visual and cognitive impairments, should receive individual attention, continuous education and monitoring to ensure that they have correct drug-storage practice^[27]. In addition, important instructions should be made visible and highlighted with contrasting colors on drug labels, to assist drug-storage compliance and ensure patient safety^[9]. Usage instructions should be comprehensible to older adults, printed in a large font size, with key points in summarized and given in boldface rather than being embedded within long sentences. Simple, clear wording should be used, with a visual emphasis on important information, such as the expiry date.

4.4.2 Educational Level

Our findings showed that older adults' educational level positively influenced their compliance with drug-storage methods. Similarly, previous findings have indicated that participants who had a higher educational level showed higher drug-storage compliance^[5,17]. More than half of the older adults in this study had a primary educational level at most; thus, they might be barely literate and might misunderstand usage instructions. Literacy would facilitate individuals' comprehension of drug labels^[5], and education would improve awareness and understanding of drug-storage instructions^[12]. In addition to easy-to-read drug instructions, illustrations and audio-visual demonstrations may help older adults, especially those who are

illiterate^[27].

4.4.3 Living Status

This study showed that older adults who lived alone were less compliant with drug-storage instructions than those who lived with family members. This result agrees with a local study that showed that older adults who lived alone lacked social support, and thus were unable to obtain resources and support when they encountered difficulties in drug management^[20]. However, family members at home could help explain drug instructions to elders and increase their safety awareness. Further, when living with others in a shared living environment, the temperature, humidity and lighting will also be adjusted by other family members. In mainland China, the number of family members was found to be associated with in-home drug-storage temperature compliance^[12]. For those living with others, it is strongly suggested that family members be involved in drug-storage compliance.

To conclude, proper in-home drug storage is crucial for avoiding incorrect self-medication. The main finding of this study is that older adults often fail to comply with in-home drug-storage standards regarding drug-storage environment and drug-storage methods, and that those who are advanced in age, have lower educational levels or live alone are less compliant. Therefore, strategies are needed to promote older adults' in-home drug-storage compliance. One study has shown that 95% of participants encountered practical problems reading drug labels, understanding instructions for use and handling the packaging, and yet patients rarely raised concerns about drug management^[24]. A lack of effective communication between patients and healthcare professionals can lead to misunderstandings during treatment^[29], and misconceptions about drug storage also hinder older adults' compliance^[19,24]. Hence, we recommend that healthcare professionals proactively and regularly assess older adults' drug-storage compliance.

5. Limitations

Our use of a convenience sampling method limits this study's generalizability and may affect its internal validity. The participants' awareness of the study's purpose might have led to overestimates of their compliance rates, because that they might have changed their drug-storage environment and drug-storage methods prior to the home visit. However, due to ethical considerations, the participants were informed of the study purpose.

6. Future Research

Future studies should use a larger sample size and adopt

probability sampling to increase the generalizability of the findings. To implement drug-storage enhancement programs among older adults, further research should examine the effectiveness of drug-education program elements and home support and investigate how elder-friendly drug-package design could facilitate correct in-home drug storage by older adults.

7. Recommendations

Healthcare professionals should proactively use our in-home drug-storage checklist to identify high-risk individuals, develop educational programs, and provide home support. Special attention should be given to those who are advanced in age, less educated or living alone. In addition, existing health-education strategies should be revised to emphasize the importance of correct drug-storage environments and drug-storage methods. Specific areas to emphasize include maintaining appropriate drug-storage temperature, maintaining drug safety, keeping original drug labels intact with clear drug usage information, checking drug expiry dates and discarding expired drugs, double-checking after sealing drug packaging and using primary packaging. Improved drug-package design could also increase in-home drug-storage compliance, and such improvements should include easy-to-seal packaging and easy-to-read instructions. The use of supplementary pictorial illustrations and audio-visual aids can help older adults understand drug-storage instructions. Family members should be encouraged to support older adults' in-home drug-storage compliance.

8. Conclusion

This study found that older adults often failed to comply with in-home drug-storage instructions, in terms of drug-storage environments and drug-storage methods. Older adults who were advanced in age, were less educated, or lived alone exhibited lower in-home drug-storage compliance. Healthcare professionals should take a proactive role in assessing older adults' in-home drug-storage compliance, delivering drug-storage support and revising health education strategies. Elder-friendly drug-package design and supplementary pictorial illustrations and audio-visual aids can help older adults understand drug-storage instructions. Family members should also be involved in increasing in-home drug-storage compliance among older adults.

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