Medication safety in older inpatients: Measurement and intervention strategies
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Improving medication administration in nursing home residents with swallowing difficulties

Sustainability of the effect of a multifaceted medication safety programme

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ABSTRACT

BACKGROUND
Crushing solid oral dosage forms is an important risk factor for medication administration errors (MAEs) in patients with swallowing difficulties. Nursing home (NH) residents, especially those on psychogeriatric wards, have a high prevalence of such difficulties.

CONTEXT
Six different psychogeriatric wards in two Dutch NH facilities, participating over a total period of 1 year divided into pre-intervention, implementation, and the first and second evaluation period.

KEY MEASURES FOR IMPROVEMENT
Number of MAEs per number of observed medication administrations calculated for all and three subtypes of MAEs: crushing-uncrushable-medicine, inappropriate-technique, and food-drug interactions.

STRATEGIES FOR CHANGE
The intervention included (i) education for nursing staff about crushing medication safely, (ii) a medication administration protocol for patients with swallowing difficulties, (iii) a ‘do-not-crush-medicine’ pocket card for the nursing staff, (iv) screening of medication charts by pharmacy technicians on potential crushing problems, and (v) advices on medication charts on safe medication administration to residents with swallowing problems.

EFFECTS OF CHANGE
The number of crushing uncrushable medication errors, an MAE subtype with the highest potential risk for patient harm, was reduced significantly from 19 (9.6%) to 7 (3.0%, first evaluation period), adjusted odds ratio (OR) = 0.20 [95% Confidence Interval (CI), 0.07 to 0.55]. During the second evaluation period, the proportion crushing uncrushable medications errors was the only outcome that remained significantly lower in comparison with the pre-intervention period (p = 0.045).

LESSONS LEARNED
Introduction of a multifaceted medication safety programme in NH facilities by a pharmacy team is a tool towards safer medication administration practice in residents with swallowing difficulties. Commitment on organizational level is, however, vital to achieve sustainable improvements.

KEYWORDS
Nursing homes, administration, oral, deglutition disorders, pharmacists, medication errors, pharmacoepidemiology.
INTRODUCTION

Medication administration errors (MAEs) include every situation that differs from the situation as it should be: the right medicine, in the right dose and correct way, to the right patient, on the right time. A survey amongst nurses employed in nursing home (NH) facilities in the United Kingdom revealed crushing or opening medication in more than 80% of all NHs on at least a weekly basis.\(^1\) An important risk factor for MAEs is crushing solid oral dosage forms.\(^2,3\) Several studies show that enteral-feeding-tube obstructions occur in more than 15% of patients who have their medication administered crushed through the tube.\(^5,4\) Furthermore, crushing enteric-coated, sustained-release medication can result in potentially toxic levels and subsequent sub-therapeutic drug concentrations of the components in the blood.\(^5\) Therefore, errors involving crushing of medication are relevant not only to patients with enteral feeding tubes, but also to patients having difficulties with swallowing solid food and oral medication. These patients often reside in NH facilities, especially on psychogeriatric wards.\(^1-4\)

In hospitals, a medication safety programme aiming at MAEs in patients with enteral feeding tubes effectively reduced such errors.\(^4\) Research on quality improvements of crushing solid oral dosage forms in NH settings is scarce\(^5\) and often not specifically targeted on MAEs in patients with swallowing-difficulties.\(^7\) Another aspect is the sustainability of interventions.\(^8\) Positive effects of quality improvements tend to decrease once the interventions are no longer under supervision of the research team.\(^9\) Knowledge on their consistency in daily practice is of great importance to maximise the impact of such interventions.

Therefore, we developed a multifaceted medication safety (MMS) programme that was implemented by a pharmacy team, and investigated the effect of this programme on the MAEs in patients with swallowing difficulties as well as the sustainability of the effect in two NH facilities.

SETTING

Six psychogeriatric wards of two NH facilities in the Netherlands (NH1 = 90 residents, NH2 200 = residents) participated in this study. NHs staff involved in daily care for the residents consisted of nurses, nurse attendants, volunteers, pharmacy technicians, managers, and physicians specializing in long-term care. The hospital pharmacy department of Westfriesgasthuis hospital provided medication services to both NH facilities through on-site pharmacy teams and on managerial level by one hospital pharmacist (TvdS). In 2008 full-time equivalents (FTEs) for ambulatory care physicians in NH1 were 3.22 and 5.33 for NH2. In both NH facilities, medicines were dispensed in medication boxes per week per four administration times a day (8:00 AM, 12:00 PM, 5:00 PM, and 9:00 PM). Once a week, an updated medication chart per patient was printed by the pharmacy.

When applicable, medication orders included instructions such as ‘administer dissolved in water’ or ‘do not crush’. Nurses and nurse attendants permitted to administer medication, and referred to as the nursing staff, recorded administrations on medication charts.

During the pre-intervention measurement period, multiple problems were identified as contributing to MAEs in patients with swallowing difficulties: (i) instructions on...
medication charts were not up-to-date, incomplete, and frequently ignored by the nursing staff; (ii) communication between the nursing staff and the local pharmacy staff was poor; information about swallowing difficulties of a resident was seldom communicated to the pharmacy to check for potential problems of medication to be crushed; (iii) the physicians were often not aware of swallowing problems because nursing staff did not routinely inform the physicians about such problems; (iv) in daily routine, medication of residents with the swallowing difficulties was crushed by the nursing staff without authorization by the physicians or the pharmacy staff; and (v) the nursing staff had not been trained on best practice regarding crushing medication safely.

The key goal of the intervention was a reduction MAEs in patients with swallowing difficulties by 50%. The intervention was an MMS programme implemented by a pharmacy team over a period of 5 weeks at both NH facilities.

**METHODS**

This study was part of a larger study in the Netherlands, in which four university hospitals work together to improve quality and safety of pharmaceutical care in elderly people (≥65 year; CAREFUL study: pharmacist coordinated ADE reducing efforts for use in all levels of health care). A similar medication safety project has been carried out in an institution for individuals with an intellectual disability (‘Gemiva’, Gouda, the Netherlands).

**DESIGN**

A prospective, before-after design was chosen to evaluate the effect of the MMS programme. During 4 weeks in September/October 2008, a pre-intervention measurement was conducted. The programme was implemented in both NH facilities during 5 weeks in November/December 2008. One week after implementation, the first evaluation measurement was conducted during 4 weeks in December 2008 and January 2009. In September 2009, a second 4-week evaluation was conducted to measure the sustainability of the implemented programme (Figure 1).
The findings of the pre-intervention period were presented to NH facilities’ managers, physicians, and pharmacy staff. During three multidisciplinary meetings, these findings were discussed, and a brief risk analysis was conducted to design an intervention programme. Results from previous research on quality improvements aimed at MAEs were used to choose effective interventions with the potential to reduce MAEs in residents with swallowing difficulties.4,6,9,10 The designed MMS programme consisted of the following interventions:

- A protocol was developed describing all steps to be taken along with responsibilities regarding medication administration in residents with swallowing difficulties. Physicians were made the only authorized persons to take decisions about crushing medication of residents with swallowing problems. The nursing staff was made responsible for timely informing physicians and the pharmacy staff about residents with swallowing difficulties. The pharmacy staff was appointed to check medication for potential problems if crushed and provide advice to the physicians and the nursing staff. This protocol was summarized and available on the wards as a quick reference.

- Residents with swallowing difficulties were high-lighted in the electronic pharmacy medication system by an alert ‘resident with swallowing problems’ after confirmation from a physician. Pharmacy technicians checked medication for potential problems, and if necessary, changes were conducted under supervision of a hospital pharmacist. If applicable, the pharmacist discussed changes with the medical staff. Furthermore, advices regarding medication administration were typed on medication orders to inform the nursing staff.

- During several presentations in the NH facilities, the nursing staff was instructed about the importance of the alerts on the medication charts and about appropriate medication administration procedures. To guarantee that in the future, the nursing staff will receive sufficient training about this subject, an educational programme was designed in cooperation with NH facilities’ managers and the local nursing school.

- A pocket-sized card with frequently prescribed medications and instructions on how to safely crush these medications was handed out to all the nursing staff.

The disguised observation method 6 was used for identification of MAEs during all three measurement periods. This method is the most suitable and valid method for identification of MAEs.11 Briefly, the nursing staff is being observed during medication administrations without communicating the actual goal of the observations. In this study, two pharmacy students trained in this technique (CK-vD, NL) were appointed as disguised observers. Conversely, the nursing staff was informed that the purpose of these observations was to gain experience and knowledge about medication processes in NH facilities. Each nursing staff member was asked for permission to be accompanied by the students before observations.

Each moment of medication administration (8:00 AM, 12:00 PM, 5:00 PM, and 9:00 PM) has been observed at least once at each of the six wards during the pre-intervention and the first evaluation period. During the second evaluation period, the medication round at 9:00 PM was not observed due to logistic difficulties. A case
report form specifically designed for this study was used for data collection after a medication round was finished. The nationally prevailing guideline Handbook Enteral Medication\textsuperscript{12} was used by the students to evaluate MAEs’ occurrence. These evaluations were subsequently verified by two pharmacists (CS, JK). Data collected included residents’ name, age, the number of medication administrations a day, medication names, dosages, dosage forms, administration times and techniques used, and work experience of the nursing staff observed.

An MAE was defined as any deviation from the guideline Handbook Enteral Medication\textsuperscript{12} and classified into the following three subtypes: (i) crushing uncrushable medication, (ii) inappropriate technique, and (iii) food–drug interactions. Example of crushing uncrushable medication is crushing an extended release; inappropriate technique errors, crushing of effervescent tablets or not taking protective measures while crushing corticosteroids; and food–drug interactions, administration of tetracyclines with milk (reduced absorption). The primary outcome measure was the proportion of all MAEs per total number of medication administrations observed. Other outcome measures were the proportions of each MAE subtype per total number of medication administrations observed.

The Medical Ethics Committee (MEC) of the Westfriesgasthuis hospital and the management team of both NH facilities gave permission to conduct this research. The study protocol was exempted from review by the MEC. According to the Dutch Medical Research Involving Human Subjects Act, such review and approval was not required because no direct interaction with human subjects was involved. All patient data were analyzed anonymously by coding every included patient by a three-digit number.

Based on the expected frequency of 20\% MAEs in the pre-intervention period and intended 50\% reduction by the intervention, 200 observations were needed, equally divided between the pre-intervention and post- intervention period ($\alpha = 0.05$ and $\beta = 0.8$).\textsuperscript{4,13,14} All gathered data were entered in a database using Microsoft Office Access version 2003 (Microsoft Corp., Redmond, WA, USA). Computer software SPSS version 18.0 (SPSS Inc., Chicago, IL, USA) was used for the calculations. Depending on the type and distribution of a variable, the Student’s $t$-test, the chi-square test, or the Mann–Whitney $U$ test was performed to compare the pre-evaluation and evaluation cohorts and the characteristics of the observations per study period.

For comparison of outcome measures between the study periods, odds ratios with their 95\% Confidence Interval (CI) were calculated using binary logistic regression analysis. Exploration of interaction and confounding was considered methodologically relevant. We first focused on the uncorrected effect of the MMS programme on MAEs. Then, statistical and clinically relevant covariates were added as an interaction term. As a significant interaction was not found, the model was examined for confounding. Confounding was defined as $\pm 10\%$ change in the coefficient of the intervention as a consequence of adding a covariate. Statistical significance is considered to be at $p = 0.05$, if appropriate statistical uncertainty will be expressed by the 95\% CI.
RESULTS

A total of 198, 230, and 201 observations during, respectively, the pre-intervention and the first and second evaluation period amongst 60, 55, and 62 subjects were conducted. In Table 1, characteristics of the residents, the nursing staff and the medication administrations observed during all study periods are shown. No differences in age, gender, or number of medications per patients were noticed.

During the pre-intervention and the first evaluation period, the numbers of FTEs of physicians employed by the NH facilities were equal (8.55), and the resident-to-nursing-staff ratios per observation day did not differ significantly [pre-intervention: median with inter-quartile range (IQR) 5.0, 0.4; the first evaluation median with IQR, 5.0, 0.2; p = 0.552]. Through all measurement periods, most medication (> 80%) was administered covert in food or drinks. Significant differences between the measurements conducted during the pre-intervention and the first evaluation period were the distribution of observations per time of medication round (p <0.001) and the type of nursing staff member observed (p = 0.002). No nurses were observed during the first evaluation period.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>General residents’ and medication administration characteristics during the pre-intervention, and two evaluation periods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient characteristic</strong></td>
<td><strong>Pre-intervention</strong></td>
</tr>
<tr>
<td>Age, mean in years± SD in years</td>
<td>80.2 ± 8.45</td>
</tr>
<tr>
<td>Female, n (%)</td>
<td>44 (73.3)</td>
</tr>
<tr>
<td>Number of medication administrations per patient, mean±SD</td>
<td>9.8±4.3</td>
</tr>
<tr>
<td>Number of medication administrations covert in food or drinks per patient, mean±SD</td>
<td>8.0±4.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Observed medication administration characteristics</strong></th>
<th><strong>Pre-intervention</strong></th>
<th><strong>1st Evaluation</strong></th>
<th><strong>2nd Evaluation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations in NH 1, n (%)</td>
<td>47 (23.7)</td>
<td>59 (25.7)</td>
<td>86 (42.8)</td>
</tr>
<tr>
<td>Observed medication round, n (%)</td>
<td>93 (47.0)</td>
<td>137 (59.6)</td>
<td>77 (38.3)</td>
</tr>
<tr>
<td>8 AM</td>
<td>24 (12.1)</td>
<td>7 (3.0)</td>
<td>46 (22.9)</td>
</tr>
<tr>
<td>12 PM</td>
<td>43 (21.7)</td>
<td>63 (27.4)</td>
<td>78 (38.8)</td>
</tr>
<tr>
<td>5 PM</td>
<td>38 (19.2)</td>
<td>23 (10.0)</td>
<td></td>
</tr>
<tr>
<td>Type of nursing-staff member observed, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurse</td>
<td>0 (0.0)</td>
<td>14 (6.1)</td>
<td>23 (11.4)</td>
</tr>
<tr>
<td>Senior nurse attendant</td>
<td>167 (84.3)</td>
<td>182 (79.1)</td>
<td>160 (79.6)</td>
</tr>
<tr>
<td>Junior nurse attendant</td>
<td>31 (15.7)</td>
<td>34 (14.8)</td>
<td>18 (9.0)</td>
</tr>
</tbody>
</table>

Abbreviations: SD, standard deviation; NH 1, nursing home facility 1.

During the first evaluation, the overall proportion of MAEs decreased significantly by 23.9% and crushing uncrushable medications errors by 63.2% (p = 0.035 and p = 0.005, respectively; Table 2).
Table 2  Effect of the multifaceted medication safety programme on medication administration errors (MAEs) according to study period

<table>
<thead>
<tr>
<th>Type of Error</th>
<th>Pre-intervention (%)</th>
<th>1st Evaluation (%)</th>
<th>P-value (Chi-square test)</th>
<th>2nd Evaluation (%)</th>
<th>P-value (Chi-square test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All MAEs</td>
<td>46 (23.2)</td>
<td>35 (15.2)</td>
<td>0.035</td>
<td>41 (20.4)</td>
<td>0.493</td>
</tr>
<tr>
<td>Crushing uncrushable medication</td>
<td>19 (9.6)</td>
<td>7 (3.0)</td>
<td>0.005</td>
<td>9 (4.5)</td>
<td>0.045</td>
</tr>
<tr>
<td>Inappropriate technique</td>
<td>13 (6.6)</td>
<td>16 (7.0)</td>
<td>0.873</td>
<td>17 (8.5)</td>
<td>0.474</td>
</tr>
<tr>
<td>Food-medication interaction</td>
<td>26 (13.1)</td>
<td>24 (10.4)</td>
<td>0.387</td>
<td>29 (14.4)</td>
<td>0.707</td>
</tr>
</tbody>
</table>

Differences between the pre-intervention and the first evaluation period. Differences in proportion between the pre-intervention and the second evaluation period.

The proportions of inappropriate technique and food-drug interaction errors were not significantly reduced. Also, after adjustment for confounders, a significant reduction in odds of observing an overall MAE [Odds Ratio (OR) = 0.59; 95% CI, 0.36 to 0.99] and in crushing uncrushable medication error (OR = 0.20; 95% CI, 0.07 to 0.55) was found during the first evaluation period (Table 3). The odds of observing inappropriate technique and food-drug interaction errors remained non-significant after adjusting for confounders.

Table 3  Risk reduction of medication administration errors (MAEs)

<table>
<thead>
<tr>
<th>Type of Error</th>
<th>1st Evaluation*</th>
<th>2nd Evaluation*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds Ratio</td>
<td>Adjusted OR</td>
</tr>
<tr>
<td></td>
<td>(95% CI)</td>
<td>(95% CI)</td>
</tr>
<tr>
<td>All MAEs</td>
<td>0.59</td>
<td>0.59†</td>
</tr>
<tr>
<td></td>
<td>(0.36 to 0.97)</td>
<td>(0.36 to 0.99)</td>
</tr>
<tr>
<td>Crushing uncrushable medication</td>
<td>0.30</td>
<td>0.20†</td>
</tr>
<tr>
<td></td>
<td>(0.12 to 0.72)</td>
<td>(0.07 to 0.55)</td>
</tr>
<tr>
<td>Inappropriate technique</td>
<td>1.06</td>
<td>0.86§</td>
</tr>
<tr>
<td></td>
<td>(0.50 to 2.27)</td>
<td>(0.38 to 1.98)</td>
</tr>
<tr>
<td>Food-medication interaction</td>
<td>0.77</td>
<td>0.77§</td>
</tr>
<tr>
<td></td>
<td>(0.43 to 1.39)</td>
<td>(0.40 to 1.46)</td>
</tr>
</tbody>
</table>

*Compared to pre-intervention period. †Adjusted for round time and patient to nursing staff ratio. ‡Adjusted for round time, patient to nursing staff ratio, and sex. §Adjusted for round time, patient to nursing staff ratio, sex, nursing home, and the number of medication administrations per patient. ¶Adjusted for round time, sex, type of nursing staff observed. ‖Adjusted for round time, patient to nursing staff ratio, sex, type of nursing staff observed, the number of medication administration per patient, and age. **Adjusted for patient to nursing staff ratio, nursing home, and age. ††Adjusted for round time, patient to nursing staff ratio, sex, nursing home, type of nursing staff observed, and age. †‡Adjusted for round time, patient to nursing staff ratio, nursing home, the number of medication administration per patient, type of nursing staff observed, and age.

During the second evaluation, the proportion of errors due to crushing uncrushable medications remained significantly lower in comparison with that in the pre-
intervention period (p = 0.045; Table 2). However, after adjusting for confounders, the odds of observing these type of error during the second evaluations was non-significant (OR = 0.71; 95% CI, 0.28 to 1.80) (Table 3). Proportions of all other outcomes were not significantly reduced, not even after adjusting for confounders. At the time of the second evaluation, due to local reformations, fewer physicians were employed in the NH facilities (FTE, 5.72 versus 8.55 during the pre-intervention period). Also, the resident-to-nursing-staff ratio was significantly different compared with the pre-intervention period (median with IQR: 5.2, 1.2; p < 0.001). Other significant differences between the pre-intervention and the second evaluation period were distribution of observations per medication rounds, NHs, and type of nursing staff member observed (all p < 0.001; Table 1).

**DISCUSSION**

To our best knowledge, this is the first publication on both short- and long-term effects of an MMS programme aiming for reduction of MAEs in NH residents with swallowing difficulties. The results of our study provide evidence of a significant and sustainable quality improvement in medication administration in NH residents with swallowing difficulties following implementation of our MMS programme. During the first evaluation measurement of crushing uncrushable medication errors, a MAE subtype with the highest potential risk for patient harm and the overall proportion of MAEs were significantly reduced by 63.2% and 23.9%, respectively (p = 0.005). This is an important finding as preventing medication errors has been shown to decrease preventable medication-related harm.⁹

Our pre-intervention incidence of MAEs was higher compared to recently published studies on MAEs in Norwegian and Belgian NHs⁷-¹⁴ but in proportion with other Dutch-hospital-based studies.⁴-¹⁵ The effect of our quality improvements on crushing uncrushable medication error was however lower in comparison to the Belgian study; their interventions decreased all crushing uncrushable medication errors compared with 63.2% reduction in our study as measured during the first evaluation period (Table 1).

Differences between the effect of other medication safety programmes and our programme can be explained by several factors. First, in our setting, the attendance to lessons about crushing medication safely was only compulsory in NH2; not more than 50% of the nursing staff attended lessons in NH1. Second, only written instructions had been implemented on participating wards. In the Dutch-hospital-based study on medication administrations through enteral feeding tubes, instructions were personally communicated to all nurses on the study ward in combination with a daily visit by that in the pre-intervention measurement, to give instructions.⁴ These interventions were, however, not feasible in daily practice in NH facilities participating in our study due to a large number of crushed medication administrations per day (9.5% to 63.9% of all oral medication administrations) and availability of one to three pharmacy technicians a day for 290 residents. Third, the new policy regarding highlighting medication charts of residents with swallowing difficulties after confirmation by a physician was not sufficiently implemented at the start of the first evaluation. Therefore, the pharmacy technicians were not always able to check all medications of patients with swallowing difficulties and make changes to other, more suitable, dosage forms.
Although, in our opinion, the interventions implemented were feasible to carry out in daily practice,\(^7\) months after the first evaluation, quality improvement in terms of significant reduction in proportions of MAEs sustained only for crushing uncrushable medication errors (52.6% reduction in comparison with pre-measurement period, \(p = 0.045\)). This finding underpins the challenge of gaining a long-term quality improvement when assistance and supervision by a research team is no longer available (second evaluation period in this study).\(^8\)

As experienced by the observers, it has been difficult to involve the nursing staff throughout this research project due to lack of time, insufficient supervision, and/or unawareness of the importance of safe medication administration practice. However, a survey amongst Australian nurses revealed a strong responsibility for medication administration amongst them.\(^13\) These nurses were concerned that they were working in an information vacuum, due to limited information resources and limited communication with other healthcare workers. For those reasons, we assume the lack of involvement of the nursing staff in our study to be a result of a high workload and internal reformations. These reformations were induced by recent resources reduction resulting in reorganization in NH facilities. As a direct consequence of this reorganization, fewer physicians were available for consultations (8.55 versus 5.72 FTE). This might have contributed to communication problems.\(^9\)-\(^13\)

Another effect of the reorganizations was a substantial number of experienced nursing personnel (responsible for food and medication distribution on the wards) was given notice. This policy resulted in employment of more junior, inexperienced nurse attendants for medication-related tasks. Although the number of senior nurses observed during the second evaluation measurement was higher in comparison with the number in the pre-intervention measurement, the shift in workload for this more experienced personnel (higher resident-to-nursing-staff ratio during the second evaluation, \(p<0.001\)) had probably a negative effect on the quality of medication administration.\(^16\)

Improvement of the quality of medication administration technique and reduction in food-drug interaction errors proved to be not feasible. Due to time restraints, most nursing staff members administered medications in one medication round, ignoring advices like ‘administer one hour before meal’ or use of protective measures (disposable gloves). To gain quality improvement on these aspects, a rearrangement of the process of medication administration and more experienced staff to conduct this task seem necessary. Implementation of such changes requests commitment and investments by NHs management.

Strengths of this study include the use of an observation-based approach, allowing us to explore MAEs that would not have been documented by studies relying on patient chart review.\(^11\),\(^17\) The inclusion of a second evaluation measurement gave us more insight into factors that must be taken into account when aiming for a sustained quality improvement in the medication administration process in NHs. Limitations of our study include a short time interval between the starting point of the implementation of the MMS programme and the first evaluation period, and lack of an analysis on the influence of the individual nursing staff members on MAEs. Furthermore, the actual patient harm as a result of MAEs observed has not been investigated. Despite its limitations, our work provides valuable information on short- and long-term effects of quality improvements in NHs.
The interventions implemented in our study have the potential to assure safe crushing of medications in NHs long term. The information on organizational barriers in NHs, as provided by this study, can be used to develop sustainable strategies to reduce MAEs in nursing/residential homes. Future research should focus on frequency and form of education, feedback, and auditing.

**KEY POINTS**

- MAEs in NH facilities can be significantly reduced by an MMS programme.
- Specifically, errors due to crushing uncrushable medication are reduced.
- This effect can be maintained long term provided that sufficient managerial support is offered.

**ACKNOWLEDGEMENTS**

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**CONFLICTS OF INTEREST**

The authors declare no conflicts of interest.
REFERENCES


