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## Drug modification by nurses in Norwegian nursing homes: A cross-sectional study

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### ABSTRACT

Crushing and dividing pills among older patients in nursing homes appears to be a common yet not harmless practice. Because few updates exist regarding the role of nurses and their dispensing of drugs in nursing homes, this study sought to describe the occurrence, methods, and causes of nurses' drug modification and to examine possible factors associated with drug modification in this context. A cross-sectional study of 273 dispensing episodes of solid oral drugs made by nurses, were observed during day and evening shifts. Modifications were made in 20.5% of the dispensing episodes, including 80.4% where alterations were made by crushing and 19.6% where alterations were made dividing. The most commonly reported reasons for modification were 'swallowing difficulties' (53.6%) and 'lack of understanding by the patient' (19.6%). The logistic regression analysis showed a significant association between the occurrence of drug modification and both cognitive impairment and administration method.

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### Introduction

Medication administration exists among the core activities in nursing<sup>1,2</sup> and nurses play a key role in ensuring drug safety among nursing home patients.<sup>3</sup> The majority of patients in nursing homes are old and thus particularly vulnerable to adverse drug effects.<sup>4</sup> The patient group is characterized by comorbidities, high drug consumption, and altered pharmacokinetics and pharmacodynamics, which complicate safe drug use.<sup>3,5</sup> In particular, the latter characteristics imply that special considerations must be adopted according to medication selection and dosage. In addition, nursing home patients often have impaired physical and mental functioning, which may complicate the intake of drugs and subsequently pose challenges to the effective administration of drugs.<sup>6,7</sup>

The medication management process is complex and demands nursing considerations in several areas such as data collection, planning, taking action, and monitoring effects including adverse effects.<sup>3</sup> The drug administration procedure is vulnerable to triggering adverse

events<sup>8</sup> and is seen as one of the most critical duties of nurses since resulting errors may lead to serious consequences for the patient, such as increased morbidity, hospitalization, and costs as well as death.<sup>9,10</sup> Among errors made by health professionals, nursing medication errors are reported to be the most common<sup>11</sup> and have been correlated with drug type, number of drugs, kind of distribution system, level of knowledge, presence of distractions, and workload.<sup>12–14</sup> Heavy workload, especially in day and evening shifts, can cause fatigue and distraction and thereby lead to medication errors.<sup>15</sup>

The existence of swallowing problems among older patients is another factor that complicates nurses' drug administration.<sup>16</sup> Dysphagia limits or precludes the administration of solid oral dosage forms, which are by far the most common formulations on the market.<sup>17</sup>

Modifications, such as crushing or splitting tablets and opening capsules, are common in nursing practice.<sup>6,14,18–22</sup> In addition to patients with dysphagia, people with mental illness are also often exposed to drug modification.<sup>21</sup> A review of qualitative research<sup>14</sup> showed that challenges related to modification of solid drugs included variations in the individual patient's requirements, poor communication practice, and lack of knowledge. Also educational level of the professional administering the drugs may impact the occurrence of drug modification: Forough et al.<sup>23</sup> found that most

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instances (96.2%) of inappropriate drug modifications in aged care facilities were performed by enrolled nurses or assistants in nursing and only 3.8% by registered nurses.

A decade ago, in the Norwegian context, Wannebo<sup>22</sup> found that eight nursing homes among a sample of 19 modified more than 20 drugs on a daily basis. In two Australian studies, one published in 2002<sup>20</sup> and one in 2020,<sup>23</sup> drug modifications occurred in 34% and 25.7% of all dispensing episodes examined, respectively. Kirkevold and Engedahl<sup>24</sup> also showed that drugs were often hidden in food or modified without being perceived or reported as a deviant practice. These findings are in line with the results of recent international research showing that nurses report drug modification to be a routine practice and a necessary evil due to limitations of available formulations and the presence of age-related challenges during drug administration.<sup>25</sup> Nurses tend to believe that the practice is quality-assured by constantly adapting to the patient's individual needs and through consultations with collaborating pharmacists. Simultaneously, however, nurses continue to request more knowledge and access to specific professional guidelines.<sup>25</sup> Along these lines, the use of guidelines when conducting drug administration also seems to correspond with the nurses' level of pharmacological knowledge.<sup>26</sup>

Although it seems commonplace, drug modification is not a harmless practice<sup>27,28</sup> and presents a number of problems in terms of the risk of adverse drug reactions, including, notably, under- or overdosing of or interactions between drugs.<sup>29,30</sup> Drugs that are converted to powder or mixed with food may have altered uptake and effects. For example, in this form, the entire amount of an active ingredient can be released immediately, reducing the duration of effect or even causing toxic reactions.<sup>21</sup> Removal of the protective layer surrounding tablets and capsules may also irritate the mucous membranes of the gastrointestinal tract and cause physical damage.<sup>20</sup> Furthermore, splitting or crushing also causes drug loss<sup>31</sup> and may lead to a reluctance to take the drug due to its unpleasant taste.<sup>32</sup>

Although adverse drug-related incidents have gained worldwide attention,<sup>10</sup> few updates are available concerning the role of nurses and their provision of drugs in nursing homes.<sup>33</sup> Our literature review shows that drug modification occur frequently in nursing homes, and are mostly made by crushing and frequently explained by swallowing difficulties. Occurrence of drug modifications seems to be affected by knowledge and educational level of professionals administering the drugs, and medication errors in general have been linked to number of drugs, distribution system, distractions and workload. Patients with dysphagia and mental illness are often exposed to drug modification. Since sex and age have been found related to the occurrence of swallowing difficulties (which also is strongly related to drug modifications<sup>17</sup>), it is reasonable to suppose that sex and age may be indirectly related to nurses' drug modification practice. The aim of this study was therefore twofold: first, to describe the occurrence, methods, and causes of nurses' drug modification in nursing homes and, second, to examine possible factors associated with drug modification in this context. Specifically, it was hypothesized that drug modifications were associated with the resident's cognitive status, drug administration method, dosing time, number of drugs given in the dispensing episode, and professionals administering the drug – when controlled for patient's age and sex.

## Materials and methods

### Design

A cross-sectional study of episodes of drug dispensing performed by nurses in nursing homes was conducted.

### Sample and study setting

This study was performed in eight nursing home wards across six municipalities in mid-Norway from October 2018 to March 2019. The sample of dispensing episodes was convenient and based on nursing students' observations in their practical studies at nursing homes. Nursing students (first year and third year) were asked to use one day (both day and evening shift) in their practice, to map how nurses performed drug dispensing to their patients. During this period, 31 registered nurses (RNs) and 8 auxiliary nurses (ANs) were invited to be observed and all consented, resulting in a study sample of 273 episodes of drug dispensing.

In Norway, nursing homes are subject to municipal responsibility and RNs, social workers, and ANs can be involved in drug administration. A nursing home physician or one employed on an hourly basis has the responsibility to direct medical care for the patients, including determining the choice of drug, dosage form, dose, timing of administration, and initiation and continuation or termination of treatment. The nursing staff is responsible for the delivery of medications and of making sure that the nursing home residents get their drugs.<sup>34</sup> Pill organizers and multi-dose package (multi-dose drug dispensing) are widely used administration aids in elderly care.<sup>35</sup> A pill organizer is a portable medicine box, including separate rooms for four doses a day, and seven days a week. The nurses prepare and fill up the pill organizers based on the physicians prescription described in the medication chart, and all pill organizers are double-checked before dispensing to the patient.<sup>36</sup> A multi-dose package is machine-dispensed from the pharmacy for a specific patient, comprising a series of containers (one unit for each doses and packed in transparent and disposable bags), and marked with patient data, drug content, date and time to be taken.<sup>37</sup> Nurses and social workers are authorized to dispense medicines, while auxiliary nurses may gain temporary exemptions for dispensing medicines after undergoing special training. The medicines are distributed at fixed times, preferably in connection with a meal. Although the nursing home population is characterized by multiple morbidities, polypharmacy, and age-related vulnerability,<sup>38</sup> physicians frequently prescribe drugs without conducting a proper clinical evaluation of the patients.<sup>39</sup> In Norway, the patient safety culture is found to be poorer in nursing homes as compared with general practices, out-of-hours casualty clinics, and home health nursing.<sup>40</sup>

### Measures

An observation form was developed inspired by the survey described by Wannebo.<sup>22</sup> This instrument was used to map how nurses (RNs, and ANs with dispensation) distributed medicines to nursing home patients. The observations included variables of patient characteristics (age, sex, and whether they had cognitive impairment or not), overview of medications that were distributed, dose, dosing time, dosage form, and whether capsules or tablets were modified or not and why. The observations also included whether patients were given food and fluids together with their drugs, whether the modification of the medication was documented in the electronic patient record and whether the physician or nurse had given permission to modify the drugs. Information about the drug administration method (e.g., weekly pill organizer, multidose packaging, or a combination) was collected as well.

The nursing students who collected the data, were instructed on how to complete the observation form by experienced researchers (third, fourth and last authors) before leaving the university. Then, based on the consent of the nurses, the medication rounds and dispensing of drugs, were mapped in line with the observation form by the nursing students.

## Statistical analysis

The Statistical Package for the Social Sciences version 26.0 for Windows (IBM Corporation, Armonk, NY, USA) was used for statistical analysis. Descriptive statistics were reported as frequencies, means, standard deviations (SDs), and percentages. To provide descriptions and prepare for regression analysis bivariate relationships were reviewed between the dependent variable (drug modifications) and independent variables (sex, age, cognitive impairment, professionals involved in the dispensing and administration methods). Pearson's chi-square test was conducted and the odds ratio (OR) was calculated for each independent variable. Inferential statistics were reported as numbers, percentages, p-values, ORs, and 95% confidence intervals of ORs. Finally, associations between the dependent variable (drug modification) and the aforementioned independent variables were quantified using two logistic regression models and Enter method; of these, model 1 included cognitive impairment and administration methods, while model 2 was expanded and adjusted for age and sex. Hosmer and Lemeshow's goodness-of-fit test<sup>41</sup> was chosen to assess how well the selected model fitted the data. A p-value of less than 0.05 was considered to be statistically significant.

## Ethical considerations

The participating nurses were informed both in writing and orally about the purpose and procedure of the study. All the nurses who were invited by the nursing students, gave written consent to participate. This project was first reported to the Regional Committees for Medical and Health Research Ethics (REK), which considered that it did not fall within the Health Research Act (project no. 2018/543/REK nord) as it did not concern health research on the participants (the nurses) or a third party (the patients).<sup>42</sup> The project was therefore reported to the Norwegian Centre for Research Data (NSD), which approved the procedure for securing privacy and data handling (project no. 59615). In addition, the healthcare administrations in the municipalities gave permission to perform data collection after receiving written information about the study.

## Results

Nurses medication administration to 100 nursing home residents was observed, including 47 men and 53 women. The mean age of the patients was 84.4 years (SD: 8.8 years; range: 60–100 years). In total 62 patients had cognitive impairment.

### Descriptive characteristics of episodes of solid oral drug dispensing

A total of 273 of dispensing episodes of solid oral drugs were observed, with 55.3% occurring during the day shift and 44.7% occurring during the evening shift (Table 1). Most of these episodes (87.9%) were handled by RNs. The patients received drugs dispensed from a weekly pill organizer in 49.8% of the episodes, from multidose packaging in 18.8%, and from a combination of multidose packaging and pill organizers in 31.4%. In 94.5% of the episodes, the patient was given a drink along with the drugs, while, in 43.6%, food was given. The dispensed doses included from one to 13 solid drugs (mean 2.5 drugs; median: 2.0 drugs; SD: 2.0 drugs).

### Drug modification

Modifications were performed in 56 (20.5%) of the 273 dispensing episodes, including 45 (80.4%) that involved crushing and 11 (19.6%) that involved dividing. In total, six (10.7%) of these instances (i.e., 2.2% of all dispensing episodes) included drugs that are not supposed to be modified according to professional guidelines and manufacturers' advice. All modified drugs were mixed into food (i.e. jam or yogurt), and in 26 (46.4%) of these instances several drugs were modified and mixed together. The most commonly reported reasons for modification were 'swallowing difficulties' (30/56; 53.6%), 'lack of understanding by the patient' (11/56; 19.6%), 'routine' 8/56 (14.3%), 'unknown reasons' (4/56; 7.1%) and 'the patient's own wishes' (3/56; 5.4%). In 39 (69.6%) instances, the modification was not documented in the electronic patient record. Drug modification was clarified with the physician in 34 (60.7%) instances, with a nurse in 19 (33.9%) and not clarified with anyone in three (5.4%).

**Table 1**  
Relationships between the prevalence of drug modification and independent variables (N = 273).

Variable	n	%	missing	Drug modification				p-value	OR	95% CI
				No		Yes				
				n	%	n	%			
Sex										
Male	132	48.4		112	84.8	20	15.2		1.0 (ref)	
Female	141	51.6		105	74.5	36	25.5	0.034	1.92	1.05–3.53
Cognitive impairment										
No	111	40.7		98	88.3	13	11.7		1.0 (ref)	
Yes	162	59.3		119	73.5	43	26.5	0.003	2.72	1.39–5.35
Age, years			7							
85–100	150	56.4		123	82.0	27	18.0		1.0 (ref)	
60–84	116	43.6		93	80.2	23	19.8	0.705	1.13	0.61–2.09
Administration methods			2							
Pill organizer and multidose packaging	85	31.4		80	94.1	5	5.9		1.0 (ref)	
Pill organizer	135	49.8		102	75.6	33	24.4	0.000	5.18	1.93–13.86
Multidose packaging	51	18.8		35	68.6	16	31.4		7.31	2.48–21.54
Time delivery										
Evening shift (16–24 hrs)	122	44.7		99	81.1	23	18.9		1.0 (ref)	
Day shift (06–15 hrs)	151	55.3		118	78.1	33	21.9	0.541	1.20	0.66–2.18
Professional administrating the drugs										
RN	240	87.9		193	80.4	47	19.6		1.0 (ref)	
AN	33	12.1		24	72.7	9	27.3	0.305	1.54	0.67–3.53
Numbers of solid drugs										
1–4	226	82.8		181	80.1	45	19.9		1.0 (ref)	
5–13	47	17.2		36	76.6	11	23.4	0.590	1.23	0.58–2.60

**Table 2**  
Observed drug modifications contrary to the recommendations of professional guidelines and manufacturers.

Drug	ATC-number	Modification observed	Incidence <sup>a</sup>	Potential consequences	Recommendations <sup>b</sup>
Metoprolol depot tablets	C07A B02	Crushed	2	Altered drug absorption profile. Risk of severe effect and side effects. <sup>c</sup>	Do not crush. Must be swallowed whole or divided along scale line.
Selozok depot tablets	C07A B02	Divided	1	Altered drug absorption profile. Risk of severe effect and side effects. <sup>c</sup>	Do not crush. Must be swallowed whole or divided along scale line.
Tegretol depot tablets	N03A F01	Crushed	2	Altered drug absorption profile. Risk of severe effect and side effects. <sup>d</sup>	Do not crush. Must be swallowed whole or divided along scale line.
Pradaxa capsules	B01A E07	Divided	2	Altered bioavailability—risk of bleeding. <sup>d</sup>	Do not crush or divide. Must be swallowed whole.
Betmiga depot tablet	G04B D12	Divided	1	Altered drug absorption profile. Risk of severe effect and side effects. <sup>d</sup>	Do not crush or divide. Must be swallowed whole
Reltebon depot tablet	N02A A05	Divided	1	Altered drug absorption profile. Risk of severe effect and side effects. <sup>e</sup>	Do not crush or divide. Must be swallowed whole
Nexium capsule	A02B C05	Crushed	1	Poor or no effect. <sup>c</sup>	Capsule can be opened but do not crush granules

<sup>a</sup> Several drugs (pharmaceutical preparations) could have appeared in more than one dispensing episode.

<sup>b</sup> Oslo University Hospital.<sup>43</sup>

<sup>c</sup> Apoteket AB.<sup>44</sup>

<sup>d</sup> Hospitalsapoteket Region Midtjylland.<sup>45</sup>

<sup>e</sup> SPC (Summary of Product Characteristics).<sup>46</sup>

Among those drugs that were modified, ordinary-release, modified-release, and immediate-release tablets were divided and/or crushed and capsules were opened. The drugs (i.e., active substances) most frequently involved in drug modification were paracetamol (acetaminophen) (39/56; 69.6%), followed by olanzapine (5/56; 8.9%), propranolol (5/56; 8.9%), metoclopramide (4/56; 7.1%) and metoprolol (3/56; 5.4%). Table 2 reports the drugs that, per the manufacturer and existing professional guidelines, should not be modified.

#### Factors associated with drug modification

Findings regarding the relationships between the prevalence of drug modification and independent variables are presented in Table 1. Significant associations were found between drug modification and cognitive impairment ( $p = 0.003$ ), sex ( $p = 0.034$ ) and administration method ( $p \leq 0.001$ ). Calculations of the ORs for drug modification because of having a cognitive impairment, being female, and having drugs dispensed from multidose packaging yielded values of 2.72, 1.92, and 7.31, respectively.

The results from the logistic regression analysis (Table 3) suggested the significant association ( $p < 0.01$ ) of both cognitive impairment and administration method (model 1) with the occurrence of drug modification. These associations were weakened when

adjusting for sex and age (model 2), but remained significant with ORs of 2.442 ( $p < 0.05$ ) for cognitive impairment, and 4.646 ( $p < 0.01$ ) for the pill organizer and 8.530 ( $p < 0.01$ ) for multidose packaging as administration methods, respectively.

#### Discussion

In this study, we described the occurrence, methods, and causes of drug modification in nursing homes and also examined possible factors associated with drug modification. Drug modification occurred frequently in the nursing homes, with crushing as the most common method for modification, and swallowing difficulties as the most frequently reported reason. Hypothesis regarding associated factors was partially supported, in that drug modification occurred more frequently in patients who had cognitive impairment, and less frequently when the patient's medicine dose was administered from both the pill organizer and multidose packaging than when administered from either one of these separately. However, no associations were found between drug modification and dosing time, number of drugs given in the dispensing episode, and professionals administering the drug. In the following section, findings and implications for future research and practice are discussed.

**Table 3**  
Results from logistic regression analysis with drug modification as a dependent variable.

Included variables	Model 1					Model 2				
	B	(SE)	Wald	OR	95% CI	B	(SE)	Wald	OR	95% CI
Cognitive impairment										
No				1.0 (ref.)					1.0 (ref.)	
Yes	1.135	(0.359)*	10.022	3.111	1.541–6.282	0.893	(0.375)**		2.442	1.172–5.088
Administration methods										
Both pill organizer and multidose packaging			15.590	1.0 (ref.)				14.342	1.0 (ref.)	
Pill organizer	1.757	(0.509)*	11.941	5.797	2.140–15.707	1.536	(0.518)*	8.109	4.646	1.682–12.831
Multidose packaging	2.178	(0.563)*	14.963	8.824	2.928–26.598	2.144	(0.567)*	14.303	8.530	2.809–25.908
Sex										
Male									1.0 (ref.)	
Female						0.684	(0.363)	3.562	1.982	0.974–4.034
Age, years										
85–100									1.0 (ref.)	
60–84						0.310	(0.349)	0.789	1.364	0.688–2.703

Model 1:  $R^2 =$  (Cox & Snell) 0.105, (Nagelkerke) 0.167. Hosmer & Lemeshow = 0.561. Model  $X^2 = 30.170$ ,  $p < 0.001$ .

Model 2:  $R^2 =$  (Cox & Snell) 0.104, (Nagelkerke) 0.170. Hosmer & Lemeshow = 0.168. Model  $X^2 = 11.634$ ,  $p < 0.001$ .

\*  $p < 0.01$ .

\*\*  $p < 0.05$ .

Drug modifications were performed during approximately every fifth dispensing episode in our study. It is challenging to find comparable studies in the literature, as methods of measuring drug modifications vary. For instance, some studies have examined drug modification *per patient*<sup>6,19</sup> and others have measured modifications *per prescription*,<sup>47</sup> while we looked at *episodes* in our study. However, we did locate two relevant observational studies conducted in aged-care facilities in South Australia and, as compared with the findings of these investigations, our results are somewhat more encouraging: while we detected drug modifications in 20.5% of all dispensing episodes, Paradiso et al.<sup>20</sup> reported the same in 34% and Forough et al.<sup>23</sup> reported such in 25.7% of dispensing episodes, respectively. Both of these studies also reported greater proportions of inappropriate drug modifications (i.e., the modification of drugs that should not be modified) at 17% and 12.5%, respectively, relative to our rate of 10.7%. The distinction between these findings may be due to cultural and organizational differences between countries and facilities as well as variations in the basis for determining which drugs should not be modified.

We found that most modifications were conducted by crushing, which is in line with observations of other studies.<sup>20,23</sup> Also similar to in other studies,<sup>6,23,25</sup> the most frequently reported reason for drug modification was difficulties with swallowing. This is not surprising, considering the relatively high prevalence of dysphagia among nursing home residents<sup>48</sup> and the fact that dysphagia among patients is a complicating factor in nurses' drug administration.<sup>16</sup> The fact that 'lack of understanding by the patient' was the second most commonly reported reason for modification in our study can be considered valid given the high proportion of cognitive impairment among the residents in the sample. Cognitive impairment was also significantly associated with drug modification in the regression model, even after adjusting for age and sex. Cognitive impairments are common in this patient population and pose challenges to the nurses' administration of drugs.<sup>6</sup>

An interesting finding in our study is the significant association between drug modification and the administration method—specifically, nurses modified drugs less often when the patient's medicine dose was administered from both the pill organizer and multidose packaging than when administered from either one of these separately. We are unsure how to interpret this association and suggest that further research is required to understand this finding. One explanation could be that nurses are more vigilant when administering medication from both dispensing systems in combination. The combination of the weekly pill organizer and multidose packaging is used when the patient is prescribed medicine that cannot or should not be packed in a multidose format, such as 'as required' (pro-re-nata) medicines, those with a time-limited prescription (e.g., antibiotics) or solid drugs that for various reasons cannot be packed in multidose bags. Although nurses have reported that multidose packaging simplifies drug administration and reduces time consumption, some are concerned that the method of administration may weaken their drug knowledge and overview of the medications given to patients.<sup>37</sup> Experiences of uncertainty and lack of control may lead nurses to be more alert during their drug distribution and more aware of unsafe practices. Multidose packaging is a relatively new way of administering drugs<sup>49</sup> and we need more knowledge about how it might affect drug safety. The fact that also administering drugs from the pill organizer was a predictor of drug modification in our study may suggest that there are other factors that could have an influence on the same—for instance, the characteristics of the facility's structure and processes.

Our findings reveal that drug modification was more frequent among ANs than among RNs, but the variation between the two groups was not significant according to the bivariate analysis. Considering RNs' more comprehensive education in pharmacology and medication management, we anticipated that the difference between these occupational groups would be conspicuous. One explanation

for the relatively small difference may be that the administration of medicines depends not only on the level of education of the employees but also on the culture in the workplace. Hoffman and Mark<sup>50</sup> reported that a strong safety culture was significantly correlated with fewer medication administration errors in hospitals. Odberg<sup>51</sup> explored medication administration in nursing homes and identified facilitators and barriers in the work system linked to the medication-administration process. These included tools and technology, organization, and tasks and appeared early on in the medication-administration process.

Most of the inappropriate modifications in this study increased the risk for an altered drug-absorption profile and thereby the risk of severe effects and/or side effects. This is especially worrisome considering that this population is particularly vulnerable to adverse drug effects.<sup>4</sup> Even though most of the drug modifications were not contrary to existing guidelines, the practice may still have some consequences for certain patients. Many tablets release a bad taste when they are crushed and this may impact the patient's appetite—which is very unfortunate considering the high prevalence of malnutrition in nursing homes.<sup>48</sup> A drug's bad taste is also likely to increase future reluctance to taking medication among patients with cognitive impairment. Meanwhile, another consequence of crushing tablets may be drug loss due to difficulty in removing all of the powder from the equipment used to crush. Thong et al.<sup>31</sup> investigated drug loss while crushing immediate-release paracetamol tablets and found that almost half of the tablet crushers resulted in a greater than 5% loss of paracetamol after crushing and tapping the powder out, resulting in less than 95% of the intended dose being delivered to the patient in comparison with when administering a whole tablet. Paracetamol is widely used as an analgesic and antipyretic in older patients and was also the most frequently modified drug in this study, a finding in line with those of Forough et al.<sup>23</sup> Whether a 5% reduction in dosage due to drug loss during crushing<sup>31</sup> had any clinical relevance was, however, not reported.

The drugs modified in this study included ordinary-, immediate- and modified-release tablets and several of the active substances are available in other formulations. For instance, alternative formulations to paracetamol tablets appropriate for these patients could be oral liquid solutions, dispersible tablets, effervescent (soluble) tablets, or suppositories. Nurses have, however, reported significant limitations with alternative formulations such as greater costs and a lack of availability in sourcing alternatives.<sup>25</sup> Appropriate drug use and medication administration require good communication and cooperation between nurses and physicians. The physician must evaluate the patient's drug needs and prescribe the best formulation, which presupposes that nurses communicate their observations of the patient's drug use and any possible problems related to the administration process. In our study, nearly 70% of the episodes including drug modification were not documented in the electronic patient record and 30% were not clarified with the physician. From this point of view, it may seem that the nurses' attention to problems with crushing was low. However, we did not have adequate data available in our study to confirm this conclusion. Nurses' reasoning about problems with crushing tablets and their bedside evaluation of residents should be studied further.

Altogether, our findings demonstrated that the modification of drugs still is relatively common in Norwegian nursing homes and is associated with the patient's level of cognitive function and drug administration methods in use. To ensure patient safety, greater focus on both the nurses' practices and the context in which the modification takes place is required. Ensuring safe practices necessitates that education is continued so as to increase nurses' knowledge and awareness of pharmacological issues and that nurses and physicians work together and communicate closely with one another. Continuous interdisciplinary drug reviews could be a response to the latter.<sup>25</sup>

Physicians are responsible for prescribing appropriate formulation but need information about the patient of interest that the nurses possess.

The present findings also provide a basis for further investigations of contextual conditions that may affect the practice, such as the organization's culture, quality-control systems, and methods of drug administration. Why the route of administration may increase the risk of drug modification remains uncertain and more studies, especially qualitative studies, are necessary to examine nurses' thinking and assessment processes when modifying medicines for older patients in long-term care.

### Strengths and limitations

The use of a convenience sample affected the generalizability of the results of this study. In addition, although the sample size met the minimum statistical requirements, it was still relatively small and further studies with larger sample sizes are needed to validate our results. Another limitation in this study is that we lacked demographic data on the nurses participating in our study. Information on, for instance, age, sex, experience and education, could provide a better insight into the praxis observed, and strengthen the transferability of the study results. To develop a full picture of drug modification praxis in nursing homes, additional studies will be needed that also include data on the nurses administering the drugs. The fact that nursing students conducted the observations may also have impacted the results: on one hand, although they all had received training in pharmacology and medication management during their undergraduate studies and were given instructions about how to complete the observation form by experienced researchers, their experience and skills in medication administration varied. On the other hand, their student role, as well as their familiarity with the units, may have reduced the 'research effect' (i.e., the effect of being observed) that could have influenced the nurses' behavior while administering the drugs as nurses are used to guiding students while working. Last, we did not have information on patients' diagnoses, physical functioning and medication regimens, and further studies should take such variables into account when investigating drug-modification associations in this population

### Conclusion

Crushing and dividing solid oral drugs are still common among nurses in Norwegian nursing homes. The most frequently stated cause was difficulty with swallowing. Drug modification was linked to cognitive impairment in the patient and certain methods of drug administration. Further examinations are needed to validate and fully understand the associations. Education must continue to raise awareness among nurses and closer collaboration and better communication between nurses and physicians are clear necessities. Continuous interdisciplinary drug reviews are recommended. Further investigations of contextual conditions that may affect the practice, such as culture, quality-improvement systems, and methods of drug administration, as well as nurses reasoning about the need to modify drugs are also required.

### Declaration of Competing Interest

None.

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