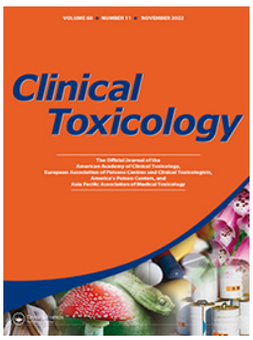

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Poisoning in older adults: characterization of exposures reported to the Dutch Poisons Information Center

Saskia J. Rietjens[a], Joyce E. M. van der Heijden[a] and Dylan W. de Lange[a,b]

[a]Dutch Poisons Information Center, University Medical Center Utrecht, Utrecht University, Utrecht, The Netherlands; [b]Department of Intensive Care Medicine, University Medical Center Utrecht, Utrecht University, Utrecht, The Netherlands

ABSTRACT

Introduction: The annual number of patients > 65 years old about whom the Dutch Poisons Information Center (DPIC) was consulted has more than doubled in the last decade. We aimed to gain insight in the type and circumstances of exposures reported to the DPIC involving older patients, in order to help prevent future poisonings.

Methods: Enquiries to the DPIC involving patients > 65 years old were prospectively included from January 2019 to June 2019. Data were collected on patient characteristics (e.g., age, gender, and living situation) and exposure characteristics (e.g., type and exposure scenario).

Results: In the first half of 2019, the DPIC was consulted about 1051 patients > 65 years old. The median age of the patients was 77 years old (range: 66–104 years) and women were over-represented (61%). A total of 1650 different substances were reported, 1213 pharmaceutical exposures (74%) and 437 non-pharmaceutical exposures (26%), mostly household products ($n = 162$). Most pharmaceutical exposures involved cardiovascular agents ($n = 367$, 30%), central and peripheral nervous system agents ($n = 354$, 29%), and analgesics ($n = 152$, 13%). In 71% of the patients exposed to pharmaceuticals, the drugs were taken unintentionally ($n = 471$), frequently caused by medication errors made by the patients themselves ($n = 357$, 76%). Most common scenarios included inadvertently taken/given a double ($n = 140$, 30%) or more than double ($n = 94$, 20%) dose or the wrong medication ($n = 124$, 26%). The most common scenario for unintentional exposure to non-pharmaceuticals was "mistook product for food/drink" ($n = 122$, 37%).

Conclusions: The majority of intoxications in older adults are accidental and often involve medication errors. Unintentional poisoning is often preventable. If patients are cognitively impaired, potentially harmful substances should be kept out of their reach and medication should only be administered under direct supervision. Clear labelling, simplified drug regimens and the use of automatic medication dispensers could reduce the risk of medication errors in older patients.

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Elderly; intoxication; medication error; overdose; poisoning

Introduction

Due to increasing life expectancy the number of older people is increasing worldwide. At a global level in 2019, the percentage of the population aged ≥ 65 years old is approximately 9%, and this percentage is estimated to reach ~12% in 2030, ~16% in 2050 and it could reach ~23% by 2100 [1]. Because of the ageing of the population more people are likely to suffer from multiple long-term illnesses. The higher prevalence of multimorbidity and polypharmacy in older individuals increases the risk for medication errors and adverse drug reactions [2]. In addition to a higher risk of unintentional medication-related harm, older individuals are also a high-risk population with respect to suicidal poisonings due to several factors including mental and neurocognitive disorders, chronic physical illnesses, pain, social isolation, loss of relatives, and loss of autonomy [3–5].

Older patients generally have a higher risk of mortality when exposed to a potential toxic compound, compared to younger patients [6,7]. Although patients ≥ 70 years old represent a relatively small proportion of cases reported to American Poison Control Centers (5%), they contributed to 16% of the poison-related deaths in 2020 [8]. In addition, mean length of stay in the intensive care unit was prolonged in elderly patients, compared to younger patients, also indicating a more serious course of acute poisoning [9].

In the Netherlands, the annual number of patients >65 years old about whom the Dutch Poisons Information Center (DPIC) was consulted by telephone disproportionally increased by 129%, from 974 in 2010 to 2230 in 2020. This increase is larger than expected taken into account the rise in the Dutch population aged ≥ 65 years (from ~2.54 million in 2010 to ~3.39 million in 2020 [10]) and the overall increase in the number of patients the DPIC was consulted about (19% from 2010 to 2020, regardless of age) (Figure 1).

The higher risk of major outcomes in elderly poisoned patients and the growing elderly population highlight the

CONTACT Saskia J. Rietjens s.rietjens@umcutrecht.nl Dutch Poisons Information Center, University Medical Center Utrecht, Utrecht University, PO Box 85500, Utrecht 3508, GA, The Netherlands

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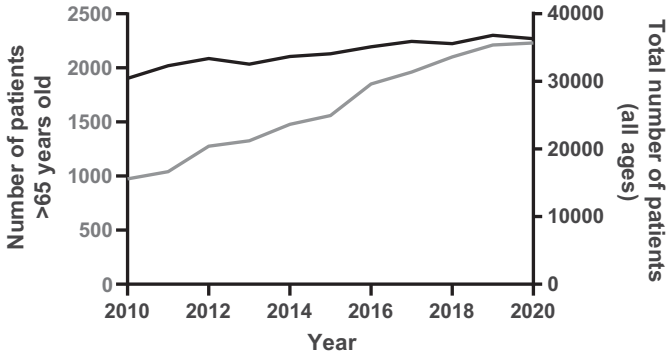

Figure 1. Number of patients > 65 years old (grey line) and total number of patients (all ages) (black line) about whom the Dutch Poisons Information Center (DPIC) was consulted by telephone from 2010 to 2020.

importance of implementing poisoning preventing programs targeting older adults. Although the number of poisonings in older people is expected to increase worldwide in line with demographic trends, few studies [11–20] have focused on exposure scenarios of poisoning in older patients. No such data are available yet for the Dutch population. The aim of this study is to gain insight in the number, type, and circumstances of pharmaceutical and non-pharmaceutical exposures reported to the DPIC involving patients > 65 years old in order to identify poisoning prevention strategies to reduce the number of poisonings in older individuals.

Methods

The DPIC provides a 24/7 telephone service providing expert advice to health care professionals on the diagnosis and treatment of poisoned patients, serving the entire Dutch population of 17.6 million. Reports to the DPIC are made on a voluntary basis. In a limited number of cases the DPIC is consulted by members of the public. In these cases, first-aid advice is given and patients are advised to contact their physician for further medical assistance.

Enquiries involving individuals > 65 years old were prospectively included from January 1, 2019 to June 30, 2019. Anonymous case information was recorded using a standard data format to ensure uniform data collection. Standard data fields include patient characteristics (i.e., age and gender), exposure(s), dose, intention (i.e., intentional/unintentional), and the DPIC's advice (i.e., observation at home, evaluation by a physician, or observation in hospital). For the purpose of the study, additional information regarding the living situation (e.g., living at home or in a nursing home), the presence of comorbidities, and exposure scenario was recorded by the Specialists in Poison Information. During DPIC consultation, data were collected anonymously, i.e., no personal identifiable information was recorded (only age and gender were known). The study is fully GDPR compliant. No explicit consent from the patients was required, because there was no direct contact by researchers with patients during the study and data were collected anonymously.

From the exposure scenario that was explicitly asked during DPIC consultation, the investigators categorized the intentional and unintentional exposures. Cases were discussed in case of discrepancies in order to reach consensus. Unintentional pharmaceutical exposures were categorized as: "too high dose prescribed", "incorrect dose or product dispensed", "inadvertently taken or given wrong medication", "inadvertently taken or given double dose", "inadvertently taken or given more than double dose", "medication doses taken or given too close together", "incorrect dosing route", "adverse effect/drug interaction" and "taken too high dose because of persistent pain". Patients with exposure to both medication and another substance were included in the group of patients with pharmaceutical exposures.

Unintentional non-pharmaceutical exposures were categorized by exposure route. Scenarios for unintentional non-pharmaceutical exposure *via* oral route included: "mistook product for food or drink", "took non-food item for no apparent reason", "mistook product for medication" and "other". Scenarios for unintentional non-pharmaceutical exposure *via* inhalation included: "occurred while a product was being used", "mixed two products together" and "other". Unintentional non-pharmaceutical exposures *via* ocular route were categorized as: "spray/splash to eye", "mistook product for eye drop", "eye exposure *via* hand contact" and "other", and *via* dermal route as: "spray/splash to skin" and "other". Intentional non-pharmaceutical exposures were categorized as: "(suspected) self-harm or cry for attention", "use of alcohol", "use of drugs of abuse (excl. abuse of pharmaceuticals)" and "other". Pharmaceutical and non-pharmaceutical exposures were subdivided in categories based on the DPIC classification system.

In some cases, the DPIC is contacted more than once about a specific exposure. When we were contacted within a 24 h timespan about a patient with exactly the same age, gender, exposure(s), exposure route and exposure scenario, then the call was classified as a follow-up call. Multiple enquiries regarding the same patient and same exposure(s) were analyzed as a single case. Descriptive statistics (percentage, median, interquartile range [IQR] and full ranges) were used to provide an overview of patient characteristics (e.g., age, gender, comorbidities and living situation) and exposure characteristics (e.g., type of exposures and exposure scenarios). Analyses were conducted using IBM SPSS Statistics version 26.0.0.1 (IBM SPSS, Armonk, NY).

Results

DPIC enquiries

The DPIC received a total of 1045 enquiries regarding 1051 patients > 65 years old from January through June 2019. Six enquiries involved two individuals who were simultaneously exposed and, therefore, separately included. We were mostly consulted by general practitioners (67%), followed by geriatric physicians (9%), paramedics (7%), Emergency Departments (6%), pharmacists (3%), psychiatrists (3%), hospital physicians (2%), and members of the public (1%).

Table 1. Patient characteristics stratified by intentionality.

	Total group	Unintentional[a]	Intentional[a]
	N (%)	*N* (%)	*N* (%)
Total number of patients	1051	805	193
Gender[b]			
Female	642 (61.1)	484 (60.1)	126 (65.3)
Male	408 (38.8)	320 (39.8)	67 (34.7)
Median age (IQR)	77 years (71–84 years)	78 years (72–85 years)	74 years (69–80 years)
Age category			
66 – 70 years	228 (21.7)	154 (19.1)	64 (33.2)
71 – 75 years	230 (21.9)	168 (20.9)	50 (25.9)
76 – 80 years	200 (19.0)	154 (19.1)	36 (18.7)
81 – 85 years	149 (14.2)	123 (15.3)	18 (9.3)
86 – 90 years	141 (13.4)	115 (14.3)	15 (7.8)
> 90 years	83 (7.9)	71 (8.8)	10 (5.2)
Not exactly specified	20 (1.9)	20 (2.5)	–
Underlying comorbidities			
Present	670 (63.7)	526 (65.3)	116 (60.1)
Cardiovascular diseases	327 (48.8[c])	266 (50.6[c])	45 (38.8[c])
Cognitive impairment (incl. dementia)	177 (26.4[c])	158 (30.0[c])	5 (4.3[c])
Diabetes	110 (16.4[c])	89 (16.9[c])	18 (15.6[c])
Psychiatric disorders[d]	98 (14.6[c])	35 (6.7[c])	58 (50.0[c])
Respiratory diseases	75 (11.2[c])	67 (12.7[c])	8 (6.9[c])
Renal impairment	69 (10.3[c])	54 (10.3[c])	11 (9.4[c])
Parkinson's disease	21 (3.1[c])	17 (3.2[c])	2 (1.7[c])
Alcohol abuse	18 (2.7[c])	6 (1.1[c])	10 (8.6[c])
Epilepsy	14 (2.1[c])	12 (2.3[c])	2 (1.7[c])
Not present	95 (9.0)	78 (9.7)	16 (8.3)
Unknown	286 (27.2)	201 (25.0)	61 (31.6)
Living situation			
Independently or with care at home	660 (62.8)	503 (62.5)	133 (68.9)
Nursing home	177 (16.8)	161 (20.0)	8 (4.1)
Psychiatric institution	22 (2.1)	11 (1.4)	10 (5.2)
Senior apartment	15 (1.4)	12 (1.5)	2 (1.0)
Other	5 (0.5)	4 (0.5)	1 (0.5)
Unknown	172 (16.4)	114 (14.2)	39 (20.2)

[a]The intention was unknown in 53 cases.
[b]Gender was unknown for one patient.
[c]Represents the percentage of the patients with underlying illnesses.
[d]Psychiatric disorders include conditions such as mood disorders (e.g., depression and bipolar disorder), anxiety disorders, and personality disorders (e.g., borderline).

Patient characteristics

The median age of the patients was 77 years old (range 66–104) and women were over-represented ($n = 642$, 61%) (Table 1, stratified by intentionality). Almost two in three patients ($n = 660$, 63%) lived independently or with care at home, while a smaller part lived in a nursing home ($n = 177$, 17%) or psychiatric institution ($n = 22$, 2%). One or more comorbidities were present in at least 64% of the patients ($n = 670$) (unknown in 286 patients). Almost half of the patients with an underlying illness had a cardiovascular condition ($n = 327$). Psychiatric disorders were more prevalent in patients with intentional exposures compared to patients with unintentional exposures (50 *vs.* 7%, respectively), whereas cognitive impairment was more often reported in patients with unintentional exposures compared to patients with intentional exposures (30 *vs.* 4%, respectively). Demographics of patients exposed to pharmaceuticals and non-pharmaceuticals are shown in Supplemental Table 1.

Exposure characteristics

In total, 1051 individuals were exposed to 1650 different substances (range: exposure to 1–18 substances per patient occurring in one poisoning episode). Patients were exposed to a single substance in 79% of the cases ($n = 826$) and to multiple substances in 21% of the cases ($n = 225$). In 77% of the patients ($n = 805$), the exposure was unintentional, in 18% intentional ($n = 193$) and in 5% the intention was unknown ($n = 53$) (Table 1). 73% of all exposures involved a pharmaceutical ($n = 1213$ exposures), i.e., drugs for human ($n = 1196$) or veterinary ($n = 17$) use. 10% of exposures were household products ($n = 162$) and 4% involved food (supplements), alcohol and drugs of abuse ($n = 69$) (Figure 2).

Pharmaceutical exposures

Most pharmaceutical exposures ($n = 1213$) involved cardiovascular agents ($n = 367$, 30%), central and peripheral nervous system agents ($n = 354$, 29%), analgesics ($n = 152$, 13%) and hormonal and metabolic pathway drugs ($n = 92$, 8%). In most patients, route of exposure to pharmaceuticals was oral ($n = 605$, 92%), followed by ocular ($n = 32$, 5%) and parenteral ($n = 21$, 3%) route.

In 71% of the patients exposed to medication, the drugs were taken unintentionally ($n = 471$) (Table 2). Drugs often involved were: metoprolol ($n = 35$ exposures), paracetamol ($n = 34$), metformin ($n = 24$), acetylsalicylic acid ($n = 22$), levodopa (combined with benserazide or carbidopa or carbidopa and entacapone) ($n = 20$), pantoprazole ($n = 19$), digoxin

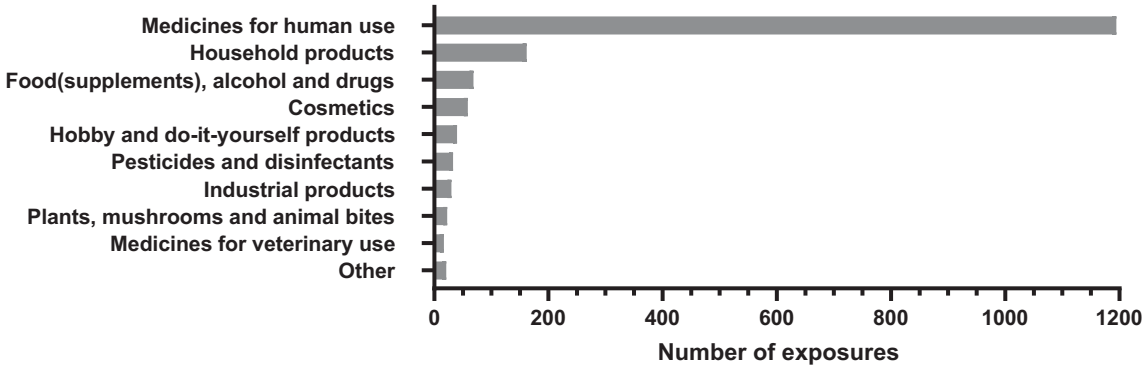

Figure 2. Number of exposures per product category in patients > 65 years old reported to the Dutch Poisons Information Center (DPIC) from January 2019 to June 2019.

Table 2. Scenarios for pharmaceutical exposures in patients > 65 years old.

Scenario	Number of patients (%)
Unintentional exposure	471 (71.4)
Inadvertently taken/given double dose	140 (29.7)
Inadvertently given/taken wrong medication	124 (26.3)
Someone else's medication	42 (33.9)[a]
Veterinary medication	11 (8.9)
Mistook other medication for eye drop	26 (21.0)
Other	45 (36.3)
Inadvertently taken/given more than double dose	94 (20.0)
Incorrect dosing route	33 (7.0)[b]
Medication doses taken/given too close together	24 (5.1)
Weekly oral medication taken for several successive days	17 (70.8)
Injection doses given too close together	7 (29.2)
Taken too high dose because of persistent pain	16 (3.4)
Adverse effects or drug interaction	11 (2.3)
Incorrect dose or product dispensed	11 (2.3)
Too high dose prescribed	6 (1.3)
Other[c]	12 (2.5)
Intentional exposure[d]	152 (23.0)
Intention unknown	37 (5.6)
Total	660

[a]Mostly involving medication from another resident (nursing home/psychiatric institution; ($n = 24$)) or the partner's medicines ($n = 15$).
[b]Often involving ingestion of medication that is normally used by inhalatory route ($n = 19$).
[c]Including needlestick injury ($n = 2$).
[d](Suspected) self-harm or cry for attention.

($n = 17$), clopidogrel ($n = 17$) and rivaroxaban ($n = 16$) (see also Table 3). Of the unintentional pharmaceutical exposures, the most common scenarios included: "inadvertent double-dosing" ($n = 140$, 30%) or "more than double-dosing" ($n = 94$, 20%) and "inadvertently taken/given the wrong medication" ($n = 124$, 26%) (Table 2). The majority of unintentional pharmaceutical exposures was caused by the patients themselves ($n = 357$, 76%). Almost three out of four of these patients were living at home ($n = 261$) and in at least 15% of these cases ($n = 40$) cognitive impairment was involved (underlying illnesses unknown in 43 cases). A smaller number of unintentional pharmaceutical exposures were caused by mistakes made by nurses ($n = 65$, 14%), pharmacists ($n = 11$, 2%), family members ($n = 8$, 2%), and physicians ($n = 7$, 1%). The greater part of the patients unintentionally exposed to medication lived independently or with care at home ($n = 302$, 64%), while a smaller proportion lived in a nursing home ($n = 82$, 17%). Medication errors made by nurses working in nursing homes ($n = 40$) most often involved inadvertent administration of medication of another resident ($n = 19$, 48%) or double dosing ($n = 13$, 33%). The median age of the patients unintentionally exposed to medication was 79 years old (IQR: 72-85; range: 66–100). The majority of the patients who were unintentionally exposed to medication were advised to be observed at home or in nursing home ($n = 308$, 65%), whereas in 24% of the cases ($n = 114$) evaluation by an physician and in 10% of the cases ($n = 49$) hospital observation was advised.

In 23% of the patients exposed to medication, the drugs were taken intentionally ($n = 152$) (Table 2). In intentional drug overdose, most commonly involved medication was: oxazepam ($n = 32$ exposures), paracetamol ($n = 30$), oxycodone ($n = 15$), lorazepam ($n = 12$), temazepam ($n = 11$), zolpidem ($n = 9$), quetiapine ($n = 9$) and citalopram ($n = 7$) (see also Table 3). The median age of the patients intentionally exposed to medication was 73 years old (IQR: 69–79; range: 66–94). The majority of the patients who were intentionally exposed to medication were advised to be evaluated by a physician ($n = 43$, 28%) or to be observed in hospital ($n = 54$, 36%), whereas (from a pure toxicological point of view) in 36% ($n = 55$) observation at home or in nursing home was advised.

Non-pharmaceutical exposures

Non-pharmaceutical exposures in older adults are shown in Figure 2. Most of the non-pharmaceutical exposures were unintentional ($n = 334$, 85%) (Table 4), mainly occurring *via* oral route ($n = 246$, 74%). Household products (40%, $n = 140$ exposures) were mainly involved in accidental exposures, mostly cleaning products ($n = 80$), dishwasher detergents ($n = 23$) and laundry detergents ($n = 9$). Other accidental exposures often reported included cosmetics (16%, $n = 54$), mostly dental care products ($n = 30$), i.e., denture cleaning tablets ($n = 26$) or mouthwash ($n = 4$), followed by hobby and do-it-yourself products (11%, $n = 38$), and pesticides (4%, $n = 14$) and disinfectants (4%, $n = 14$).

The most common scenario for unintentional non-pharmaceutical exposure was "mistook product for food or drink" (Table 4). The ingestion of a descaling agent that was still present in a coffee machine or kettle was often reported ($n = 27$). Another common scenario was "for no apparent reason eating or drinking substances stored within

Table 3. Unintentional and intentional pharmaceutical exposures in patients > 65 years old.

	Unintentional exposures[b,c]	Intentional exposures[b,c]
Medication category[a]	Number (%)	Number (%)
Cardiovascular agents	296 (35.2)	44 (15.5)
Antihypertensives	103 (34.8)	19 (43.2)
Antithrombotics	71 (24.0)	8 (18.2)
Antiarrhythmics and medication for coronary artery disease	50 (16.9)	10 (22.7)
Lipid-lowering agents	33 (11.1)	3 (6.8)
Diuretics	31 (10.5)	4 (9.1)
Other	8 (2.7)	0 (0)
Central and peripheral nervous system agents	174 (20.7)	145 (51.2)
Hypnotics, sedatives, and anxiolytics	36 (20.7)	83 (57.2)
Antidepressants	33 (19.0)	34 (23.4)
Antipsychotics	31 (17.8)	15 (10.3)
Anticonvulsants	28 (16.1)	7 (4.8)
Anti-Parkinson agents	27 (15.5)	2 (1.4)
Anti-Dementia agents	9 (5.2)	0 (0)
Other	10 (5.7)	4 (2.8)
Hormonal and metabolic pathway agents	77 (9.2)	11 (3.9)
Diabetes medication	37 (48.1)	5 (45.5)
Corticosteroids	13 (16.9)	2 (18.2)
Thyroid agents	13 (16.9)	3 (27.3)
Other	14 (18.2)	1 (9.1)
Analgesics	76 (9.0)	64 (22.6)
Non-opioid analgesics[d]	59 (77.6)	40 (62.5)
Opioid analgesics[e]	17 (22.4)	24 (37.5)
Antimicrobial and antiparasitic agents	51 (6.1)	5 (1.8)
Agents targeting gastrointestinal tract	42 (5.0)	6 (2.1)
Respiratory agents	28 (3.3)	2 (0.7)
Agents targeting skin, throat, nose, ear and eye	13 (1.5)	0 (0)
Musculoskeletal agents	12 (1.4)	0 (0)
Genitourinary agents	10 (1.2)	1 (0.4)
Other	46 (5.5)	4 (1.4)
Veterinary drugs	16 (1.9)	1 (0.4)
Total pharmaceutical exposures	841	283

[a]Pharmaceuticals were subdivided in categories based on the DPIC classification system.
[b]In one poisoning episode, patients can be exposed to multiple pharmaceuticals (>1 medication class).
[c]The intention was unknown in 37 patients exposed to pharmaceuticals. These exposures are not included in this table.
[d]Including NSAIDs.
[e]Including combination preparations with opioid drugs.

their reach" ($n = 78$). These cases often involved patients with cognitive impairment ($n = 65$, 83%), and exposures often reported included: plants ($n = 13$), shower gel/shampoo/soap ($n = 8$), dishwasher tablets ($n = 7$), cigarettes (including butts and ash) ($n = 7$), and denture cleaning tablets ($n = 5$). The median age of the patients unintentionally exposed to non-pharmaceuticals was 76 years old (IQR: 71–84; range: 66–104). The majority of the patients was advised to be observed at home or in nursing home ($n = 239$, 72%), whereas in 25% of the cases ($n = 83$) evaluation by a physician and in 4% of the cases ($n = 12$) hospital observation was advised.

A small part of the non-pharmaceutical exposures was intentional ($n = 41$, 10%), mostly in the context of (suspected) self-harm or cry for attention ($n = 23$) (Table 4). Route of exposure was often oral ($n = 35$, e.g., ingestion of chlorine bleach ($n = 5$)), followed by inhalation ($n = 4$, e.g., inhalation of natural gas or helium). The median age of the patients intentionally exposed to non-pharmaceuticals was 76 years old (IQR: 70–81; range: 66–94). The majority of the patients was advised to be evaluated by a physician (44%) ($n = 18$) or to be observed in hospital (24%) ($n = 10$), whereas (from a pure toxicological point of view) in 32% ($n = 13$) observation at home or in nursing home was advised.

Discussion

The majority of DPIC consultations regarding older patients involve unintentional pharmaceutical exposures. Most common scenarios were inadvertently taken or given a double or more than double dose or the wrong medication, mostly caused by the patients themselves due to forgetfulness or during a state of confusion. American Poison Center data showed similar results, i.e., the most common scenarios for medication errors in older patients were: inadvertently took or given medication twice, wrong medication taken or given, other incorrect dose, medication doses given or taken too close together and inadvertently took or given someone else's medication [14]. Fortunately, each of these five scenarios resulted in low rates of serious outcomes (<1%) [14]. A Danish Poison Center study showed that in nursing homes most poisonings were caused by administration errors [15]. We showed that approximately half of the medication errors made by nurses working in nursing homes involved inadvertent administration of medication of another resident.

Polypharmacy and complicated drug regimens in older people increases the risk of medication errors and adverse drug reactions [21,22]. A strategy to reduce this type of poisonings is prescribing medication with a wider therapeutic window and using simplified drugs regimens and electronic

Table 4. Scenarios for non-pharmaceutical exposures in patients >65 years old.

Scenario[a]	Number of patients (%)
Unintentional exposure	334 (85.4)
Oral exposures	246 (73.7)
Mistook product for food or drink[b]	122 (49.6)
Took non-food item for no apparent reason	78 (31.7)
Mistook product for medication[c]	17 (6.9)
Other	29 (11.8)
Inhalation exposures	39 (11.7)
Occurred while a product was being used	18 (46.1)
Mixed two products together	2 (5.1)
Other[d]	19 (48.7)
Ocular exposures	30 (9.0)
Spray/splash to eye	22 (73.3)
Mistook product for eye drop	5 (16.7)
Ocular exposure to plant juice (*via* hand contact)	3 (10.0)
Dermal exposures	12 (3.6)
Spray/splash to skin	7 (58.3)
Other	5 (41.7)
Combined route of exposure[e]	4 (1.2)
Other route of exposure[f]	3 (0.9)
Intentional exposure	41 (10.5)
(Suspected) self-harm or cry for attention	23 (56.1)
Use of drugs of abuse[g]	12 (29.3)
Use of alcohol	2 (4.9)
Other	4 (9.8)
Intention unknown	16 (4.1)
Total	391

[a]Patients with exposure to both pharmaceuticals and non-pharmaceuticals were included in the group of patients with pharmaceutical exposures (Table 2).
[b]27 cases involved ingestion of a descaling agent that was still present in coffee machine or kettle. 11 cases involved ingestion of white spirit/turpentine. 8 cases involved ingestion of (part of) a dissolved denture cleaning tablet.
[c]In 9 cases, a denture cleaning tablet was mistaken for medication.
[d]Including carbon monoxide exposure ($n = 4$) and mercury vapor exposure ($n = 3$).
[e]For example: combination dermal and inhalation exposure.
[f]Including rectal route ($n = 1$), sting (plant) ($n = 1$), and spider bite ($n = 1$).
[g]10 cases involved exposure to cannabis, cannabis oil, or cannabidiol (CBD) oil.

prescription systems. Furthermore, clear medication instructions by pharmacists and the use of daily or weekly medication dispensers or automatic medication dispensers (automatically releasing the correct dose of the medication at a specified time) will improve medication adherence. Especially, drugs with a narrow therapeutic window, such as digoxin [23] and lithium [24], should be prescribed and monitored carefully. If patients are severely cognitively impaired, medications should be kept out of their reach and only administered under direct supervision. Confusion between medication may be caused by similar appearances of the medications or poor eyesight. Clear labelling of medication and using larger font size may prevent these mistakes [25,26]. Administration errors occurring in nursing homes could be prevented by independent double-checking, especially when high-risk medication is involved.

In our study, cardiovascular, central and peripheral nervous system drugs, hormonal/metabolic pathway agents, and analgesics were most often involved in unintentional pharmaceutical exposures, corresponding with medication commonly used in patients of older age. An American study among patients $\geq$ 65 years old also showed that most common medication categories associated with preventable adverse drug events include cardiovascular drugs, followed by diuretics, non-opioid analgesics, hypoglycemics, anticoagulants and opioids [27]. An Australian Poison Center study showed that medication errors in patients $\geq$ 75 years old particularly involved cardiovascular drugs, anticoagulants, antidiabetics, opioids, and paracetamol-containing analgesics [28]. The DPIC does not routinely conduct follow-up to investigate the medical outcome. However, other studies have shown that especially certain medication classes, such as analgesics (e.g., opioids), anticoagulants (e.g., warfarin), asthma therapies (e.g., beta-agonists), psychotherapeutics (e.g., lithium) and some cardiovascular agents (e.g., cardiac glycoside) were associated with high hazard factors in older patients following unintentional exposure [12,14,29].

In our study, 18% of the poisonings were intentional. Cobaugh et al. showed that paracetamol, aspirin, barbiturates, cardiovascular drugs, cyclic antidepressants, and opioids had the greatest risk for harm and lethality in older patients with respect to suicide-related exposures [30]. If suicide is secondary to an underlying psychiatric illness which is not diagnosed or inadequately treated, then these type of poisonings could be preventable [25]. Depression in older patients is often undetected or inadequately treated [31,32]. Therefore, diagnosis and treatment of psychiatric conditions should be optimized in older persons [3,25]. Additional prevention strategies may include prescribing of less toxic medication, and limiting the amount of medication dispensed when an older person is (suspected to be) suicidal [6]. In addition, caregivers should be advised to reduce the availability of dangerous medication and other chemicals at home [25,26,30].

In our study, approximately a quarter of exposures in older patients involve non-pharmaceutical substances, mostly household products and cosmetics. The most common scenario for unintentional non-pharmaceutical exposure was "mistook product for food or drink", e.g., caused by transfer of substances from the original packaging to a container that would normally contain food or drink. Other common scenarios for non-pharmaceutical exposures involved patients with cognitive impairment who, for no apparent reason, ingested a non-food item stored within their reach, such as plants, dishwasher tablets, cigarettes and cosmetics (e.g., denture cleaning tablets and soap). A French Poison Center study also showed that older adults residing in structured living facilities, with a history of dementia and/or cognitive impairment, are at risk of non-pharmaceutical poisoning, e.g., by ingesting personal hygiene products (e.g., soap) and plants [13]. An Australian Poison Center study showed that hand sanitizers, soap and denture cleaning agents were commonly involved in accidental ingestions in patients with dementia [20]. Most of the accidental non-pharmaceutical exposures seem preventable. Edible products should be stored separated from non-edible products and chemicals should be kept in their original container and should not be transferred to food containers. Moreover, to avoid mistakes, better labelling of products and using clear warning statements and user instructions on products is advised.

The last decade, the number of enquiries to the DPIC involving older adults steadily increased. Although our data

cannot identify an underlying cause of this trend, possible explanations could be increased use of medications, or longer waiting lists for home care or admission to nursing homes, which subsequently increases the risk of accidents occurring at home.

There are several limitations to Poison Center data that may bias our results. First, data are based on voluntary reports to the DPIC, which underestimates the true incidence of poisonings in the Netherlands. Moreover, it is expected that especially exposures that require the expertise of a Poison Control Center may be reported, which may lead to an underreporting of cases with minor outcomes that do not require medical attention. In addition, as the DPIC only receives a limited number of calls from members of the public, data are likely to be biased toward more severe poisonings. Furthermore, it is expected that there is underreporting of common poisonings that clinicians have experience with regarding treatment (e.g., paracetamol or benzodiazepines) and cases in which the patient has died and there is no need to consult a Poison Center about clinical management. Therefore, Poison Center data may not reflect the true patterns of poisoning in older adults. On the other hand, using data from Poison Centers enables characterization of poisoning exposures managed at home (or nursing home) or in a health care facility. The DPIC does not routinely follow-up all cases, therefore no outcome data could be reported. In addition, some cases could have been double-counted due to anonymous processing of cases. The study period involved a 6-month period and, therefore, variation in call types associated with seasonal changes could not be evaluated.

Conclusions

Older people are a high-risk group, because of the high prevalence of comorbidities and polypharmacy, and potential cognitive dysfunction. Poisoning prevention strategies need to be tailored to target individuals residing at home and in aged care facilities. In our study, the majority of intoxications in older adults involved medication errors. Most common scenarios were inadvertently taken or given a (more than) double dose or the wrong medication. Simplified drug regimens and the use of innovative technologies, such as automatic medication dispensers could reduce these type of medication errors. In addition, if patients are cognitively impaired, potentially harmful substances should be kept out of their reach and medication should only be administered under direct supervision. Furthermore, manufacturers of pharmaceuticals and consumer products should be encouraged to design labels which can be easily read and understood by older people to avoid mistakes. A multidisciplinary approach involving instruction and monitoring by general practitioners, geriatric physicians, pharmacists, nursing home staff, and home care providers may prevent future poisonings in older individuals.

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ORCID

Saskia J. Rietjens http://orcid.org/0000-0002-0338-1350
Joyce E. M. van der Heijden http://orcid.org/0000-0002-3584-2318
Dylan W. de Lange http://orcid.org/0000-0002-0191-7270

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