




The Dutch list of essential drugs for undergraduate medical education: A modified Delphi study

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Aims: Prescribing errors among junior doctors are common in clinical practice because many lack prescribing competence after graduation. This is in part due to inadequate education in clinical pharmacology and therapeutics (CP&T) in the undergraduate medical curriculum. To support CP&T education, it is important to determine which drugs medical undergraduates should be able to prescribe safely and effectively without direct supervision by the time they graduate. Currently, there is

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no such list with broad-based consensus. Therefore, the aim was to reach consensus on a list of essential drugs for undergraduate medical education in the Netherlands.

Methods: A two-round modified Delphi study was conducted among pharmacists, medical specialists, junior doctors and pharmacotherapy teachers from all eight Dutch academic hospitals. Participants were asked to indicate whether it was essential that medical graduates could prescribe specific drugs included on a preliminary list. Drugs for which $\geq 80\%$ of all respondents agreed or strongly agreed were included in the final list.

Results: In all, 42 (65%) participants completed the two Delphi rounds. A total of 132 drugs (39%) from the preliminary list and two (3%) newly proposed drugs were included.

Conclusions: This is the first Delphi consensus study to identify the drugs that Dutch junior doctors should be able to prescribe safely and effectively without direct supervision. This list can be used to harmonize and support the teaching and assessment of CP&T. Moreover, this study shows that a Delphi method is suitable to reach consensus on such a list, and could be used for a European list.

KEYWORDS

clinical pharmacology, medical education, pharmacology teaching, pharmacotherapy

1 | INTRODUCTION

The transition from medical student to junior doctor is often experienced as being challenging, especially when it comes to prescribing drugs.¹ Not only is the list of available drugs exhaustive and ever expanding, drugs are also available in various formulations for different routes of administration. Not surprisingly, junior doctors often feel unprepared for their prescribing duties and lack confidence.² In clinical practice, junior doctors make many, potentially avoidable, prescribing errors.^{3,4} For example, in the UK, juniors doctors write most prescriptions (70%) but unfortunately have a high rate of prescribing errors (9%) compared with experienced prescribers (5%).⁵ In the Netherlands, approximately 6% of all unplanned hospital admissions are drug related.⁶ Similar numbers have been reported in other European countries.⁷ One explanation for the large number of errors and lack of prescribing competence among medical graduates is inadequate education and training in clinical pharmacology and therapeutics (CP&T) in undergraduate medical curricula.² Improving undergraduate training in CP&T is therefore a pivotal step to reduce future prescribing errors.⁸

To support CP&T education, it is important to limit the number of drugs that medical undergraduates should be able to prescribe safely and effectively without direct supervision. Incorporating a core drug list together with the list of essential diseases for prescribing and a final pharmacotherapy assessment into the undergraduate medical curriculum would ensure optimal knowledge and prescribing skills of the drugs at the time of graduation.⁹ This has also been recommended

What is already known about this subject

- Essential drug lists are used in several countries to ensure safe prescribing and to meet the needs of the national health care system.
- For medical education purposes, existing lists are in practice too extensive or outdated.
- There is as yet no broad-based consensus list of commonly prescribed drugs that junior doctors should be able to prescribe safely and effectively without direct supervision.

What this study adds

- This study shows that the Delphi method is feasible to reach consensus within a country about a list of essential drugs for medical education.
- A list of essential drugs will harmonize and support the teaching and assessment of clinical pharmacology and therapeutics in undergraduate medical curricula.
- This is the first study to identify drugs that Dutch junior doctors should be able to prescribe safely and effectively without direct supervision.

by the World Health Organization.¹⁰ There are existing drug formularies and drug lists, such as the 'core drug list' in the UK and 'The Wise List' in Sweden.^{11–15} However, these lists may not be directly applicable in the Netherlands because of differences in local preferences, guidelines and drug accessibility. More importantly, some are outdated or are not developed with the goal to improve medical education but more for use in daily clinical practice. Therefore, together with all eight Dutch medical schools, we aim to develop a list of essential drugs that junior doctors in the Netherlands should be able to prescribe safely and effectively without direct supervision. This list can be used to harmonize and support training and assessment of CP&T in the undergraduate medical curriculum.

2 | METHODS

2.1 | Study design

The Delphi method is a commonly used approach in research to reach consensus on subjects with a lack of evidence or diverse opinions.^{16–20} A Delphi usually consists of multiple rounds. In each round, participating experts are asked to evaluate statements or items in a questionnaire. Based on the average scores, items are added or removed in subsequent rounds.²¹ Our modified Delphi study was conducted between November 2020 and April 2021 and comprised the following: selecting an expert panel; creating a preliminary drug list; and carrying out a two-round Delphi procedure.

This study was initiated by the Pharmacotherapy Education working group of the Dutch Society for Clinical Pharmacology & Biopharmacy and was approved by the Dutch Association for Medical Education Ethical Review Board (NERB: 2020.5) and the Medical Ethics Review Committee of VU University Medical Center (2020.337).

2.2 | Delphi panel

All eight Dutch medical faculties were invited to participate in the study. A representative from each medical faculty, appointed by the Pharmacotherapy Education working group, was asked to select at least nine participants affiliated to their faculty, to form a broadly representative expert panel with different clinical interests. Participation was voluntary and informed consent was obtained from all participants. The following selection criteria were applied.

- Two experienced (≥ 3 years of teaching experience) teachers of CP&T in the undergraduate medical curriculum, of which at least one teacher is a registered clinical pharmacologist.
- Five healthcare professionals, preferably a surgeon; an internist (e.g., general internist, gastroenterologist, pulmonologist or cardiologist); a general practitioner; a specialist in geriatric medicine; and a (hospital) pharmacist.

- Two recently graduated junior doctors (graduated ≤ 1 year ago) working in clinical practice and prescribing drugs on a regular basis.

2.3 | Drug list

We developed a preliminary list of 337 drugs including various formulations, based on the WHO model list of essential medicines,¹⁵ the most commonly prescribed drugs in the Netherlands,²² the drugs associated with medication-related hospital admissions in the Netherlands,⁶ a local formulary used in the undergraduate program of the Erasmus Medical University, and the website of

TABLE 1 Participant characteristics

	Round 1 (n = 51)	Round 2 (n = 42)
Affiliation		
Amsterdam University Medical Centers, location AMC	4 (7.8)	3 (7.1)
Amsterdam University Medical Centers, location VUMC	13 (25.5)	11 (26.2)
Erasmus University Medical Center	5 (9.8)	5 (11.9)
Leiden University Medical Center	4 (7.8)	1 (2.4)
Maastricht University Medical Center	3 (5.9)	2 (4.8)
Radboud University Medical Center	6 (11.8)	5 (11.9)
Affiliated regional centers	6 (11.8)	6 (14.3)
University Medical Center Groningen	1 (2.0)	1 (2.4)
University Medical Center Utrecht	9 (17.6)	8 (19.0)
Primary profession		
Junior doctor/resident	12 (23.5)	11 (26.2)
Geriatrician	4 (7.8)	4 (9.5)
General practitioner	3 (5.9)	2 (4.8)
Internist	8 (15.7)	5 (11.9)
Paediatrician	4 (7.8)	4 (9.5)
Psychiatrist	1 (2.0)	1 (2.4)
Surgeon	3 (5.9)	3 (7.1)
Community pharmacist	1 (2.0)	1 (2.4)
Hospital pharmacist	3 (5.9)	3 (7.1)
Pharmacotherapy teacher	12 (23.5)	8 (19.0)
Clinical pharmacologist (or in training)		
Yes	27 (52.9)	21 (50.0)
No	24 (47.1)	21 (50.0)
Experience		
Clinical experience	8 (0–46)	8 (0–46)
Teaching experience	4 (0–35)	5.5 (0–35)

Note: Data are expressed as numbers and percentages (in brackets). Clinical and teaching experience are expressed as median and range in years.

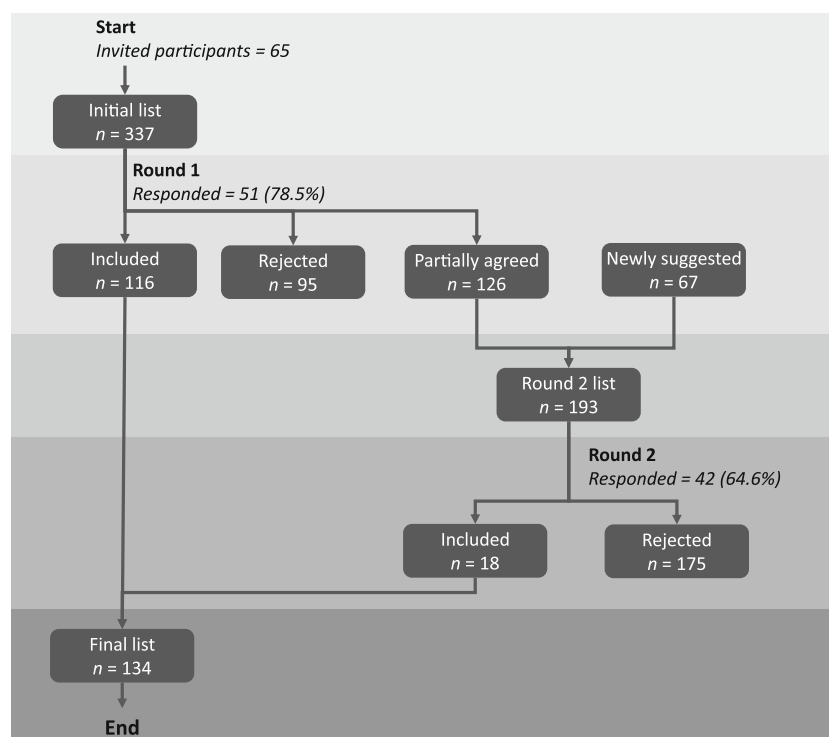


FIGURE 1 Overview of the results of the Delphi rounds Response rates are indicated as percentages of invited participants.

the Dutch College of General Practitioners.²³ The list was broadly sorted on the Anatomical Therapeutic Chemical classification (ATC) code, and drugs were shown on the level of their route of administration.²⁴

2.4 | Data collection and analysis

Participants were approached by email to complete a questionnaire about the relevance of the drugs on the preliminary drug list, using the web-based platform Qualtrics (Qualtrics International Inc. [XM], Provo, UT, USA). Participants were anonymous and scored all items without conferring with others. In the first round, participants had to evaluate each drug based on a 5-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = neither agree, nor disagree; 4 = agree; 5 = strongly agree) indicating their agreement that junior doctors should be able to prescribe the drug without direct supervision. Participants could also provide arguments for their choices and suggestions of drugs or dosing forms missing from the preliminary list. Drugs rated 4 or 5 by $\geq 80\%$ of participants were immediately included in the list. Drugs rated 4 or 5 by 50%–80% of the participants (partial agreement) and newly suggested drugs in round 1 were included for (re)evaluation in round 2. Round 2 had the same set-up as the first round. Only the items for which $\geq 80\%$ of all respondents gave a rating of 4 or 5 were added to the final list of essential drugs. All other drugs were rejected. For each round, participants were given 3 weeks to respond. The statistical software SPSS (version 26, IBM, Armonk, NY, USA) and Microsoft Excel 2016 (Microsoft, Albuquerque, NM, USA) were used to analyse the data using descriptive statistics.

3 | RESULTS

3.1 | Demographic data

Sixty-five eligible experts were asked to participate, 51 (78.5%) of whom completed round 1 and 42 (64.6%) round 2. The experts had a wide range of clinical and teaching experience (Table 1).

3.2 | Essential list of drugs

Of the 337 drugs in the preliminary list, 116 were accepted after round one, and another 18 after round two. Of the 67 newly suggested drugs, two were accepted (Figure 1). The final list of essential drugs is shown in Table 2: there are 134 drugs in the list, consisting of 124 different drugs, and ten being different formulations (e.g., different routes of administration). The top three ATC code groups are (1) alimentary tract and metabolism ($n = 26$), (2) cardiovascular ($n = 15$) and (3) anti-infective for systemic use ($n = 19$). Appendix Table A1 shows the list of all assessed drugs in rounds 1 and 2, and Appendix Table B1 shows the final list.

4 | DISCUSSION

This Delphi study identified 134 drugs that Dutch junior doctors, according to our expert panel, should be able to prescribe safely and effectively without direct supervision. This essential list of drugs is the first of its kind in the Netherlands and is a crucial step to improve CP&T teaching with a view to reduce the number of prescribing errors

TABLE 2 Delphi scores for all accepted items

Drug groups	Drug names	Round 1 (% score 4 or 5)	Round 2 (% score 4 or 5)
Alimentary tract and metabolism (N = 26)			
Drugs for intestinal infections and inflammations (N = 2)	Miconazole	82.4	-
	Nystatin	74.5	88.1
Drugs for acid related disorders (N = 5)	Esomeprazole	82.4	-
	Omeprazole	96.1	-
	Pantoprazole	96.1	-
	Ranitidine	92.2	-
	Magnesium hydroxide	82.4	-
Drugs affecting gastrointestinal motility (N = 10)	Bisacodyl	88.2	-
	Macrogol	96.1	-
	Macrogol/electrolytes	-	88.1
	Psyllium seed	74.5	81.0
	Lactulose	94.1	-
	Loperamide	100	-
	Metoclopramide	98.0	-
	Domperidone	90.2	-
	Ondansetron	90.2	-
	Oral rehydration solution	94.1	-
Drugs used in diabetes (N = 9)	Gliclazide	94.1	-
	Glimepiride	80.4	-
	Metformin	94.1	-
	Insulin (SC)	84.3	-
	Insulin aspart (SC)	86.3	-
	Insulin aspart/insulin aspart protamine (SC)	84.3	-
	Insulin glargine (SC)	76.5	88.1
	Glucose solution (IV)	86.3	-
	Glucagon (IM)	90.2	-
Blood and blood forming organs (N = 12)			
Drugs affecting blood platelets or coagulation (N = 9)	Acetylsalicylic acid	100	-
	Carbasalate calcium	94.1	-
	Clopidogrel	94.1	-
	Acenocoumarol	98.0	-
	Phenprocoumon	92.2	-
	Apixaban	94.1	-
	Dabigatran	88.2	-
	Rivaroxaban	88.2	-
	Nadroparin (SC)	80.4	-
Drugs for treating anaemia (N = 2)	Ferrous fumarate	98.0	-
	Folic acid	96.1	-
Intravenous fluids (N = 1)	Sodium chloride solution 0.9% (IV)	92.2	-
Cardiovascular system (N = 25)			
Drugs affecting cardiac contractility (N = 1)	Adrenaline autoinjector (IM)	-	83.3
Drugs for treating high blood pressure (N = 20)	Amlodipine	96.1	-
	Nifedipine	86.3	-
	Atenolol	86.3	-

(Continues)

TABLE 2 (Continued)

Drug groups	Drug names	Round 1 (% score 4 or 5)	Round 2 (% score 4 or 5)
	Metoprolol	98.0	-
	Propranolol	86.3	-
	Bumetanide	80.4	-
	Furosemide (IV)	74.5	81.0
	Furosemide	100	-
	Spirolactone	92.2	-
	Enalapril	96.1	-
	Lisinopril	88.2	-
	Perindopril	84.3	-
	Hydrochlorothiazide	100	-
	Isosorbide dinitrate	78.4	83.3
	Isosorbide dinitrate (SL)	82.4	-
	Isosorbide mononitrate	86.3	-
	Potassium chloride	76.5	85.7
	Losartan	96.1	-
	Valsartan	84.3	-
	Nitroglycerin (SL)	96.1	-
Drugs for treating dyslipidaemias (N = 4)	Atorvastatin	94.1	-
	Pravastatin	72.5	81.0
	Rosuvastatin	88.2	-
	Simvastatin	96.1	-
Dermatologicals (N = 5)			
Creams and ointments (N = 2)	Soft paraffin and fat products (dermal)	94.1	-
	Zinc oxide (dermal)	84.3	-
Antimicrobial drugs and steroids (N = 3)	Fusidic acid (dermal)	90.2	-
	Hydrocortisone (dermal)	96.1	-
	Miconazole (dermal)	96.1	-
Genito-urinary system and sex hormones (N = 3)			
Drugs for treating vaginal infections (N = 1)	Miconazole (mucosal)	86.3	-
Drugs affecting reproductive function (N = 1)	Ethinyl oestradiol/levonorgestrel	94.1	-
Drugs for treating benign prostate hyperplasia (N = 1)	Tamsulosin	92.2	-
Systemic hormonal preparations excluding sex steroids (N = 4)			
Corticosteroids for systemic use (N = 3)	Dexamethasone	80.4	-
	Hydrocortisone	84.3	-
	Prednisolone	96.1	-
Drugs for treating thyroid disorders (N = 1)	Levothyroxine	96.1	-
Antiinfective for systemic use (N = 19)			
Antibacterial drugs (N = 13)	Amoxicillin	100	-
	Amoxicillin (IV)	70.6	83.3
	Amoxicillin/clavulanic acid	100	-
	Amoxicillin/clavulanic acid (IV)	70.6	83.3
	Flucloxacillin	98.0	-
	Azithromycin	90.2	-
	Clarithromycin	88.2	-
	Ciprofloxacin	96.1	-

TABLE 2 (Continued)

Drug groups	Drug names	Round 1 (% score 4 or 5)	Round 2 (% score 4 or 5)
	Clindamycin	86.3	-
	Nitrofurantoin	100	-
	Cotrimoxazole	96.1	-
	Trimethoprim	86.3	-
	Doxycycline	98.0	-
Antifungal drugs (N = 1)	Fluconazole	80.4	-
Antiviral drugs (N = 1)	Acyclovir	84.3	-
Vaccines and immunoglobulins (N = 3)	Influenza vaccine (IM)	82.4	-
	Tetanus immunoglobulin (IM)	84.3	-
	Tetanus toxoid (IM)	78.4	85.7
Antiprotozoal drugs (N = 1)	Metronidazole	82.4	-
Musculoskeletal system (N = 15)			
Drugs used for pain management including treatment of gout (N = 12)	Allopurinol	84.3	-
	Colchicine	86.3	-
	Diclofenac	100	-
	Ibuprofen	100	-
	Naproxen	98.0	-
	Fentanyl (dermal)	86.3	-
	Morphine	92.2	-
	Morphine (SC)	76.5	88.1
	Oxycodone	92.2	-
	Tramadol	92.2	-
	Acetaminophen	100	-
	Acetaminophen (rectal)	90.2	-
Drugs affecting bone homeostasis (N = 3)	Alendronic acid	84.3	-
	Calcium with vitamin D	96.1	-
	Cholecalciferol	92.2	-
Nervous system (N = 12)			
Local anaesthetics (N = 1)	Lidocaine/adrenaline (SC)	72.5	81.0
Drugs for treating depression, anxiety disorders, psychosis and addiction (N = 10)	Amitriptyline	80.4	-
	Citalopram	88.2	-
	Diazepam	92.2	-
	Diazepam (rectal)	78.4	92.9
	Lorazepam	90.2	-
	Oxazepam	92.2	-
	Temazepam	92.2	-
	Zolpidem	74.5	83.3
	Haloperidol	92.2	-
	Thiamine	74.5	81.0
Drugs for treating migraine (N = 1)	Sumatriptan	76.5	81.0
Respiratory system (N = 13)			
Nasal decongestants (N = 1)	Xylometazoline (nasal)	88.2	-
Bronchodilators (N = 8)	Beclomethasone (inhalation)	90.2	-
	Budesonide (inhalation)	92.2	-
	Fluticasone (inhalation)	84.3	-

(Continues)

TABLE 2 (Continued)

Drug groups	Drug names	Round 1 (% score 4 or 5)	Round 2 (% score 4 or 5)
Drugs for treating allergies (N = 4)	Formoterol (inhalation)	84.3	-
	Salbutamol (inhalation)	100	-
	Salmeterol (inhalation)	88.2	-
	Ipratropium (inhalation)	98.0	-
	Tiotropium (inhalation)	84.3	-
	Cetirizine	88.2	-
	Clemastine	84.3	-
	Desloratadine	80.4	-
	Levocetirizine	82.4	-

Note: N indicates the number of accepted items per drug group. The route of administration is oral, unless otherwise stated. Other routes of administration include dermal, inhalation, intramuscular (IM), intravenous (IV), rectal, subcutaneous (SC) and sublingual (SL) routes.

made by junior doctors. Used alongside the list of essential diseases and the Dutch National Pharmacotherapy Assessment,^{19,25,26} this list will provide a solid framework for CP&T education in medical curricula in the Netherlands. This will enable students to become acquainted with these drugs in their preclinical years,²⁸ thereby forming a sound basis on which their prescribing skills and knowledge can be developed further during clinical training and clerkships.

Drug formularies can be effective for developing skills in pharmacotherapy in problem-based curricula,²⁹ such as those used in Dutch medical schools.³⁰ Over the years, a number of national formularies have been developed.^{11–14} While many national formularies overlap with regard to the drugs included, there are between-country differences in prescribing practice and regulations. Examples include prescriptions of antibiotics and analgesics.^{31,32} Moreover, these formularies are based mainly on the most frequently prescribed drugs in general, and not on drugs where undergraduate medical education should focus. This might also lead to differences. For example, the ‘core drug list’ in the UK also included secondary, or even tertiary, care drugs (e.g., methotrexate, acetylcholinesterase inhibitors, alteplase).¹¹ This all underlines the need for national formularies focusing on medical education, such as the one proposed here.

The current study used a Delphi approach whereby a panel of experts was asked to evaluate a list of drugs. This list was based on the drugs most frequently prescribed in The Netherlands.²² The panel included both primary and secondary health-care professionals as well as pharmacotherapy teachers. The broad representation of the various medical disciplines (general physician, internist, surgeon, paediatrician, etc.), including the response from all medical universities, ensured a full coverage and proper representation of the field of work of medical graduates. We also included junior doctors because they write the bulk of prescriptions in hospitals.⁵ Almost 50% of the panel participants were either clinical pharmacologists or in training, which would ensure an expert opinion concerning pharmacotherapy. This approach is unique compared to that of other studies in which only a limited number of experts were consulted to reach consensus.¹⁴

Furthermore, in contrast to other lists, the current list includes different formulations of individual drugs. This gives students a concrete idea on the expected learning outcomes and it could also avoid unsupervised prescription of high-risk drugs. The list did not include many intravenously administered formulations, probably because unsupervised prescription of these high-risk drugs was considered inappropriate.

The findings of current study should be interpreted in the light of some limitations. Firstly, the composition of the panel has a strong influence on the outcome of the study. For example, a relatively large number of experts were affiliated to the Amsterdam University Medical Centers, location VUmc. As research on CP&T education is one of the focus points of this centre, participants might have been more intrinsically motivated to fill in the questionnaire. This uneven distribution may affect the reproducibility of the current study. However, this is a drawback of all panel-based studies. Secondly, the number of participants per medical faculty varied greatly and not all faculties provided the minimum of nine participants, nor did all faculties have representatives of the five professions mentioned in the inclusion criteria. Junior doctors or residents in training were well represented in the panel, but this was not the case for general physicians (primary health care). Although a homogeneous distribution is preferred, this is not always possible in studies with volunteers. Thirdly, the questionnaire took a considerable amount of time, which could have affected the attention span of participants and could have led to dropouts. In an attempt to avoid this, participants did not have to complete the questionnaire in one sitting. The high response rate for both rounds (79% and 82%, respectively) supports the idea that the length of the questionnaire was not a problem for most participants.

It is important to mention that two drugs (lidocaine subcutaneous for local anaesthesia and promethazine for motion sickness) were not evaluated in round 2 because of a technical error. Nevertheless, lidocaine in combination with adrenaline (subcutaneous) was evaluated in round 2 and was included in the final list. Similarly, although promethazine was not evaluated for motion sickness in round 2, it was

suggested in round 1 as an anti-allergic drug (Appendix B), but was not included in the final list. Although ranitidine was included in the final list, it has recently been withdrawn from the market and therefore another, currently available, histamine type 2 receptor antagonist (famotidine or cimetidine) could be a suitable alternative.

4.1 | Implications and future direction

In the upcoming year, the current list will be integrated into the undergraduate medical curriculum of Dutch medical faculties, enabling students to become acquainted with the drugs right from their early years of medical training. Prescribing knowledge and skills of these drugs can be educated with the use of the list of essential diseases for prescribing and the Essential Drug Knowledge item list defined by Brinkman and colleagues (e.g., lectures, role-playing workgroups, bed-side teaching).^{19,28} The Dutch National Pharmacotherapy Assessment could be one of the ways to assess students during the clinical years. It is important to bear in mind that the essential drug list is to provide a framework for medical students, not to suppress academic curiosity or to limit medical education solely to the drugs on the list. In the Netherlands, physician assistants and specialist nurses have prescribing powers, and this list could also be used to train these professionals. Similar lists could also be considered for pharmacists, as dispensing errors are not uncommon,³³ as well as for dentists.

Also, other European countries could benefit from this study. Indeed, there are between-country differences in accessibility and guidelines, but on the group level of drugs there is a large overlap. Moreover, this study shows that the Delphi method is a feasible way to reach consensus on a national drug list. However, to perform this in all European countries would require a lot of effort. By using the European Association for Clinical Pharmacology and Therapeutics (EACPT) Network of Teachers in Pharmacotherapy, a European list, with if necessary national adjustments, could be developed.³⁴ This will contribute to the continuity of the path taken by the EACPT (i.e., the Key Learning Outcomes for Clinical Pharmacology and Therapeutics Education, the European Prescribing Exam and the European Open Platform for Prescribing Education).^{20,27,35,36}

Having compiled an essential list of drugs, the question arises about how often the list should be updated. While 'the top-100' drug list in the UK was updated after 6 years, the WHO updates the Model List of Essential Medicines every 2 years. Interestingly, 'the Wise list' in Sweden and 'the core drug list' of the UK are stable over time and show only minimal changes in specific drugs.^{11,37} Nevertheless, a similar study should be performed every 2–3 years to keep up with recent advances in pharmacotherapy. An alternative is the establishment of a reviewing panel of experts from the medical faculties. This panel updates the list, for example, when existing guidelines are updated (e.g., sodium glucose cotransporter 2 inhibitors for diabetes or discovery of new drugs such as biologicals) or drugs are withdrawn (e.g., ranitidine). Although studies show a high adherence of prescribers to drug formularies,³⁷ it is not known whether the use of

formularies leads to fewer prescribing errors. While national studies on drug errors would be the best parameter for this, such studies are usually complicated to perform as they involve multiple stakeholders. Instead, prescriber knowledge and prescribing confidence, both key factors that contribute to prescribing errors,³⁸ could be used as a surrogate marker to measure the effectiveness of educational interventions such as the current one.

5 | CONCLUSION

The current study provides a list of 134 drugs that, according to a panel of experts, medical students and graduates should be able to prescribe safely and effectively without direct supervision. This list provides a lean learning structure and can be used to harmonize and improve pharmacotherapy education in Dutch medical faculties. Moreover, this study shows that a Delphi method is suitable to reach consensus on such a list, and could be used for a European list of essential medicines.

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COMPETING INTERESTS

All authors declare that they had no financial support; no financial relationships with any organizations that might have an interest in the submitted work in the previous three years; J.v.S., M.v.A. and J.T. are member of the Pharmacotherapy Education working group of the Dutch Society for Clinical Pharmacology & Biopharmacy. M.v.A. and J.T. are member of the Education working group of the European Association for Clinical Pharmacology and Therapeutics. There are no other relationships or activities that could appear to have influenced the submitted work.

CONTRIBUTORS

E.D., R.P., M.P., D.B. and J.T. contributed to study design. E.D., R.P., M.P., D.B. and J.T. contributed to data collection and analysis. E.D., R.P., M.P., D.B. and J.T. contributed to writing the report. All authors contributed to data interpretation and approved the final version of the submitted report.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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APPENDIX A. LIST OF DRUGS IN ROUND 1 AND ROUND 2

TABLE A1 List of drugs and dosage forms for rounds 1 ($N = 337$) and 2 ($N = 193$). The number of newly suggested drugs is indicated in brackets and the individual drugs are indicated in bold. The route of administration is oral, unless otherwise stated. Other routes of administration include dermal, inhalation, intramuscular (IM), intravenous (IV), rectal, subcutaneous (SC) and sublingual (SL) routes

Questionnaire round 1	Questionnaire round 2
Alimentary tract and metabolism $N = 45$	$N = 17$ (8)
1. Miconazole	1. Lidocaine (oral gel)
2. Nystatin	3. Nystatin
4. Aluminium hydroxide/magnesium hydroxide	5. Aluminium hydroxide/magnesium hydroxide
6. Esomeprazole (IV)	7. Pantoprazole (IV)
8. Esomeprazole	9. Bisacodyl (rectal)
10. Magnesium hydroxide	11. Erythromycin
12. Misoprostol	13. Macrogol/electrolytes
14. Omeprazole	15. Metoclopramide (IV)
16. Pantoprazole	17. Metoclopramide (rectal)
18. Ranitidine	19. Sodium phosphate (rectal)
20. Atropine (IV)	21. Ondansetron (IV)
22. Bisacodyl	23. Ondansetron (rectal)
24. Bisacodyl (rectal)	25. Psyllium seed
26. Butylscopolamine	27. Insulin degludec (SC)
28. Domperidone	29. Insulin glargine (SC)
30. Lactulose	31. Semaglutide (SC)
32. Loperamide	33. Tolbutamide
34. Macrogol	
35. Mebeverine	
36. Metoclopramide (IV)	
37. Metoclopramide	
38. Metoclopramide (rectal)	
39. Ondansetron (IV)	
40. Ondansetron	
41. Ondansetron (rectal)	
42. Oral rehydration solution	
43. Psyllium seed	
44. Acarbose	
45. Canagliflozin	
46. Empagliflozin	
47. Exenatide (SC)	
48. Gliclazide	
49. Glimepiride	
50. Glucagon (IM)	
51. Glucose solution (IV)	
52. Insulin (SC)	
53. Insulin aspart (SC)	
54. Insulin aspart/insulin aspart protamine (SC)	
55. Insulin glargine (SC)	
56. Linagliptin	

TABLE A1 (Continued)

Questionnaire round 1	Questionnaire round 2
57. Liraglutide (SC)	
58. Metformin	
59. Pioglitazone	
60. Repaglinide	
61. Sitagliptin	
Blood and blood forming organs N = 31	N = 16 (5)
62. Acenocoumarol	63. Dipyridamole
64. Acetylsalicylic acid (IV)	65. Edoxaban
66. Acetylsalicylic acid	67. Enoxaparin (SC)
68. Apixaban	69. Phytomenadione
70. Carbasalate calcium	71. Heparin (iv)
72. Clopidogrel	73. Prasugrel
74. Dabigatran	75. Ticagrelor
76. Dipyridamole	77. Cyanocobalamin
78. Enoxaparin (SC)	79. Hydroxocobalamin (IM)
80. Phenprocoumon	81. Hydroxocobalamin (SC)
82. Fondaparinux (IV)	83. Glucose 5% (IV)
84. Fondaparinux (SC)	85. Glucose 10% (IV)
86. Phytomenadione (IV)	87. Sodium chloride 0.45% + glucose 2.5% (IV)
88. Phytomenadione	89. Sodium chloride solution 3% (IV)
90. Heparin (IV)	91. Sodium bicarbonate (IV)
92. Nadroparin (SC)	93. Ringer's lactate solution (IV)
94. Prasugrel	
95. Protamine (IV)	
96. Prothrombin complex (IV)	
97. Rivaroxaban	
98. Ticagrelor	
99. Tranexamic acid (IV)	
100. Tranexamic acid	
101. Ferrous fumarate	
102. Folic acid	
103. Hydroxocobalamin (IM)	
104. Hydroxocobalamin (SC)	
105. Sodium chloride 0.45% + glucose 2.5% (i.v.)	
106. Sodium chloride solution 0.9% (IV)	
107. Sodium chloride solution 3% (IV)	
108. Ringer's lactate solution (IV)	
Cardiovascular system N = 53	N = 24 (3)
109. Amiodarone (IV)	110. Adrenaline pen (IM)
111. Amiodarone	112. Amiodarone
113. Digoxin (IV)	114. Digoxin
115. Digoxin	116. Epinephrine (IM)
117. Epinephrine (IM)	118. Barnidipine
119. Flecainide	120. Bisoprolol
121. Amlodipine	122. Bumetanide (IV)
123. Atenolol	124. Candesartan

(Continues)

TABLE A1 (Continued)

Questionnaire round 1	Questionnaire round 2
125. Barnidipine	126. Chlorthalidone
127. Bisoprolol	128. Diltiazem
129. Bumetanide (IV)	130. Eplerenone
131. Bumetanide	132. Fosinopril
133. Candesartan	134. Furosemide (IM)
135. Chlorthalidone	136. Furosemide (IV)
137. Diltiazem	138. Irbesartan
139. Enalapril	140. Isosorbide dinitrate
141. Fosinopril	142. Potassium chloride (IV)
143. Furosemide (IV)	144. Potassium chloride
145. Furosemide	146. Labetalol
147. Hydrochlorothiazide	148. Ramipril
149. Irbesartan	150. Sotalol
151. Isosorbide dinitrate	152. Verapamil
153. Isosorbide dinitrate (SL)	154. Ezetimib
155. Isosorbide mononitrate	156. Pravastatin
157. Potassium chloride (IV)	
158. Potassium chloride	
159. Labetalol (IV)	
160. Labetalol	
161. Lercanidipine	
162. Lisinopril	
163. Losartan	
164. Methyl dopa	
165. Metoprolol (IV)	
166. Metoprolol	
167. Nicardipine (IV)	
168. Nifedipine	
169. Nitroglycerin (SL)	
170. Perindopril	
171. Propranolol	
172. Ramipril	
173. Sotalol	
174. Spironolactone	
175. Valsartan	
176. Verapamil (IV)	
177. Verapamil	
178. Atorvastatin	
179. Cholestyramine	
180. Evolocumab (SC)	
181. Ezetimibe	
182. Gemfibrozil	
183. Pravastatin	
184. Rosuvastatin	
185. Simvastatin	

TABLE A1 (Continued)

Questionnaire round 1	Questionnaire round 2
Dermatologicals N = 12	N = 10 (4)
186. Emollientia (e.g., cremor vaselini cetomacrogolis) (dermal)	187. Emollientia (e.g., cremor vaselini cetomacrogolis) (dermal)
188. Lidocaine cream (dermal)	189. Isosorbide dinitrate cream (dermal)
190. Menthol in hydrophilic cream (dermal)	191. Lidocaine cream (dermal)
192. Soft paraffin and fat products (dermal)	193. Menthol in hydrophilic cream (dermal)
194. Zinc oxide (dermal)	195. Betamethasone (dermal)
196. Betamethasone (dermal)	197. Clotrimazole cream (dermal)
198. Clobetasol (dermal)	199. Ketoconazol cream (dermal)
200. Fusidic acid (dermal)	201. Mometasone (dermal)
202. Hydrocortisone (dermal)	203. Triamcinolone acetonide (dermal)
204. Miconazole (dermal)	205. Silver sulfadiazine cream (dermal)
206. Mometasone (dermal)	
207. Triamcinolone acetonide (dermal)	
Genito urinary system and sex hormones N = 13	N = 11 (4)
208. Clotrimazole (dermal)	209. Clotrimazole (dermal)
210. Miconazole (mucosal)	211. Desogestrel
212. Desogestrel	213. Intra-uterine device (IUD) met progestins
214. Ethinyl oestradiol/levonorgestrel	215. Levonorgestrel
216. Etonogestrel (SC)	217. Ethinyl oestradiol/etonogestrel (vaginal use)
218. Intra-uterine device (IUD) met progestins	219. Dutasteride
220. Levonorgestrel	221. Finasteride
222. Medroxyprogesterone (SC)	223. Tadalafil
224. Finasteride	225. Tolterodine
226. Oxybutynin	227. Oxybutynin
228. Sildenafil	229. Sildenafil
230. Solifenacin	
231. Tamsulosin	
Systemic hormonal preparations excluding sex steroids N = 9	N = 9 (5)
232. Betamethasone (IV)	233. Betamethasone
234. Betamethasone	235. Dexamethasone (IM)
236. Dexamethasone (IV)	237. Dexamethasone (IV)
238. Dexamethasone	239. Hydrocortisone (IV)
240. Hydrocortisone (IV)	241. Methylprednisolone (intra articular)
242. Hydrocortisone	243. Prednisolone (IM)
244. Prednisolone (IV)	245. Prednisolone (IV)
246. Prednisolone	247. Triamcinolone hexacetonide (IM)
248. Levothyroxine	249. Thiamazole
Antiinfective for systemic use N = 60	N = 31 (14)
250. Amoxicillin (IV)	251. Amoxicillin (IV)
252. Amoxicillin	253. Amoxicillin/clavulanic acid (IV)
254. Amoxicillin/clavulanic acid (IV)	255. Ceftriaxone (IV)
256. Amoxicilline/clavulanic acid	257. Cefuroxime (IV)
258. Azitromycin (IV)	259. Ciprofloxacin (IV)
260. Azitromycin	261. Clindamycin (IV)
262. Cefaclor	263. Cotrimoxazole (IV)
264. Cephalixin	265. Erytromycin

(Continues)

TABLE A1 (Continued)

Questionnaire round 1	Questionnaire round 2
266. Cefazolin (IM)	267. Pheneticillin
268. Cefazolin (IV)	269. Flucloxacillin (IV)
270. Cefotaxime (IM)	271. Fosfomycin
272. Cefotaxime (IV)	273. Fusidic acid
274. Ceftaroline fosamil (IV)	275. Gentamycin (IV)
276. Ceftazidime (IM)	277. Meropenem (IV)
278. Ceftazidime (IV)	279. Vancomycin (IV)
280. Ceftazidime/avibactam (IV)	281. Vancomycine
282. Ceftibuten	283. Itraconazol
284. Ceftolozane/tazobactam (IV)	285. Posaconazole
286. Ceftriaxone (IM)	287. Voriconazole
288. Ceftriaxone (IV)	289. Voriconazole (IV)
290. Cefuroxime (IM)	291. Ganciclovir (IV)
292. Cefuroxime (IV)	293. Valacyclovir
294. Cefuroxime axetil	295. Valganciclovir
296. Ciprofloxacin (IV)	297. Mumps/measles/rubella vaccine (IM)
298. Ciprofloxacin	299. Covid-19 mrna vaccine (IM)
300. Clarithromycin (IV)	301. Papillomavirus vaccine (IM)
302. Clarithromycin	303. Pneumococcal vaccine (IM)
304. Clindamycin (IV)	305. Tetanus toxoid (IM)
306. Clindamycin	307. Artesunate (IV)
308. Cotrimoxazole (IV)	309. Artemether/lumefantrine
310. Cotrimoxazole	311. Terbinafine
312. Doxycycline	
313. Erythromycin (IV)	
314. Erythromycin	
315. Pheneticillin (IV)	
316. Pheneticillin	
317. Flucloxacillin (IV)	
318. Flucloxacillin	
319. Fosfomycin	
320. Fusidic acid	
321. Gentamycin (IV)	
322. Meropenem (IV)	
323. Nitrofurantoin	
324. Rifampicin (IV)	
325. Rifampicin	
326. Trimethoprim	
327. Vancomycin (IV)	
328. Fluconazole (IV)	
329. Fluconazole	
330. Acyclovir (IV)	
331. Acyclovir	
332. Oseltamivir	
333. Valacyclovir	
334. Influenza vaccine (IM)	

TABLE A1 (Continued)

Questionnaire round 1	Questionnaire round 2
335. Tetanus immunoglobulin (IM)	
336. Tetanus toxoid (IM)	
337. Atovaquone/proguanil	
338. Mefloquine	
339. Metronidazole (IV)	
340. Metronidazole	
Antineoplasia and immunomodulatory agents N = 4	N = 1
341. Methotrexate (IM)	342. Methotrexate
343. Methotrexate (IV)	
344. Methotrexate	
345. Methotrexate (SC)	
Musculoskeletal system N = 31	N = 20 (8)
346. Acetylcysteine (IV)	347. Acetylcysteine (IV)
348. Allopurinol	349. Buprenorphine (IV)
350. Colchicine	351. Buprenorphine (oro-mucosal)
352. Diclofenac (IV)	353. Buprenorphine (transdermal)
354. Diclofenac	355. Diclofenac (IM)
356. Fentanyl (dermal)	357. Diclofenac (IV)
358. Fentanyl (IV)	359. Diclofenac (rectal)
360. Fentanyl (nasal)	361. Fentanyl (nasal)
362. Fentanyl	363. Fentanyl
364. Fentanyl (SL)	365. Fentanyl (SL)
366. Ibuprofen	367. Metamizole (IV)
368. Morphine	369. Morphine (SC)
370. Morphine (SC)	371. Naloxone (IV)
372. Naloxone (IV)	373. Oxycodone (SC)
374. Naproxen	375. Acetaminophen (IV)
376. Oxycodone	377. Tramadol (rectal)
378. Oxycodone (SC)	379. Diclofenac (dermal)
380. Acetaminophen (IV)	381. Ibuprofen (dermal)
382. Acetaminophen	383. Risedronic acid
384. Acetaminophen (rectal)	385. Zoledronic acid (IV)
386. Pyramidal (SC)	
387. Tramadol	
388. Tramadol (rectaal)	
389. Diclofenac (dermal)	
390. Ibuprofen (dermal)	
391. Alendronic acid	
392. Calcium with vitamin D	
393. Cholecalciferol	
394. Denosumab (SC)	
395. Oestradiol	
396. Risedronic acid	
Nervous system N = 44	N = 37 (11)
397. Lidocaine (SC)	398. Lidocaine/adrenaline (SC)
399. Lidocaine/adrenaline (SC)	400. Carbamazepine

(Continues)

TABLE A1 (Continued)

Questionnaire round 1	Questionnaire round 2
401. Levetiracetam (IV)	402. Clonazepam
403. Levetiracetam	404. Phenytoine
405. Pregabalin (IV)	406. Lamotrigine
407. Pregabalin	408. Levetiracetam
409. Valproic acid (IV)	410. Pregabalin
411. Valproic acid	412. Valproic acid
413. Amitriptyline	414. Clozapine
415. Citalopram	416. Diazepam (rectal)
417. Clomipramine	418. Escitalopram
419. Clozapine	420. Fluoxetine
421. Diazepam	422. Haloperidol (IM)
423. Diazepam (rectal)	424. Haloperidol (IV)
425. Escitalopram	426. Lorazepam (IM)
427. Flumazenil (IV)	428. Methylphenidate
429. Fluoxetine	430. Midazolam (IV)
431. Haloperidol (IV)	432. Midazolam
433. Haloperidol	434. Midazolam (nasal spray)
435. Lithium	436. Mirtazapine
437. Lorazepam (IM)	438. Nortriptyline
439. Lorazepam (IV)	440. Olanzapine
441. Lorazepam	442. Paroxetine
443. Midazolam (IV)	444. Quetiapine
445. Midazolam	446. Risperidone
447. Mirtazapine	448. Sertraline
449. Nortriptyline	450. Thiamine (IV)
451. Olanzapine	452. Thiamine
453. Oxazepam	454. Venlafaxine
455. Paroxetine	456. Zopiclon
457. Quetiapine	458. Zolpidem
459. Risperidon (IM)	460. Propranolol
461. Risperidon	462. Rizatriptan
463. Sertraline	464. Sumatriptan (nasal)
465. Temazepam	466. Sumatriptan
467. Thiamine (vitamin B1) (IV)	468. Cinnarizine
469. Thiamine (vitamin B1)	470. Varenicline
471. Venlafaxine	
472. Zolpidem	
473. Sumatriptan (nasaal)	
474. Sumatriptan	
475. Sumatriptan (SC)	
476. Cinnarizine	
477. Promethazine	
Respiratory system N = 23	N = 10 (3)
478. Beclometasone (nasal)	479. Beclometasone (nasal)
480. Budesonide (nasal)	481. Budesonide (nasal)
482. Fluticasone furoate (nasal)	483. Fluticasone furoate (nasal)

TABLE A1 (Continued)

Questionnaire round 1	Questionnaire round 2
484. Levocabastine (nasal)	485. Ciclesonide (inhalation)
486. Mometasone (nasal)	487. Glycopyrronium (inhalation)
488. Xylometazoline (nasal)	489. Clemastine (IM)
490. Beclometasone (inhalation)	491. Clemastine (IV)
492. Budesonide (inhalation)	493. Codeine
494. Ciclesonide (inhalation)	495. Loratidine
496. Fluticasone (inhalation)	497. Promethazine
498. Formoterol (inhalation)	
499. Ipratropium (inhalation)	
500. Salbutamol (inhalation)	
501. Salmeterol (inhalation)	
502. Tiotropium (inhalation)	
503. Cetirizine	
504. Clemastine (IV)	
505. Clemastine	
506. Codeine	
507. Desloratidine	
508. Levocetirizine	
509. Loratidine	
510. Meclozine	
Sensory system N = 12	N = 7 (2)
511. Chloramphenicol (ocular)	512. Atropine (ocular)
513. Dexamethasone (ocular)	514. Chloramphenicol (ocular)
515. Erythromycin (ocular)	516. Dextran/hypromellose (ocular)
517. Fusidic acid (ocular)	518. Fusidic acid (ocular)
519. Levocabastine (ocular)	520. Hydrocortisone/acetic acid (ear)
521. Prednisolone (ocular)	522. Miconazole (ear)
523. Trimethoprim/polymyxin B (ocular)	524. Triamcinolone/acetic acid (ear)
525. Aluminium acetotarrate (ear)	
526. Hydrocortisone/acetic acid (ear)	
527. Miconazol (ear)	
528. Ofloxacin (ear)	
529. Triamcinolone/acetic acid (ear)	

APPENDIX B. FINAL LIST

TABLE B1 The route of administration is oral, unless otherwise stated. Other routes of administration include rectal, inhalation, subcutaneous (SC), intramuscular (IM), intravenous (IV) and sublingual (SL) routes

Drug groups	Drug names
Alimentary tract and metabolism	N = 26
Drugs for intestinal infections and inflammations (N = 2)	Miconazole, nystatin
Drugs for treating acid-related disorders (N = 5)	Esomeprazole, omeprazole, pantoprazole, ranitidine, magnesium hydroxide
Drugs affecting gastrointestinal motility (N = 10)	Bisacodyl, macrogol, macrogol/electrolytes, psyllium seed, lactulose, loperamide, metoclopramide, domperidone, ondansetron, oral rehydration solution
Drugs used in diabetes (N = 9)	Gliclazide, glimepiride, metformin, insulin (SC), insulin aspart (SC), insulin aspart/insulin aspart protamine (SC), insulin glargine (SC), glucose solution (IV), glucagon (IM)
Blood and blood forming organs	N = 12
Drugs affecting blood platelets or coagulation (N = 9)	Acetylsalicylic acid, carbasalate calcium, clopidogrel acenocoumarol, phenprocoumon, apixaban, dabigatran, rivaroxaban, nadroparin (SC)
Drugs for treating anaemia (N = 2)	Ferrous fumarate, folic acid
Intravenous fluids (N = 1)	Sodium chloride solution 0.9% (IV)
Cardiovascular system	N = 25
Drugs affecting cardiac contractility (N = 1)	Adrenaline pen (IM)
Drugs for high blood pressure (N = 20)	Amlodipine, nifedipine, atenolol, metoprolol, propranolol, bumetanide, furosemide (IV), furosemide, spironolactone, enalapril, lisinopril, perindopril, hydrochlorothiazide, isosorbide dinitrate, isosorbide dinitrate (SL), isosorbide mononitrate, potassium chloride, losartan, valsartan, nitroglycerine (SL)
Drugs for treating dyslipidaemia (N = 4)	Atorvastatin, pravastatin, rosuvastatin, simvastatin
Dermatologicals	N = 5
Creams and ointments (N = 2)	Soft paraffin and fat products (dermal), zinc oxide (dermal)
Antimicrobial drugs and steroids (N = 3)	Fusidic acid (dermal), hydrocortisone (dermal), miconazole (dermal)
Genitourinary system and sex hormones	N = 3
Drugs for treating vaginal infections (N = 1)	Miconazole (mucosal)
Drugs affecting reproductive function (N = 1)	Ethinyl oestradiol/levonorgestrel
Drugs for treating benign prostate hyperplasia (N = 1)	Tamsulosin
Systemic hormonal preparations excluding sex steroids	N = 4
Corticosteroids for systemic use (N = 3)	Dexamethasone, hydrocortisone, prednisolone
Drugs for treating thyroid disorders (N = 1)	Levothyroxine
Anti-infective for systemic use	N = 19
Antibacterial drugs (N = 13)	Amoxicillin, amoxicillin (IV), amoxicillin/clavulanic acid amoxicillin/clavulanic acid (IV), flucloxacillin, azithromycin, clarithromycin, ciprofloxacin, clindamycin, nitrofurantoin, cotrimoxazole, trimethoprim, doxycycline
Antifungal drugs (N = 1)	Fluconazole
Antiviral drugs (N = 1)	Aciclovir
Vaccines and immunoglobulins (N = 3)	Influenza vaccine (IM), tetanus immunoglobulin (IM), tetanus toxoid (IM)
Antiprotozoal drugs (N = 1)	Metronidazole
Musculoskeletal system	N = 15
Drugs used for pain management including treatment of gout (N = 12)	Allopurinol, colchicine, diclofenac, ibuprofen, naproxen, fentanyl (dermal), morphine, morphine (SC), oxycodone, tramadol, acetaminophen, acetaminophen (rectal)
Drugs affecting bone homeostasis (N = 3)	Alendronic acid, calcium with vitamin D, cholecalciferol

TABLE B1 (Continued)

Drug groups	Drug names
Nervous system	N = 12
Local anaesthetics (N = 1)	Lidocaine/adrenaline (SC)
Drugs for treating depression, anxiety disorders, psychosis and addiction (N = 10)	Amitriptyline, citalopram, diazepam, diazepam (rectal), lorazepam, oxazepam, temazepam, zolpidem, haloperidol, thiamine
Drugs for treating migraine (N = 1)	Sumatriptan
Respiratory system	N = 13
Nasal decongestants (N = 1)	Xylometazoline (nasal)
Bronchodilators (N = 8)	Beclomethasone (inhalation), budesonide (inhalation), fluticasone (inhalation), formoterol (inhalation), salbutamol (inhalation), salmeterol (inhalation), ipratropium (inhalation), tiotropium (inhalation)
Drugs for treating allergies (N = 4)	Cetirizine, clemastine, desloratidine, levocetirizine