Received: 11 January 2021 | Revised: 8 February 2021 | Accepted: 13 February 2021

DOI: 10.1111/bcp.14786

ORIGINAL ARTICLE

The Oxford Catalogue of Opioids: A systematic synthesis of opioid drug names and their pharmacology

Georgia C. Richards[1] | Konrad Sitkowski[2] | Carl Heneghan[1] | Jeffrey K. Aronson[1]

[1]Centre for Evidence-Based Medicine, Nuffield Department of Primary Care Health Sciences, University of Oxford, Radcliffe Observatory Quarter, Woodstock Road, Oxford, OX2 6GG, UK

[2]Oxford Medical School, John Radcliffe Hospital, University of Oxford, Oxford, OX3 9DU, UK

Correspondence
Georgia C. Richards, Centre for Evidence-Based Medicine, Nuffield Department of Primary Care Health Sciences, University of Oxford, Radcliffe Observatory Quarter, Woodstock Road. Oxford, OX2 6GG, UK.
Email: georgia.richards@kellogg.ox.ac.uk

Aim: The growing demand for analgesia, coupled with an increasing need to treat opioid dependence and overdose, has escalated the development of novel opioids. We aimed to quantify the number of opioid drugs developed and to catalogue them based on their pharmacology.

Methods: We conducted a systematic search of seven sources in November 2020, including the WHO's Anatomical Therapeutic Classification index, the British National Formulary, the IUPHAR/BPS Guide to Pharmacology, the International Narcotics Control Board Index of Names of Narcotic Drugs, the WHO's International Nonproprietary Names MedNet service, Martindale's Extra Pharmacopoeia and the Merck Index, to include opioid drugs that targeted or had an effect or coeffect at one or more opioid receptors. We extracted chemical and nonproprietary names, drug stems, molecular formulas, molecular weights, receptor targets, actions at opioid receptors and classes based on their origins. We used descriptive statistics and calculated medians and interquartile ranges where appropriate.

Results: We identified 233 opioid drugs and created an online resource (https://www.catalogueofopioids.net/). There were 10 unique drug stems, and "-fentanil" accounted for one-fifth (20%) of all opioids. Most of the drugs (n = 133) targeted mu-opioid receptors and the majority (n = 191) were agonists at one or more receptors. Most (82%) were synthetic opioids, followed by semisynthetic opioids (16%) and alkaloids (3%).

Conclusion: This catalogue centralizes and disseminates information that could assist researchers, prescribers and the public to improve the safe use of opioids.

KEYWORDS
catalogue of drugs, drug indexes, drug lists, narcotics, opiates, opioids

1 | INTRODUCTION

In most high-income countries, prescribing of opioids has increased,[1–3] with corresponding increases in opioid dependence, addiction and overdose.[4,5] The growing demand for analgesia, coupled with the need to treat and manage opioid dependence and overdose, has incentivized the development of new and potentially less addictive formulations of opioids and alternatives.[6–8] Some estimate that

[Correction added on 30 April 2021, after first online publication: The copyright line was changed in this current version.]

thousands of opioids have been synthesized and investigated for their various analgesic, antidiarrheal, antitussive and dependence-producing properties,[9] but the number of opioids is unknown and there is no central repository that comprehensively catalogues their names, types and pharmacological effects.

The increased use and development of opioids may not be reflected in the confidence of prescribers or the knowledge of the public. Studies in primary care have shown that providers often report inadequate training of opioid prescribing for chronic noncancer pain.[10–12] Others have found that poor public knowledge of opioids is a barrier in observational research and may drive over- and under-reporting of opioid use and misuse.[13,14] How a drug is named and classified determines how it is used, and thus misnaming a drug or a lack of knowledge of such names can cause confusion.[15] A catalogue of opioid drug names and their pharmacology could help bridge the public's knowledge gap, aid prescribers when choosing an opioid and centralize information for those developing the next generation of opioids and their alternatives.

What is already known about this subject

- Opioids are widely used for analgesic, antidiarrheal and antitussive effects or for recreational use.
- The many opioids that have been developed have varying pharmacological properties.

What this study adds

- We identified 233 unique opioids from searching seven data sources and the published literature.
- We have created a resource detailing variations in opioid nomenclature, receptor targets and actions.
- This catalogue improves access to information for prescribers, regulators, researchers and the public.

TABLE 1 A brief timeline of selected drug nomenclatures, classification systems and indexes

Year	Event
1618	London Pharmacopoeia first published
1820	United States Pharmacopoeia first published
1864	British Pharmacopoeia first published (merging the London, Edinburgh and Dublin Pharmacopoeias)
1883	Martindale's Extra Pharmacopoeia first published
1886	Japanese Pharmacopoeia first published
1889	The Merck Index first published
1907	British Pharmaceutical Codex first published
1919	IUPAC established
1949	The BNF first published
1951	The International Pharmacopoeia first published
1953	The first list of INNs for pharmaceutical substances published and becomes operational
	The Pharmacopoeia of the People's Republic of China first published
	The BAN system created
1961	USAN council began
1969	European Pharmacopoeia first published
1977	WHO publishes the first model list of essential medicines
1981	The ATC/DDD index recommended by WHO as the international standard for drug utilization studies
1996	Dictionary of pharmacological agents first published
1999	Concise dictionary of pharmacological agents first published
2003	IUPHAR & BPS develop the Guide to PHARMACOLOGY

ATC, Anatomical Therapeutic Classification; BAN, British Approved Name; BNF, British National Formulary; BPS, British Pharmacological Society; DDD, defined daily dose; INN, International Nonproprietary Names; IUPAC, International Union of Pure and Applied Chemistry; IUPHAR, International Union of Basic and Clinical Pharmacology; USAN, United States Adopted Name; WHO, World Health Organization.

Several organizations and authorities have developed systems to name, classify and index drugs (see Table 1). City pharmacopoeias were the first to standardize and publish drug names, typically with information on available formulations that included opium. These were unified into national pharmacopoeias, such as the British Pharmacopoeia, followed by national formularies, such as the British National Formulary (BNF), and international pharmacopoeias. Drug nomenclature systems followed, including chemical names (eg, the International Union of Pure and Applied Chemistry [IUPAC] names), nonproprietary or generic names (eg, International Nonproprietary Names [INNs]) and manufacturers' proprietary or brand names. Drug indexes and classification systems followed, including the World Health Organization (WHO) Anatomical Therapeutic Classification (ATC) index and the International Union of Basic and Clinical Pharmacology/British Pharmacological Society (IUPHAR/BPS) Guide to Pharmacology.

The ubiquitous use and increased development of opioids, and the volume of naming and classification systems, highlight the need for a centralized resource. The aim of this study was therefore to systematically search relevant databases, to quantify the number of opioid drugs developed, to create a robust list of opioid drug names and to catalogue the opioids based on their pharmacological properties.

2 | METHODS

We designed and conducted a systematic synthesis of online pharmacology databases and used pharmacological onomastics.[15] The study involved three phases, as displayed in Figure 1: development of the list of opioid drugs, cataloguing the drugs based on their pharmacology and development of an online resource. Here we focus on phases one and two.

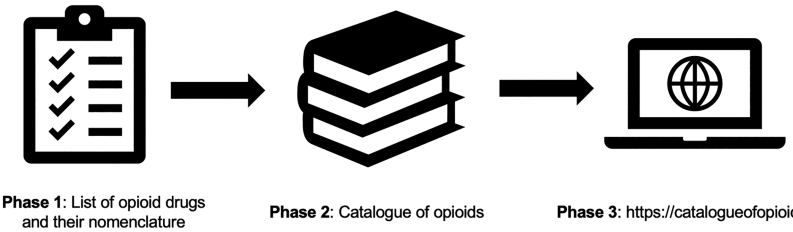

FIGURE 1 Three phases of research to develop the Oxford Catalogue of Opioids. This article outlines phases one and two, which develop the list of opioid drugs and catalogue the drugs based on their pharmacology

2.1 | Search strategy and eligibility criteria

Two study authors independently searched seven data sources across two time periods, first in January 2019 (GCR & JKA) and again in November 2020 (GCR & KS). The seven sources were the WHO's ATC index,[16] the BNF,[17] the IUPHAR/BPS Guide to Pharmacology,[18] the International Narcotics Control Board (INCB) Index of Names of Narcotic Drugs,[19] the WHO's MedNet service for INNs,[20] Martindale's Extra Pharmacopoeia[21] and the Merck Index.[22] We used "opioid", "opiate" and "narcotic" as search terms, as well as stems of common opioids to identify derivatives such as "-fentanyl" and "-orphine". We included opioids if they were defined as medicaments and targeted or had an effect or coeffect at one or more opioid receptors, including **mu** (MOP), **delta** (DOP), or **kappa** (KOP) receptors, or the **nociceptin receptor** (NOP). We excluded medicaments that did not have an IUPAC name. Endogenous opioids or opioids that were metabolites, peptides, intermediates or analogues, or raw opioid-related materials were also excluded from the list unless they were synthesized as medicaments. During the second search (GCR and KS) we consulted an experienced clinical pharmacologist (JKA) when the eligibility criteria for inclusion or exclusion were unclear.

2.2 | Phase 1: List of opioid drugs

Following each of the searches, one study author (GCR) combined the lists of opioids, compared the included drugs, and removed duplicates. We did not perform a formal systematic search of databases containing published literature (eg, MEDLINE) and the wider web. However, from reading reviews and studies on opioid pharmacology and searching the web to confirm the opioid status of drugs for inclusion, we identified and added novel opioids to the list from the published literature and Wikipedia[23] if they had not been identified in the seven databases. For each drug, the database that included the drug and the chemical name (IUPAC from PubChem[24]) and nonproprietary names (BANs, USANs and INNs from the WHO's MedNet service[20]) was extracted into a Google Sheet and ordered alphabetically. We used nonproprietary names as index names for the catalogue. If no INN was available, the BAN or the name reported in the BNF was selected, otherwise the next most familiar name was used. For example, diacetylmorphine (heroin) does not have an INN but is listed as diamorphine in the BNF, so this was selected as the index name. The stem of each opioid (suffix or prefix), defined using the WHO's Stem Book 2018,[25] was used to group drugs and to calculate the percentage occurrence for each group. Medians and IQRs were calculated where appropriate.

2.3 | Phase two: The cataloguing of opioids by pharmacological properties

One study author (KS) extracted pharmacological data into a Google Sheet for each opioid in the list, including the molecular formula, molecular weight (g/mol), receptor targets (ie, MOP, DOP, KOP or NOP), actions at opioid receptors (ie, agonist, partial agonist and antagonist, or mixed), and class based on their origin of discovery or development (ie, alkaloids, semisynthetic or synthetic). Each drug name was searched for in PubChem, the IUPHAR/BPS Guide to Pharmacology, the published literature (via PubMed) and Google when necessary to extract the pharmacological data for phase two. Descriptive statistics were used, and medians and IQRs were calculated where appropriate. We used WIX.com to create the website that hosts the database.

We have not included inverse agonism, since the phenomenon often depends on the effect of an opioid on receptors in different states. Neutral antagonists and weak partial agonists can act as inverse agonists after treatment with an agonist.[26] For example, **naloxone** can act as an inverse agonist after treatment with morphine[27]; in vitro, **GSK1521498** behaves as an inverse agonist when the MOP receptor is overexpressed, but behaves as an antagonist at low receptor levels.[28]

2.4 | Statistical software and open science practices

We registered our study protocol on the Open Science Framework (OSF),[30] and share all data, code and figures openly at GitHub,[31] which is also shared openly via our OSF project page.[32] We used pandas,[33] seaborn[34] and matplotlib[35] modules in Jupyter Notebooks, with Python v3 for analysis and to create figures.

2.5 | Nomenclature of targets and ligands

Key protein targets and ligands in this article are hyperlinked to corresponding entries in http://www.guidetopharmacology.org, the common portal for data from the IUPHAR/BPS guide to PHARMACOLOGY, and are permanently archived in the Concise Guide to PHARMACOLOGY.[29]

3 | RESULTS

We identified 233 unique opioids from seven data sources, the literature and Wikipedia (Figure 2). The WHO MedNet database of INNs contained the most (73%), followed by the INCB report (52%), the Merck Index (47%), Martindale (29%), the Guide to Pharmacology (28%), the ATC index (24%) and the BNF (13%) (Figure A1). The sources contained a median of 68 opioids (IQR 61-115) and each drug was identified in a median of two data sources (IQR 1 to 4 sources). There were 10 unique drug stems, "-fentanil" (20%) being the most common (Table 2 and Figure A2). All drugs had an IUPAC name and 27% of drugs did not have an INN. The complete list of 233 drugs in the Oxford Catalogue of Opioids, their chemical names and the data sources in which the drugs were identified are presented in Table A1.

3.1 | Cataloguing opioids by their pharmacological properties

The opioids had a median molecular weight of 348 g/mol (IQR 299-393). There was a large amount of missing data for the receptor targets and the effects at opioid receptors (Table 3). Most drugs

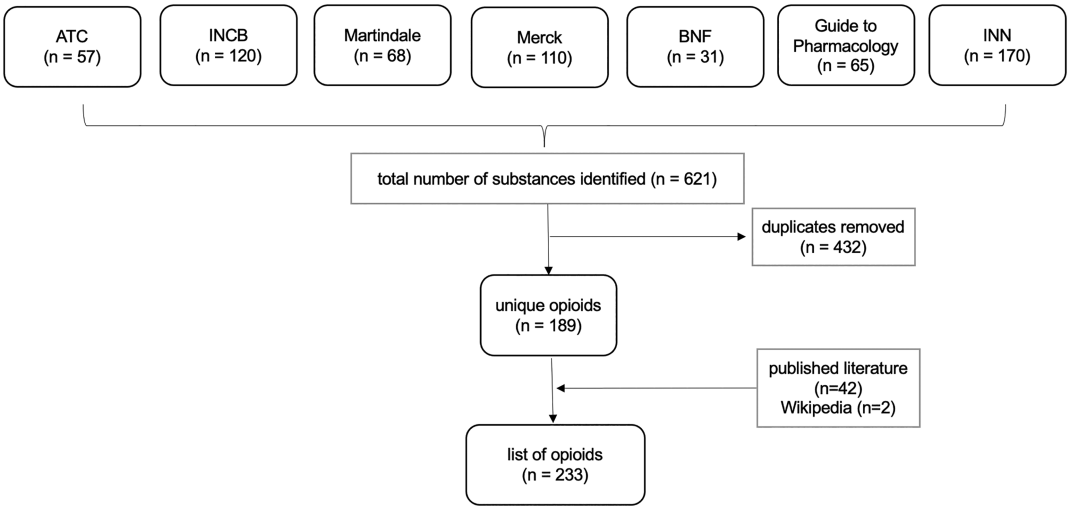

FIGURE 2 Flow diagram of the searches conducted in phase one to identify drugs for inclusion in the Oxford Catalogue of Opioids

TABLE 2 The 10 stems of the drugs in the Oxford Catalogue of Opioids according to the WHO's Stem Book 2018

WHO stem[a]	Description	Frequency (%)	Examples
-adol or -adol-	Analgesics	25 (10.7)	Acetylmethadol
-azocine	Narcotic antagonists/agonists related to 6,7-benzomorphan	18 (7.7)	Anazocine
-eridine	Pethidine derivatives	12 (5.2)	Carperidine
-ethidine	Pethidine and derivatives	4 (1.7)	Benzethidine
-fentanil[b]	Opioid receptor agonists, analgesics, fentanyl derivatives	47 (20.2)	Alfentanil
nal- or -nal-	Opioid receptor antagonists/agonists related to normorphine	14 (6.0)	Methylnaltrexone
-orphan/ol	Opioid receptor antagonists/agonists, morphinan derivatives	13 (5.6)	Butorphanol
-orphine	Opioid receptor antagonists/agonists, morphinan derivatives	20 (8.6)	Acetorphine
-orphinol	Opioid receptor antagonists/agonists, morphinan derivatives	1 (0.4)	Hydromorphinol
-orphone	Opioid receptor antagonists/agonists, morphinan derivatives	5 (2.1)	Oxymorphone
No stems	…	74 (31.8)	Alphaprodine; clonitazene

[a]Since compiling this table we identified an 11th stem, -opran (e.g., axelopran).
[b]The stem -fentanil includes novel analogues which do not have INNs.

TABLE 3 Opioid receptor targets and their effects at opioid receptors for the 233 drugs in the Oxford Catalogue of Opioids

Receptors	N[a] (%)	Agonist	Partial agonist	Antagonist	Mixed	Total[b]
MOP	140 (60)	103	8	18	4	**133**
DOP	84 (36)	40	3	16	1	**60**
KOP	84 (36)	45	8	15	1	**69**
NOP	10 (4)	3	1	-	-	**4**
	Total (%)	**191 (82)**	**20 (8.6)**	**49 (21)**	**6 (3)**	

[a]Available data for all 233 opioids.
[b]Some drugs affect more than one receptor, hence total is greater than 233.
Abbreviations: DOP, delta-opioid; KOP, kappa-opioid; NOP, nociception; MOP: mu-opioid.

targeted MOP receptors (n = 133) and were agonists (n = 191) at one or more receptors. Seven naturally occurring alkaloids accounted for 3% of all opioids: codeine, morphine, narceine, **noscapine**, oripavine, paraveretum and thebaine. Most of the drugs (82%, 190 of 233) were synthetic opioids and 15.5% were semisynthetic opioids (36 of 233). We have created an online resource (https://www.catalogueofopioids.net/) that displays this information and will be updated as phase three progresses.

4 | DISCUSSION

We identified 233 unique opioid drugs from seven sources and created an online resource at https://www.catalogueofopioids.net/. There were variations in the numbers of opioids identified from each source; the WHO's MedNet service of INNs included the most drugs and the BNF the fewest. This variation can be attributed to the type and purpose of each source. There were 10 unique drug stems, one-fifth representing "-fentanil". Most drugs targeting MOP receptors were agonists at one or more receptors and were synthetic opioids. Further research will expand the development of the catalogue and create a visual platform that will aid prescribers and inform patients, carers and other members of the public about the properties and safety of opioids.

A review of opioid pharmacology in 1983 estimated that thousands of opioids have been synthesized and investigated for their various properties.[9] Previous research synthesized information about opioids included in national Essential Medicines Lists using the ATC index, which found 33 unique opioid drugs.[36] However, it was not clear how many opioids existed, nor was there a centralized repository of information that combined the various naming and classification systems. To the best of our knowledge, this is the first study to systematically determine the number of available opioid medicaments and to assess opioid nomenclature and pharmacology. We used systematic methods to search a variety of sources, conducted in duplicate. We named opioids using nonproprietary drug names (eg, INNs where possible), which have more therapeutic utility and reduce the risk of medication errors.[37,38]

Despite using systematic methods, it is possible that there are other opioids that we have not identified from our search owing to reporting biases. Various limitations, such as spelling variants, look-alike and sound-alike names, the use of different nomenclatures for a single drug, drug abbreviations and the implications of chemical salts,[38–41] were considered throughout the study, but may have resulted in opioids being omitted. There was a large volume of missing data for receptor targets and effects at receptors. We used manual methods to search the seven sources, and despite updating the search, methods will need to be developed to automatically and efficiently update the catalogue to reflect discoveries and progress in opioid pharmacology.

Inconsistent drug names can put patients and the public at risk of harms, and can affect the ability and quality of evidence synthesis and knowledge generation. While there are national and international standards for drug nomenclature, and authorities and organizations (eg, IUPAC and the WHO) and regulatory bodies to approve such names, all opioids identified in our study may not have been through such processes, owing to either their maturity or their infancy. For example, morphine was first marketed by Merck in 1827, long before drug nomenclature standards existed, and various novel opioids are being identified on the black market, such as the rise in fentanyl analogues.[42] A consolidated list of opioids could therefore harmonize discrepancies and standardize nomenclature, which has been found to reduce confusion, medication errors and unwarranted variation, as well as improve medication knowledge, adherence, training and communication.[38,43,44]

Poor knowledge of opioid drugs is a significant barrier to assessing metrics of opioid use and misuse.[15] This list of opioids and the cataloguing of drugs based on their pharmacology could assist opioid researchers, drug developers, prescribers and the public. A centralized list of opioid drugs could be used in evidence synthesis and observational research to streamline the identification of studies or prescribing data. For systematic reviews, the list of opioids could be used to create a list of opioid search terms that includes chemical, proprietary and nonproprietary drug names. For drug utilization studies, the 233 opioids could be used to design product code lists for databases, such as the Clinical Practice Research Datalink (CPRD). Regulators and pharmaceutical companies could use the list to assist generating names for new opioids. The catalogue could assist drug developers by elucidating the heterogeneous nature of opioids, helping to create comparisons of existing opioids and providing a single repository of information to develop less addictive opioids.

At present (December 2020), the website disseminates the list of drugs and their pharmacology in a searchable database. Future research will be required to develop the catalogue and create methods that automatically and efficiently update the list of opioid drugs. Patient and public involvement and engagement (PPIE) with key stakeholders (eg, patients and prescribers) will be needed to

ensure that the catalogue meets the needs of the target audiences and is useful in improving knowledge and training of prescribers and promoting the safe use of opioids. Maintaining and developing the catalogue will be a continuous process and we shall welcome feedback or contributions as it evolves.

4.1 | Conclusions

The Oxford Catalogue of Opioids (https://www.catalogueofopioids.net/) includes 233 unique opioid drugs and collates their nomenclature and pharmacological properties. Consistent nomenclature is essential for improving the safety and communication of medicines between patients, prescribers, manufactures, regulators and researchers. Future research will expand the catalogue to create a visual platform that will assist prescribers, researchers and regulators, and improve knowledge about opioids and their safe use.

ACKNOWLEDGEMENT

No funding was provided or obtained for this study.

CONTRIBUTORS

G.C.R. and J.K.A. devised the idea for this research and independently ran the initial search for opioids. G.C.R. designed the study protocol and search strategy. K.S. contributed to the study protocol, preregistered the protocol, updated the search in seven databases and extracted the pharmacological data. J.K.A. and C.H. provided supervisory support. G.C.R. wrote the manuscript, and all authors contributed, edited and agreed to submit for publication.

COMPETING INTERESTS

G.C.R. is financially supported by the National Institute of Health Research (NIHR) School for Primary Care Research (SPCR), the Naji Foundation and the Rotary Foundation to study for a Doctor of Philosophy. K.S. has nothing to declare. C.H. is an NIHR Senior Investigator and has received expenses and fees for his media work (including payments from BBC Radio 4 Inside Health), received expenses from the WHO and FDA, and holds grant funding from the NIHR, the NIHR SPCR, the NIHR SPCR Evidence Synthesis Working Group [Project 380], the NIHR BRC Oxford and the WHO. C.H. has received financial remuneration from an asbestos case and given free legal advice on mesh cases. C.H. has also received income from the publication of a series of toolkit books published by Blackwells. On occasion, C.H. receives expenses for teaching EBM and is also paid for his GP work in NHS out of hours (contract with Oxford Health NHS Foundation Trust). C.H. is Director of the CEBM, which jointly runs the EvidenceLive/EBMLive Conference with the BMJ and the Overdiagnosis Conference with international partners, based on a nonprofit making model. J.K.A. has published articles and edited textbooks on adverse drug reactions and interactions, and has often given medicolegal advice, including appearances as an expert witness in coroners' courts, often dealing with the adverse effects of opioids. The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care.

DATA AVAILABILITY STATEMENT

All data, statistical code and study materials related to this research are openly available on our OSF project page (https://osf.io/2ph6c/) at Github (https://github.com/georgiarichards/CatalogueofOpioids) and are available at our online resource (https://www.catalogueofopioids.net/).

ORCID

Georgia C. Richards https://orcid.org/0000-0003-0244-5620

Jeffrey K. Aronson https://orcid.org/0000-0003-1139-655X

REFERENCES

1. Curtis HJ, Croker R, Walker AJ, Richards GC, Quinlan J, Goldacre B. Opioid prescribing trends and geographical variation in England, 1998-2018: a retrospective database study. *Lancet Psych*. 2019;6(2):140-150. https://doi.org/10.1016/S2215-0366(18)30471-1
2. Donovan PJ, Arroyo D, Pattullo C, Bell A. Trends in opioid prescribing in Australia: a systematic review*. *Aust Heal Rev*. 2019. Available from: http://www.publish.csiro.au/?paper=AH18245
3. Ladha KS, Neuman MD, Broms G, et al. Opioid Prescribing After Surgery in the United States, Canada, and Sweden. *JAMA Netw Open*. 2019;2(9):e1910734. Available from: https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2749239
4. Gilley M, Sivilotti MLA, Juurlink DN, Macdonald E, Yao Z, Finkelstein Y. Trends of intentional drug overdose among youth: a population-based cohort study. *Clin Toxicol*. 2020;58(7):711-715. https://doi.org/10.1080/15563650.2019.1687900
5. Alho H, Dematteis M, Lembo D, Maremmani I, Roncero C, Somaini L. Opioid-related deaths in Europe: Strategies for a comprehensive approach to address a major public health concern. *Int J Drug Policy*. 2020;76:102616. https://doi.org/10.1016/j.drugpo.2019.102616
6. Chavkin C. The therapeutic potential of κ-opioids for treatment of pain and addiction. *Neuropsychopharmacology*. 2011;36(1):369-370.
7. Raffa RB, Pergolizzi JV, Muñiz E, Taylor R, Pergolizzi J. Designing opioids that deter abuse. *Pain Res Treat*. 2012;2012:282981. https://doi.org/10.1155/2012/282981
8. Ding H, Czoty PW, Kiguchi N, et al. A novel orvinol analog, BU08028, as a safe opioid analgesic without abuse liability in primates. *Proc Natl Acad Sci U S A*. 2016;113(37):E5511-E5518.Available from: https://pubmed.ncbi.nlm.nih.gov/27573832/
9. Martin WR. Pharmacology of opioids. *Pharmacol Rev*. 1983;35(4):283-323.
10. Upshur CC, Luckmann RS, Savageau JA. Primary care provider concerns about management of chronic pain in community clinic populations. *J Gen Intern Med*. 2006;21(6):652-655. https://doi.org/10.1111/j.1525-1497.2006.00412.x
11. Johnson M, Collett B, Castro-Lopes JM. The challenges of pain management in primary care: a pan-European survey. *J Pain Res*. 2013;6:393-401.
12. Roy É, Côté RJ, Hamel D, et al. Opioid prescribing practices and training needs of québec family physicians for chronic noncancer pain. *Pain Res Manag*. 2017;2017. Available from. https://pubmed.ncbi.nlm.nih.gov/28831278/
13. Palamar JJ, Shearston JA, Cleland CM. Discordant reporting of nonmedical opioid use in a nationally representative sample of US high school seniors. *Am J Drug Alcohol Abuse*. 2016 ;42(5):530-538.

14. Palamar JJ. Barriers to accurately assessing prescription opioid misuse on surveys. *Am J Drug Alcohol Abuse*. 2019;45(2):117-123.Available from: https://10.1080/00952990.2018.1521826
15. Kenakin TP. Pharmacological Onomastics: What's in a name?. *Br J Pharmacol*. 2008;153(3):432-438.
16. WHOCC. ATC/DDD Index. WHO Collaborating Centre for Drug Statistics Methodology. 2020. Available from: https://www.whocc.no/atc_ddd_index/
17. Datalab. All BNF sections. OpenPrescribing. 2020. Available from: https://openprescribing.net/bnf/
18. Armstrong J, Faccenda E, Harding S, et al. The IUPHAR/BPS Guide to PHARMACOLOGY in 2020: extending immunopharmacology content and introducing the IUPHAR/MMV Guide to MALARIA PHARMACOLOGY. *Nucleic Acids Res*. 2020;48(D1):D1006-D1021.
19. INCB. *Narcotic Drugs — Estimated World Requirements for 2020 — Statistics for 2018*. Vienna; 2019. Available from: https://apps.who.int/iris/bitstream/handle/10665/325771/WHO-MVP-EMP-IAU-2019.06-eng.pdf
20. WHO. INN search. MedNet. 2020. Available from: https://mednet-communities.net/inn/login
21. Royal Pharmaceutical Society. Martindale: the complete drug reference [Internet]. MedicinesComplete. 2020. Available from: https://www.medicinescomplete.com/#/browse/martindale
22. Royal Society of Chemistry. The Merck Index Online [Internet]. Available from: https://www.rsc.org/Merck-Index/
23. Wikipedia. List of opioids [Internet]. 2020 [cited 2021 Feb 7]. Available from: https://en.wikipedia.org/wiki/List_of_opioids
24. NIH. PubChem [Internet]. National Library of Medicines. 2020. Available from: https://pubchem.ncbi.nlm.nih.gov/
25. WHO. The use of stems in the selection of International Nonproprietary Names (INN) for pharmaceutical substances. World Health Organization. 2018. Available from: https://www.who.int/medicines/services/inn/StemBook_2018.pdf
26. Liu JG, Prather PL. Chronic agonist treatment converts antagonists into inverse agonists at δ-opioid receptors. *J Pharmacol Exp Ther*. 2002;302(3):1070-1079.Available from: http://jpet.aspetjournals.org
27. Cruz SL, Villarreal JE, Volkow ND. Further evidence that naloxone acts as an inverse opiate agonist: Implications for drug dependence and withdrawal. *Life Sci*. 1996;58(26):381-389.Available from: https://pubmed.ncbi.nlm.nih.gov/8691979/
28. Kelly E, Mundell SJ, Sava A, et al. The opioid receptor pharmacology of GSK1521498 compared to other ligands with differential effects on compulsive reward-related behaviours. *Psychopharmacology (Berl) [Internet]*. 2015;232(1):305-314.Available from: https://pubmed.ncbi.nlm.nih.gov/24973897/
29. Alexander SPH, Christopoulos A, Davenport AP, et al. THE CONCISE GUIDE TO PHARMACOLOGY 2019/20: G protein-coupled receptors. *Br J Pharmacol*. 2019;176(S1):S21-S141. https://10.1111/bph.14748
30. Richards G, Aronson J, Sitkowski K, Heneghan C. The Oxford Catalogue of Opioids: a systematic synthesis of opioid drug names and their pharmacology. *OSF*. 2020. Available from: https://osf.io/4fu7b
31. Richards G. CatalogueofOpioids [Internet]. Github. 2020. Available from: https://github.com/georgiarichards/CatalogueofOpioids
32. Richards G, Aronson J, Sitkowski K, Heneghan C. The Oxford Catalogue of Opioids [Internet]. Open Science. *Framework*. 2020. Available from: https://osf.io/2ph6c/
33. PANDAS Development Team. *pandas-dev/pandas: PANDAS*. Zenodo; 2020.
34. Waskom M. mwaskom/seaborn. Zenodo; 2020.
35. Hunter J. Matplotlib: a 2D graphics environment. *Comput Sci Eng*. 2009;9:90-95.
36. Richards GC, Aronson JK, Heneghan C, Mahtani KR, Koshiaris C, Persaud N. Relation between opioid consumption and inclusion of opioids in 137 national essential medicines lists. *BMJ Glob Health*. 2020;5(11):1-8.
37. George CF. Naming of drugs: Pass the epinephrine, please - Confusion over international differences may put patients at risk. *Br Med J Publishing Group*. 1996;312:1315-1316.Available from: https://www.bmj.com/content/312/7042/1315
38. Aronson JK. Medication errors resulting from the confusion of drug names. *Expert Opin Drug Saf*. 2004;3(3):167-172.Available from: https://pubmed.ncbi.nlm.nih.gov/15155145/
39. Ferner RE, Aronson JK. Nominal ISOMERs (Incorrect Spellings of Medicines Eluding Researchers)-variants in the spellings of drug names in PubMed: A database review. *BMJ*. 2016;355:i4854. https://doi.org/10.1136/bmj.i4854
40. Bryan R, Aronson JK, Williams A, Jordan S. The problem of look-alike, sound-alike name errors: Drivers and solutions. *Br J Clin Pharmacol*. 2021;87(2):386-394. https://10.1111/bcp.14285
41. McDougall DJ, Hoehns JD, Feller TT, Kriener SJ, Witry MJ. Inclusion of salt form on prescription medication labeling as a source of patient confusion: A pilot study. *Pharm Pract (Granada)*. 2016;14(1):677. https://doi.org/10.18549/PharmPract.2016.01.677
42. Park JN, Rashidi E, Foti K, Zoorob M, Sherman S, Alexander GC. Fentanyl and fentanyl analogs in the illicit stimulant supply: results from U.S. drug seizure data, 2011-2016. *Drug Alcohol Depend*. 2021;218:108416. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0376871620305810
43. Ostini R, Roughead EE, Kirkpatrick CMJ, Monteith GR, Tett SE. Quality Use of Medicines - Medication safety issues in naming; Look-alike, sound-alike medicine names. *Intern J Phar Prac*. 2012;20(6):349-357.
44. Baker E, Pryce Roberts A, Wilde K, et al. Development of a core drug list towards improving prescribing education and reducing errors in the UK. *Br J Clin Pharmacol*. 2011;71(2):190-198.

How to cite this article: Richards GC, Sitkowski K, Heneghan C, Aronson JK. The Oxford Catalogue of Opioids: A systematic synthesis of opioid drug names and their pharmacology. *Brit Jnl Clinical Pharma*. 2021;87(10):3790–3812. https://doi.org/10.1111/bcp.14786

APPENDIX A

TABLE A1 The 233 drugs of the Oxford Catalogue of Opioids in alphabetical order, with their chemical (IUPAC) names and the databases in which the names were found

Index name	IUPAC	BNF	ATC	INCB	Merck	Martindale	GtoP	Total	Other
3-methylfentanyl	n-[3-methyl-1-(2-phenylethyl) piperidin-4-yl]-n-phenylpropanamide			●				1	
3-methylthiofentanyl	n-[3-methyl-1-(2-thiophen-2-ylethyl) piperidin-4-yl]-n-phenylpropanamide			●				1	
4-chloroisobutyrfentanyl	2-methyl-n-(4-chlorophenyl)-n-[1-(1-phenylpropan-2-yl) piperidin-4-yl] propenamide							0	(1)
4-fluoro isobutyrfentanyl	n-(4-fluorophenyl)-2-methyl-n-[1-(2-phenylethyl) piperidin-4-yl] propenamide			●				1	
4-phenylfentanyl	n-phenyl-n-[4-phenyl-1-(2-phenylethyl)piperidin-4-yl] propenamide							0	(2)
6′-guanidinonal trindole	2-[(1s,2s,13r,21r)-22-(cyclopropylmethyl)-2,16-dihydroxy-14-oxa-11,22-diazaheptacyclo [13.9.1.01,13.02,21.04,12.05,10.019,25] pentacosa-4(12),5(10),6,8,15,17,19(25)-heptaen-8-yl] guanidine							0	(3)
7-benzylidenenaltrexone	(4R,4aS,6E,7aR,12bS)-6-benzylidene-3-(cyclopropylmethyl)-4a,9-dihydroxy-1,2,4,5,7a,13-hexahydro-4,12-methanobenzofuro[3,2-e]isoquinolin-7-one						●	1	
Acetorphine*	[(1r,2s,6r,14r,15r,19r)-19-[(2r)-2-hydroxypentan-2-yl]-15-methoxy-5-methyl-13-oxa-5-azahexacyclo [13.2.2.12,8.01,6.02,14.012,20] icosa-8(20),9,11,16-tetraen-11-yl] acetate			●				1	
Acetyldihydrocodeine	[(4r,4ar,7s,7ar,12bs)-9-methoxy-3-methyl-2,4,4a,5,6,7,7a,13-octahydro-1h-4,12-methanobenzofuro [3,2-e]isoquinolin-7-yl] acetate		●	●		●		3	
Acetylfentanyl	n-phenyl-n-[1-(2-phenylethyl)piperidin-4-yl] acetamide			●				1	
Acetylmethadol*	[6-(dimethylamino)-4,4-diphenylheptan-3-yl] acetate			●	●			2	
Acrylfentanyl	n-phenyl-n-[1-(2-phenylethyl)piperidin-4-yl] Prop-2-enamide			●				1	
Ah-7921	3,4-dichloro-n-[[1-(dimethylamino) cyclohexyl] methyl] benzamide			●				1	
Alfentanil*	n-[1-[2-(4-ethyl-5-oxotetrazol-1-yl)ethyl]-4-(methoxymethyl) piperidin-4-yl]-n-phenylpropanamide	●	●	●	●	●	●	6	
Alimadol*	3-methoxy-3,3-diphenyl-n-prop-2-enylpropan-1-amine							0	INN
Alletorphine*	(1r,2s,6r,14r,15r,19r)-19-[(2r)-2-hydroxypentan-2-yl]-15-methoxy-5-prop-2-enyl-13-oxa-5-azahexacyclo							0	INN

(Continues)

TABLE A1 (Continued)

Index name	IUPAC	BNF	ATC	INCB	Merck	Martindale	GtoP	Total	Other
	[13.2.2.12,8.01,6.02,14.012,20] icosa-8 (20),9,11,16-tetraen-11-ol								
Allylprodine*	(1-methyl-4-phenyl-3-prop-2-enylpiperidin-4-yl) propanoate			●	●			2	
Alphacetylmethadol*	[(3r,6r)-6-(dimethylamino)-4,4-diphenylheptan-3-yl] acetate			●				1	
Alphameprodine*	[(3s,4r)-3-ethyl-1-methyl-4-phenylpiperidin-4-yl] propanoate			●				1	
Alphamethadol*	(3r,6r)-6-(dimethylamino)-4,4-diphenylheptan-3-ol			●				1	
Alphamethylacetylfentanyl	n-phenyl-n-[1-(1-phenylpropan-2-yl)piperidin-4-yl] acetamide			●				1	
Alphamethylfentanyl	n-phenyl-n-[1-(1-phenylpropan-2-yl)-4-piperidyl] propenamide			●	●			2	
Alphamethylthiofentanyl	n-phenyl-n-[1-(1-thiophen-2-ylpropan-2-yl) piperidin-4-yl] propanamide			●				1	
Alphamethylthiofentanyl	n-phenyl-n-[1-(1-thiophen-2-ylpropan-2-yl)-4-piperidyl] propenamide			●				1	
Alphaprodine	[(3s,4r)-1,3-dimethyl-4-phenylpiperidin-4-yl] propanoate; hydrochloride			●	●	●		2	
Alvimopan*	2-[[(2s)-2-benzyl-3-[(3r,4r)-4-(3-hydroxyphenyl)-3,4-dimethylpiperidin-1-yl]propanoyl]amino] acetic acid		●		●	●	●	4	
Anazocine*	9-methoxy-3-methyl-9-phenyl-3-azabicyclo [3.3.1] nonane							0	INN
Anileridine*	Ethyl 1-[2-(4-aminophenyl)ethyl]-4-phenylpiperidine-4-carboxylate		●	●	●	●	●	5	
Apadoline*	n-propyl-10-[(2r)-1-pyrrolidin-1-ylpropan-2-yl]phenothiazine-2-carboxamide							0	(4)
Asalhydromorphone*	[(4r,4ar,7ar,12bs)-9-(2-acetyloxybenzoyl)oxy-3-methyl-2,4,4a,5,7a,13-hexahydro-1h-4,12-methanobenzofuro [3,2-e]isoquinolin-7-yl] 2-acetyloxybenzoate							0	(5)
Asimadoline*	n-[(1s)-2-[(3s)-3-hydroxypyrrolidin-1-yl]-1-phenylethyl]-n-methyl-2,2-diphenylacetamide				●		●	2	
Axomadol*	(1r,3r,6r)-6-[(dimethylamino)methyl]-1-(3-methoxyphenyl) cyclohexane-1,3-diol							0	INN
Benzethidine*	Ethyl 4-phenyl-1-(2-phenylmethoxyethyl)piperidine-4-carboxylate			●				1	
Benzhydrocodone	[(4r,4ar,7ar,12bs)-9-methoxy-3-methyl-2,4,4a,5,7a,13-hexahydro-1h-4,12-methanobenzofuro [3,2-e]isoquinolin-7-yl] benzoate							0	(6-8)
Benzodioxolefentanyl	n-phenyl-n-[1-(2-phenylethyl)piperidin-4-yl]-2h-1,3-benzodioxole-5-carboxamide							0	(9)
Benzoylfentanyl	n-phenyl-n-[1-(2-phenylethyl)piperidin-4-yl] benzamide							0	(10)
Benzylfentanyl	n-(1-benzylpiperidin-4-yl)-n-phenylpropanamide							0	(11)

TABLE A1 (Continued)

Index name	IUPAC	BNF	ATC	INCB	Merck	Martindale	GtoP	Total	Other
Benzylmorphine	(4r,4ar,7s,7ar,12bs)-3-methyl-9-phenylmethoxy-2,4,4a,7,7a,13-hexahydro-1h-4,12-methanobenzofuro[3,2-e]isoquinolin-7-ol			●	●			2	
Betacetylmethadol*	[(3s,6r)-6-(dimethylamino)-4,4-diphenylheptan-3-yl] acetate			●				1	
Betahydroxyfentanyl	n-[1-(2-hydroxy-2-phenylethyl)piperidin-4-yl]-n-phenylpropanamide			●				1	
Betahydroxythiofentanyl	n-{1-[2-hydroxy-2-(thiophen-2-yl)ethyl]piperidin-4-yl}-n-phenylpropanamide							0	(12)
Betameprodine*	(3-ethyl-1-methyl-4-phenylpiperidin-4-yl) propanoate			●				1	
Betamethadol*	(3s,6r)-6-(dimethylamino)-4,4-diphenylheptan-3-ol			●				1	
Betamethylfentanyl	n-phenyl-n-[1-(2-phenylpropyl)piperidin-4-yl] propenamide							0	(13)
Betaprodine*	[(3r,4r)-1,3-dimethyl-4-phenylpiperidin-4-yl] propanoate			●				1	
Bezitramide*	4-[4-(2-oxo-3-propanoylbenzimidazol-1-yl)piperidin-1-yl]-2,2-diphenylbutanenitrile		●	●	●	●		4	
Bremazocine*	(1s,9r)-1-ethyl-10-[(1-hydroxycyclopropyl)methyl]-13,13-dimethyl-10-azatricyclo[7.3.1.02,7]trideca-2(7),3,5-trien-4-ol						●	1	
Brifentanil*	n-[(3r,4s)-1-[2-(4-ethyl-5-oxotetrazol-1-yl)ethyl]-3-methylpiperidin-4-yl]-n-(2-fluorophenyl)-2-methoxyacetamide							0	INN
Bromadoline*	4-bromo-n-[(1s,2s)-2-(dimethylamino) cyclohexyl]benzamide							0	(14)
Brorphine	1-{1-[1-(4-bromophenyl)ethyl]piperidin-4-yl}-1,3-dihydro-2h-benzimidazol-2-one							0	(15)
Bu-08028	(1s,2s,6r,14r,15r,16r)-5-(cyclopropylmethyl)-16-[(2s)-2-hydroxy-3,3-dimethylpentan-2-yl]-15-methoxy-13-oxa-5-azahexacyclo [13.2.2.12,8.01,6.02,14.012,20]icosa-8(20),9,11-trien-11-ol						●	1	(16)
Buprenorphine*	(1s,2s,6r,14r,15r,16r)-5-(cyclopropylmethyl)-16-[(2s)-2-hydroxy-3,3-dimethylbutan-2-yl]-15-methoxy-13-oxa-5-azahexacyclo [13.2.2.12,8.01,6.02,14.012,20]icosa-8(20),9,11-trien-11-ol	●	●		●	●	●	5	
Butinazocine*	10-but-3-ynyl-13,13-dimethyl-10-azatricyclo[7.3.1.02,7]trideca-2(7),3,5-triene-1,4-diol							0	INN
Butorphanol*	(1s,9r,10s)-17-(cyclobutylmethyl)-17-azatetracyclo[7.5.3.01,10.02,7]heptadeca-2(7),3,5-triene-4,10-diol		●		●	●	●	4	
Butyrfentanyl	n-phenyl-n-[1-(2-phenylethyl)piperidin-4-yl]butanamide			●				1	
Carbazocine	20-(cyclopropylmethyl)-3,20-diazapentacyclo[10.5.3.01,13.02,10.04,9]icosa-2(10),4,6,8-tetraene							0	INN

(Continues)

TABLE A1 (Continued)

Index name	IUPAC	BNF	ATC	INCB	Merck	Martindale	GtoP	Total	Other
Carfentanil*	Methyl 1-(2-phenylethyl)-4-(n-propanoylanilino) piperidine-4-carboxylate			●		●	●	3	
Carperidine*	Ethyl 1-(3-amino-3-oxopropyl)-4-phenylpiperidine-4-carboxylate							0	INN
Ciramadol*	3-[(r)-dimethylamino-[(1r,2r)-2-hydroxycyclohexyl]methyl] phenol				●	●		2	
Clonitazene*	2-[2-[(4-chlorophenyl)methyl]-5-nitrobenzimidazol-1-yl]-n,n-diethylethanamine			●	●	●		3	
Codeine	(4r,4ar,7s,7ar,12bs)-9-methoxy-3-methyl-2,4,4a,7,7a,13-hexahydro-1h-4,12-methanobenzofuro [3,2-e]isoquinolin-7-ol	●	●	●	●	●	●	6	
Codoxime*	2-[(z)-[(4r,4ar,7ar,12bs)-9-methoxy-3-methyl-1,2,4,4a,5,6,7a,13-octahydro-4,12-methanobenzofuro [3,2-e] isoquinolin-7-ylidene] amino] oxyacetic acid			●				1	
Cogazocine	10-(cyclobutylmethyl)-1-ethyl-13,13-dimethyl-10-azatricyclo [7.3.1.02,7]trideca-2(7),3,5-trien-4-ol							0	(17)
Crotonylfentanyl	(2e)-n-phenyl-n-[1-(2-phenylethyl)piperidin-4-yl]but-2-enamide			●				1	
Cyclazocine*	10-(cyclopropylmethyl)-1,13-dimethyl-10-azatricyclo [7.3.1.02,7]trideca-2(7),3,5-trien-4-ol				●		●	2	INN
Cyclopentylfentanyl	n-phenyl-n-[1-(2-phenylethyl)piperidin-4-yl] cyclopentanecarboxamide							0	(18)
Cyclopropylfentanyl	n-phenyl-n-[1-(2-phenylethyl)piperidin-4-yl] cyclopropanecarboxamide			●				1	
Cyprenorphine*	(1r,2s,6r,14r,15r,19r)-5-(cyclopropylmethyl)-19-(2-hydroxypropan-2-yl)-15-methoxy-13-oxa-5-azahexacyclo[13.2.2.12,8.01,6.02,14.012,20]icosa-8(20),9,11,16-tetraen-11-ol				●			1	INN
Desmethylmoramide*	4-morpholin-4-yl-2,2-diphenyl-1-pyrrolidin-1-ylbutan-1-one							0	INN
Desmethylprodine	(1-methyl-4-phenylpiperidin-4-yl) propanoate			●				1	
Desmetramadol*	3-[(1r,2r)-2-[(dimethylamino)methyl]-1-hydroxycyclohexyl] phenol							0	(19)
Desomorphine*	(4r,4ar,7as,12bs)-3-methyl-2,4,4a,5,6,7,7a,13-octahydro-1h-4,12-methanobenzofuro[3,2-e] isoquinolin-9-ol			●	●			2	
Dextromethorphan*	(1s,9s,10s)-4-methoxy-17-methyl-17-azatetracyclo [7.5.3.01,10.02,7] heptadeca-2(7),3,5-triene	●	●		●	●	●	5	
Dextromoramide*	(3s)-3-methyl-4-morpholin-4-yl-2,2-diphenyl-1-pyrrolidin-1-ylbutan-1-one	●	●	●	●	●		5	

TABLE A1 (Continued)

Index name	IUPAC	BNF	ATC	INCB	Merck	Martindale	GtoP	Total	Other
Dextropropoxyphene*	[(2s,3r)-4-(dimethylamino)-3-methyl-1,2-diphenylbutan-2-yl] propanoate	●	●	●			●	4	
Dezocine*	(1r,9s,15s)-15-amino-1-methyltricyclo [7.5.1.02,7]pentadeca-2 (7),3,5-trien-4-ol		●		●	●		3	
Diamorphine	[(4r,4ar,7s,7ar,12bs)-9-acetyloxy-3-methyl-2,4,4a,7,7a,13-hexahydro-1h-4,12-methanobenzofuro [3,2-e]isoquinolin-7-yl] acetate	●	●	●	●	●	●	6	
Diampromide*	n-[2-[methyl(2-phenylethyl)amino]propyl]-n-phenylpropanamide			●	●			2	
Dibenzoylmorphine	(9-benzoyloxy-3-methyl-2,4,4a,7,7a,13-hexahydro-1h-4,12-methanobenzofuro[3,2-e]isoquinolin-7-yl) benzoate							0	(20)
Diethylthiambutene*	n,n-diethyl-4,4-dithiophen-2-ylbut-3-en-2-amine			●				1	
Difenoxin*	1-(3-cyano-3,3-diphenylpropyl)-4-phenylpiperidine-4-carboxylic acid		●	●	●		●	4	
Dihydrocodeine*	(4r,4ar,7s,7ar,12bs)-9-methoxy-3-methyl-2,4,4a,5,6,7,7a,13-octahydro-1h-4,12-methanobenzofuro [3,2-e]isoquinolin-7-ol	●	●	●	●	●		5	
Dihydroetorphine	(1s,2s,6r,14r,15r,16r)-16-[(2r)-2-hydroxypentan-2-yl]-15-methoxy-5-methyl-13-oxa-5-azahexacyclo [13.2.2.12,8.01,6.02,14.012,20] icosa-8(20),9,11-trien-11-ol			●				1	
Dihydromorphine	(4r,4ar,7s,7ar,12bs)-3-methyl-2,4,4a,5,6,7,7a,13-octahydro-1h-4,12-methanobenzofuro[3,2-e]isoquinoline-7,9-diol			●	●		●	3	
Dimemorfan*	(1s,9s,10s)-4,17-dimethyl-17-azatetracyclo[7.5.3.01,10.02,7] heptadeca-2(7),3,5-triene		●		●			2	
Dimenoxadol*	2-(dimethylamino)ethyl 2-ethoxy-2,2-diphenylacetate			●	●			2	
Dimepheptanol*	6-(dimethylamino)-4,4-diphenylheptan-3-ol			●	●			2	
Dimethylthiambutene*	n,n-dimethyl-4,4-dithiophen-2-yl but-3-en-2-amine			●	●			2	
Dinalbuphine sebacate*	Bis[(4r,4as,7s,7ar,12bs)-3-(cyclobutylmethyl)-4a,7-dihydroxy-1,2,4,5,6,7,7a,13-octahydro-4,12-methanobenzofuro[3,2-e] isoquinolin-9-yl] decanedioate							0	(21,22)
Dioxaphetyl butyrate*	Ethyl 4-morpholin-4-yl-2,2-diphenylbutanoate			●	●			2	
Diphenoxylate*	Ethyl 1-(3-cyano-3,3-diphenylpropyl)-4-phenylpiperidine-4-carboxylate	●	●	●	●	●	●	6	
Dipipanone*	4,4-diphenyl-6-piperidin-1-ylheptan-3-one	●		●	●	●	●	5	
Diprenorphine*	(1s,2s,6r,14r,15r,16r)-5-(cyclopropylmethyl)-16-(2-hydroxypropan-2-yl)-15-methoxy-13-oxa-5-azahexacyclo [13.2.2.12,8.01,6.02,14.012,20]icosa-8 (20),9,11-trien-11-ol				●	●	●	3	

(Continues)

TABLE A1 (Continued)

Index name	IUPAC	BNF	ATC	INCB	Merck	Martindale	GtoP	Total	Other
Drotebanol*	(1r,9r,10s,13r)-3,4-dimethoxy-17-methyl-17-azatetracyclo [7.5.3.01,10.02,7]heptadeca-2(7),3,5-triene-10,13-diol			●	●	●		3	
Eluxadoline*	5-[[[(2s)-2-amino-3-(4-carbamoyl-2,6-dimethylphenyl) propanoyl]-[(1s)-1-(5-phenyl-1h-imidazol-2-yl)ethyl]amino] methyl]-2-methoxybenzoic acid	●	●		●		●	4	
Embutramide*	n-[2-ethyl-2-(3-methoxyphenyl)butyl]-4-hydroxybutanamide	●	●		●			3	
Enadoline*	2-(1-benzofuran-4-yl)-n-methyl-n-[(5r,7 s,8 s)-7-pyrrolidin-1-yl-1-oxaspiro[4.5]decan-8-yl]acetamide					●	●	2	
Eptazocine*	(1s,9s)-1,11-dimethyl-11-azatricyclo[7.4.1.02,7]tetradeca-2 (7),3,5-trien-4-ol				●			1	
Ethoheptazine	Ethyl 1-methyl-4-phenylazepane-4-carboxylate				●	●		2	
Ethylmethylthiambutene*	n-ethyl-n-methyl-4,4-dithiophen-2-ylbut-3-en-2-amine			●	●	●		3	
Ethylmorphine	(4r,4ar,7s,7ar,12bs)-9-ethoxy-3-methyl-2,4,4a,7,7a,13-hexahydro-1h-4,12-methanobenzofuro [3,2-e]isoquinolin-7-ol		●	●	●	●			
Etonitazene*	2-[2-[(4-ethoxyphenyl)methyl]-5-nitrobenzimidazol-1-yl]-n,n-diethylethanamine			●	●		●	3	
Etorphine*	(1r,2s,6r)-19-(2-hydroxypentan-2-yl)-15-methoxy-5-methyl-13-oxa-5-azahexacyclo [13.2.2.12,8.01,6.02,14.012,20] icosa-8(20),9,11,16-tetraen-11-ol			●	●	●	●	4	
Etoxeridine*	Ethyl 1-[2-(2-hydroxyethoxy)ethyl]-4-phenylpiperidine-4-carboxylate			●				1	
Fedotozine	(2r)-n,n-dimethyl-2-phenyl-1-[(3,4,5-trimethoxyphenyl) methoxy]butan-2-amine				●	●		2	
Fentanyl*	n-phenyl-n-[1-(2-phenylethyl)piperidin-4-yl] propanamide	●	●	●	●	●	●	6	
Fluradoline*	2-(3-fluorobenzo[b][1]benzoxepin-5-yl)sulfanyl-n-methylethanamine							0	(23)
Furanylfentanyl	n-phenyl-n-[1-(2-phenylethyl) piperidin-4-yl]furan-2-carboxamide			●				1	
Furethidine*	Ethyl 1-[2-(oxolan-2-ylmethoxy)ethyl]-4-phenylpiperidine-4-carboxylate			●	●			2	
Gemazocine*	10-(cyclopropylmethyl)-1-ethyl-13,13-dimethyl-10-azatricyclo [7.3.1.02,7]trideca-2(7),3,5-trien-4-ol							0	(24)
gsk1521498	N-[[2,6-difluoro-4-[3-(1H-1,2,4-triazol-5-yl)phenyl]phenyl] methyl]-2,3-dihydro-1H-inden-2-amine						●	1	
Homprenorphine*	2-[5-(cyclopropylmethyl)-11,15-dimethoxy-13-oxa-5-azahexacyclo [13.2.2.12,8.01,6.02,14.012,20] icosa-8 (20),9,11,18-tetraen-16-yl] butan-2-ol							0	INN

TABLE A1 (Continued)

Index name	IUPAC	BNF	ATC	INCB	Merck	Martindale	GtoP	Total	Other
Hydrocodone*	(4r,4ar,7ar,12bs)-9-methoxy-3-methyl-1,2,4,4a,5,6,7a,13-octahydro-4,12-methanobenzofuro [3,2-e]isoquinolin-7-one		●	●	●	●	●	5	
Hydromorphinol*	(4r,4as,7s,7ar,12bs)-3-methyl-1,2,4,5,6,7,7a,13-octahydro-4,12-methanobenzofuro [3,2-e] isoquinoline-4a,7,9-triol			●				1	
Hydromorphone*	(4r,4ar,7ar,12bs)-9-hydroxy-3-methyl-1,2,4,4a,5,6,7a,13-octahydro-4,12-methanobenzofuro [3,2-e]isoquinolin-7-one	●	●	●	●	●	●	6	
Hydroxypethidine*	Ethyl 4-(3-hydroxyphenyl)-1-methylpiperidine-4-carboxylate			●	●			2	
Ibazocine*	1,13,13-trimethyl-10-(3-methylbut-2-enyl)-10-azatricyclo [7.3.1.02,7] trideca-2(7),3,5-trien-4-ol							0	INN
Ici-174 864	(2S)-2-[[(2S)-2-[[2-[[(2S)-2-[bis (prop-2-enyl)amino]-3-(4-hydroxyphenyl)propanoyl]amino]-2-methylpropanoyl] amino]-3-phenylpropanoyl]amino]-4-methylpentanoic acid						●	1	
Iqmf-4	n-[1-phenylpyrazol-3-yl]-n-[1-(2-phenethyl)-4-piperidyl] propenamide							0	(25)
Isobutyrylfentanyl	2-methyl-n-phenyl-n-[1-(1-phenylpropan-2-yl)piperidin-4-yl] propenamide							0	(26)
Isofentanyl	n-(1-benzyl-3-methylpiperidin-4-yl)-n-phenylpropanamide							0	Wiki
Isomethadone*	6-(dimethylamino)-5-methyl-4,4-diphenylhexan-3-one			●	●			2	
Ketazocine*	(1r,9s,13r)-10-(cyclopropylmethyl)-4-hydroxy-1,13-dimethyl-10-azatricyclo[7.3.1.02,7]trideca-2(7),3,5-trien-8-one							0	(27)
Ketobemidone*	1-[4-(3-hydroxyphenyl)-1-methylpiperidin-4-yl]propan-1-one		●	●	●	●		4	
Ketorfanol*	(1s,9r,10r)-17-(cyclopropylmethyl)-3-hydroxy-17-azatetracyclo [7.5.3.01,10.02,7]heptadeca-2(7),3,5-trien-13-one				●			1	INN
Lefetamine*	(1R)-N,N-dimethyl-1,2-diphenylethanamine				●			1	(28)
Levacetylmethadol*	[(3s,6s)-6-(dimethylamino)-4,4-diphenylheptan-3-yl] acetate		●		●	●	●	4	
Levallorphan*	(1r,9r,10r)-17-prop-2-enyl-17-azatetracyclo[7.5.3.01,10.02,7] heptadeca-2(7),3,5-trien-4-ol				●	●	●	3	
Levomethadone*	(6r)-6-(dimethylamino)-4,4-diphenylheptan-3-one		●			●	●	3	
Levomethorphan*	(1r,9r,10r)-4-methoxy-17-methyl-17-azatetracyclo [7.5.3.01,10.02,7] heptadeca-2(7),3,5-triene			●	●			2	
Levomoramide*	(3r)-3-methyl-4-morpholin-4-yl-2,2-diphenyl-1-pyrrolidin-1-ylbutan-1-one			●				1	
Levophenacylmorphan*	2-[(1r,9r,10r)-4-hydroxy-17-azatetracyclo[7.5.3.01,10.02,7] heptadeca-2(7),3,5-trien-17-yl]-1-phenylethanone			●				1	
Levorphanol*				●	●	●	●	4	

(Continues)

TABLE A1 (Continued)

Index name	IUPAC	BNF	ATC	INCB	Merck	Martindale	GtoP	Total	Other
	(1r,9r,10r)-17-methyl-17-azatetracyclo[7.5.3.01,10.02,7] heptadeca-2(7),3,5-trien-4-ol								
Lofentanil*	Methyl (3r,4s)-3-methyl-1-(2-phenylethyl)-4-(n-propanoylanilino)piperidine-4-carboxylate				●			1	
Loperamide*	4-[4-(4-chlorophenyl)-4-hydroxypiperidin-1-yl]-n,n-dimethyl-2,2-diphenylbutanamide	●	●		●		●	4	
Meptazinol*	3-(3-ethyl-1-methylazepan-3-yl)phenol	●	●		●	●	●	5	
Metazocine*	1,10,13-trimethyl-10-azatricyclo[7.3.1.02,7]trideca-2(7),3,5-trien-4-ol			●	●			2	
Metethoheptazine*	Ethyl 1,3-dimethyl-4-phenylazepane-4-carboxylate							0	INN
Methadone*	6-(dimethylamino)-4,4-diphenylheptan-3-one	●	●	●	●	●	●	6	
Metheptazine*	Methyl 1,2-dimethyl-4-phenylazepane-4-carboxylate							0	INN
Methoxyacetylfentanyl	2-methoxy-n-phenyl-n-[1-(2-phenylethyl)piperidin-4-yl] acetamide			●				1	
Methyldesorphine*	(4r,4ar,7as,12bs)-3,7-dimethyl-2,4,4a,5,7a,13-hexahydro-1h-4,12-methanobenzofuro[3,2-e]isoquinolin-9-ol			●				1	
Methyldihydromorphine*	(4r,4ar,7s,7ar,12bs)-3,7-dimethyl-1,2,4,4a,5,6,7a,13-octahydro-4,12-methanobenzofuro[3,2-e]isoquinoline-7,9-diol			●				1	
Methylnaltrexone*	(4r,4as,7ar,12bs)-3-(cyclopropylmethyl)-4a,9-dihydroxy-3-methyl-2,4,5,6,7a,13-hexahydro-1 h-4,12-methanobenzofuro[3,2-e]isoquinolin-3-ium-7-one	●	●		●	●	●	5	
Metopon*	(4r,4ar,7ar,12bs)-9-hydroxy-3,7a-dimethyl-2,4,4a,5,6,13-hexahydro-1h-4,12-methanobenzofuro[3,2-e] isoquinolin-7-one			●	●			2	
Mirfentanil*	n-[1-(2-phenylethyl)piperidin-4-yl]-n-pyrazin-2-ylfuran-2-carboxamide							0	(29)
Morpheridine*	Ethyl 1-(2-morpholin-4-ylethyl)-4-phenylpiperidine-4-carboxylate			●	●			2	
Morphine*	(4r,4ar,7s,7ar,12bs)-3-methyl-2,4,4a,7,7a,13-hexahydro-1h-4,12-methanobenzofuro[3,2-e] isoquinoline-7,9-diol	●	●	●	●	●	●	6	
Moxazocine*	(1s,9r,13r)-10-(cyclopropylmethyl) -13-methoxy-1-methyl-10-azatricyclo[7.3.1.02,7] trideca-2(7),3,5-trien-4-ol							0	(30)
Mt-45	1-cyclohexyl-4-(1,2-diphenylethyl)piperazine			●			●	2	
Myrophine*	[(4r,4ar,7s,7ar,12bs)-3-methyl-9-phenylmethoxy-2,4,4a,7,7a,13-hexahydro-1h-4,12-methanobenzofuro[3,2-e]isoquinolin-7-yl] tetradecanoate			●	●			2	

TABLE A1 (Continued)

Index name	IUPAC	BNF	ATC	INCB	Merck	Martindale	GtoP	Total	Other
n-methylnorcarfentanil	Methyl 1-methyl-4-(n-phenylpropanamido)piperidine-4-carboxylate							0	Wiki
Nalbuphine*	(4r,4as,7s,7ar,12bs)-3-(cyclobutylmethyl)-1,2,4,5,6,7,7a,13-octahydro-4,12-methanobenzofuro[3,2-e] isoquinoline-4a,7,9-triol	●	●		●	●	●	5	
Naldemedine*	(4r,4as,7ar,12bs)-3-(cyclopropylmethyl)-4a,7,9-trihydroxy-n-[2-(3-phenyl-1,2,4-oxadiazol-5-yl)propan-2-yl]-1,2,4,5,7a,13-hexahydro-4,12-methanobenzofuro[3,2-e] isoquinoline-6-carboxamide	●	●		●	●	●	5	
Nalfurafine*	(e)-n-[(4r,4as,7r,7ar,12bs)-3-(cyclopropylmethyl)-4a,9-dihydroxy-1,2,4,5,6,7,7a,13-octahydro-4,12-methanobenzofuro[3,2-e]isoquinolin-7-yl]-3-(furan-3-yl)-n-methylprop-2-enamide		●		●		●	3	
Nalmefene*	(4r,4as,7as,12bs)-3-(cyclopropylmethyl)-7-methylidene-2,4,5,6,7a,13-hexahydro-1h-4,12-methanobenzofuro[3,2-e] isoquinoline-4a,9-diol	●	●		●	●	●	5	
Nalmexone*	(4r,4as,7ar,12bs)-4a,9-dihydroxy-3-(3-methylbut-2-enyl)-2,4,5,6,7a,13-hexahydro-1 h-4,12-methanobenzofuro[3,2-e] isoquinolin-7-one							0	(31)
Nalorphine*	(4r,4ar,7s,7ar,12bs)-3-prop-2-enyl-2,4,4a,7,7a,13-hexahydro-1h-4,12-methanobenzofuro[3,2-e] isoquinoline-7,9-diol		●		●	●	●	4	
Naloxegol*	(4r,4as,7s,7ar,12bs)-7-[2-[2-[2-[2-[2-[2-(2-methoxyethoxy) ethoxy] ethoxy]ethoxy]ethoxy]ethoxy]-3-prop-2-enyl-1,2,4,5,6,7,7a,13-octahydro-4,12-methanobenzofuro [3,2-e] isoquinoline-4a,9-diol	●	●		●	●	●	5	
Naloxone*	(4r,4as,7ar,12bs)-4a,9-dihydroxy-3-prop-2-enyl-2,4,5,6,7a,13-hexahydro-1h-4,12-methanobenzofuro[3,2-e] isoquinolin-7-one	●	●		●	●	●	5	
Naltrexone*	(4r,4as,7ar,12bs)-3-(cyclopropylmethyl)-4a,9-dihydroxy-2,4,5,6,7a,13-hexahydro-1 h-4,12-methanobenzofuro[3,2-e] isoquinolin-7-one	●	●		●	●		4	
Naltriben	(1S,2S,13R,21R)-22-(cyclopropylmethyl)-11,14-dioxa-22-azaheptacyclo[13.9.1.01,13.02,21.04,12.05,10.019,25] pentacosa-4(12),5,7,9,15,17,19(25)-heptaene-2,16-diol						●	1	
Naltrindole	(1S,2S,13R,21R)-22-(cyclopropylmethyl)-14-oxa-11,22-diazaheptacyclo [13.9.1.01,13.02,21.04,12.05,10.019,25]pentacosa-4 (12),5,7,9,15,17,19(25)-heptaene-2,16-diol						●	1	
Narceine	6-[2-[6-[2-(dimethylamino)ethyl]-4-methoxy-1,3-benzodioxol-5-yl]acetyl]-2,3-dimethoxybenzoic acid				●	●		2	

(Continues)

TABLE A1 (Continued)

Index name	IUPAC	BNF	ATC	INCB	Merck	Martindale	GtoP	Total	Other
Nexeridine*	[1-[1-(dimethylamino)propan-2-yl]-2-phenylcyclohexyl] acetate							0	INN
Nicocodine*	[(4r,4ar,7s,7ar,12bs)-9-methoxy-3-methyl-2,4,4a,7,7a,13-hexahydro-1h-4,12-methanobenzofuro [3,2-e] isoquinolin-7-yl] pyridine-3-carboxylate			●		●		2	
Nicodicodine*	[(4r,4ar,7s,7ar,12bs)-9-methoxy-3-methyl-2,4,4a,5,6,7,7a,13-octahydro-1h-4,12-methanobenzofuro [3,2-e] isoquinolin-7-yl] pyridine-3-carboxylate			●				1	
Nicomorphine*	[(4r,4ar,7s,7ar,12bs)-3-methyl-9-(pyridine-3-carbonyloxy)-2,4,4a,7,7a,13-hexahydro-1 h-4,12-methanobenzofuro [3,2-e]isoquinolin-7-yl] pyridine-3-carboxylate		●	●	●	●		4	
Noracymethadol*	[6-(methylamino)-4,4-diphenylheptan-3-yl] acetate			●	●			2	
Norcodeine*	(4r,4ar,7s,7ar,12bs)-9-methoxy-1,2,3,4,4a,7,7a,13-octahydro-4,12-methanobenzofuro[3,2-e]isoquinolin-7-ol			●	●			2	
Norlevorphanol*	17-azatetracyclo[7.5.3.01,10.02,7] heptadeca-2(7),3,5-trien-4-ol			●	●			2	
Normethadone*	6-(dimethylamino)-4,4-diphenylhexan-3-one		●	●	●			3	
Normorphine*	(4r,4ar,7s,7ar,12bs)-1,2,3,4,4a,7,7a,13-octahydro-4,12-methanobenzofuro[3,2-e] isoquinoline-7,9-diol			●	●		●	3	
Norpipanone*	4,4-diphenyl-6-piperidin-1-ylhexan-3-one			●	●			2	
Noscapine*	(3s)-6,7-dimethoxy-3-[(5r)-4-methoxy-6-methyl-7,8-dihydro-5h-[1,3]dioxolo[4,5-g]isoquinolin-5-yl]-3h-2-benzofuran-1-one		●		●	●	●	4	
Ocfentanil*	n-(2-fluorophenyl)-2-methoxy-n-[1-(2-phenylethyl)piperidin-4-yl] acetamide			●				1	
Ohmefentanyl	n-[1-(2-hydroxy-2-phenylethyl)-3-methylpiperidin-4-yl]-n-phenylpropanamide			●				1	
Oliceridine*	n-[(3-methoxythiophen-2-yl)methyl]-2-[(9r)-9-pyridin-2-yl-6-oxaspiro[4.5]decan-9-yl] ethanamine						●	1	(32)
Oripavine	(4r,7ar,12bs)-7-methoxy-3-methyl-2,4,7a,13-tetrahydro-1h-4,12-methanobenzofuro[3,2-e] isoquinolin-9-ol		●	●	●			3	
Orthofluorofentanyl	n-(2-fluorophenyl)-n-[1-(2-phenylethyl)piperidin-4-yl] propanamide			●				1	
Oxilorphan*	(1s,9r,10s)-17-(cyclopropylmethyl)-17-azatetracyclo [7.5.3.01,10.02,7] heptadeca-2(7),3,5-triene-4,10-diol							0	(33,34)
Oxpheneridine*	Ethyl 1-(2-hydroxy-2-phenylethyl)-4-phenylpiperidine-4-carboxylate							0	(35)

TABLE A1 (Continued)

Index name	IUPAC	BNF	ATC	INCB	Merck	Martindale	GtoP	Total	Other
Oxycodone*	(4r,4as,7ar,12bs)-4a-hydroxy-9-methoxy-3-methyl-2,4,5,6,7a,13-hexahydro-1h-4,12-methanobenzofuro[3,2-e] isoquinolin-7-one	●	●	●	●	●	●	6	
Oxymorphone*	(4r,4as,7ar,12bs)-4a,9-dihydroxy-3-methyl-2,4,5,6,7a,13-hexahydro-1h-4,12-methanobenzofuro[3,2-e] isoquinolin-7-one			●	●	●	●	4	
Papaveretum	(4r,4ar,7s,12bs)-9-methoxy-3-methyl-2,4,4a,7,7a,13-hexahydro-1h-4,12-methanobenzofuro [3,2-e]isoquinolin-7-ol;(4r,4ar,7s,12bs)-3-methyl-2,4,4a,7,7a,13-hexahydro-1h-4,12-methanobenzofuro [3,2-e] isoquinoline-7,9-diol;1-[(3,4-dimethoxyphenyl) methyl]-6,7-dimethoxyisoquinoline; hydrochloride	●	●		●	●		4	
Parafluorobutyrylfentanyl	n-(4-fluorophenyl)-n-[1-(2-phenylethyl)piperidin-4-yl] butanamide			●				1	
Parafluorofentanyl	n-(4-fluorophenyl)-n-[1-(2-phenylethyl)piperidin-4-yl] propanamide			●				1	
Pentamorphone*	(4r,4as,7ar,12br)-9-hydroxy-3-methyl-4a-(pentylamino)-2,4,7a,13-tetrahydro-1h-4,12-methanobenzofuro[3,2-e] isoquinolin-7-one					●		1	
Pentazocine*	(1r,9r,13r)-1,13-dimethyl-10-(3-methylbut-2-enyl)-10-azatricyclo[7.3.1.02,7] trideca-2(7),3,5-trien-4-ol	●	●		●	●	●	5	
Pepap	[4-phenyl-1-(2-phenylethyl)piperidin-4-yl] acetate			●				1	
Pethidine*	Ethyl 1-methyl-4-phenylpiperidine-4-carboxylate	●	●	●	●	●	●	6	
Phenadoxone*	6-morpholin-4-yl-4,4-diphenylheptan-3-one			●	●			2	
Phenampromide*	n-phenyl-n-(1-piperidin-1-ylpropan-2-yl) propenamide			●	●			2	
Phenazocine*	1,13-dimethyl-10-(2-phenylethyl)-10-azatricyclo[7.3.1.02,7] trideca-2(7),3,5-trien-4-ol		●	●	●	●		4	
Pheneridine*	Ethyl 4-phenyl-1-(2-phenylethyl)piperidine-4-carboxylate							0	INN
Phenomorphan*	(1r,9r,10r)-17-(2-phenylethyl)-17-azatetracyclo [7.5.3.01,10.02,7]heptadeca-2(7),3,5-trien-4-ol			●	●			2	
Phenoperidine*	Ethyl 1-(3-hydroxy-3-phenylpropyl)-4-phenylpiperidine-4-carboxylate		●	●	●	●		4	
Pholcodine*	(4r,4ar,7s,7ar,12bs)-3-methyl-9-(2-morpholin-4-ylethoxy)-2,4,4a,7,7a,13-hexahydro-1 h-4,12-methanobenzofuro [3,2-e] isoquinolin-7-ol	●	●	●	●		●	5	
Picenadol*	3-[(3r,4s)-1,3-dimethyl-4-propylpiperidin-4-yl]phenol					●		1	
Piminodine*	Ethyl 1-(3-anilinopropyl)-4-phenylpiperidine-4-carboxylate			●	●			2	
Pinadoline*	3-chloro-n'-(5-chloropentanoyl)-6h-benzo[b][1,4] benzoxazepine-5-carbohydrazide							0	INN

(Continues)

TABLE A1 (Continued)

Index name	IUPAC	BNF	ATC	INCB	Merck	Martindale	GtoP	Total	Other
Piritramide*	1-(3-cyano-3,3-diphenylpropyl)-4-piperidin-1-ylpiperidine-4-carboxamide		●	●	●	●		4	
Prodine	(1,3-dimethyl-4-phenylpiperidin-4-yl) propanoate							0	(36)
Proheptazine*	(1,3-dimethyl-4-phenylazepan-4-yl) propanoate			●	●			2	
Properidine*	Propan-2-yl 1-methyl-4-phenylpiperidine-4-carboxylate			●				1	
Propiram*	n-(1-piperidin-1-ylpropan-2-yl)-n-pyridin-2-ylpropanamide			●	●	●		3	
Proxorphan*	(1s,9r,10r)-17-(cyclopropylmethyl)-13-oxa-17-azatetracyclo[7.5.3.01,10.02,7] heptadeca-2(7),3,5-trien-4-ol							0	(37)
Quadazocine*	1-cyclopentyl-5-[(1s,9r)-4-hydroxy-1,10,13-trimethyl-10-azatricyclo[7.3.1.02,7]trideca-2(7),3,5-trien-13-yl] pentan-3-one						●	1	
r-30 490	n-[4-(methoxymethyl)-1-(2-phenylethyl)piperidin-4-yl]-n-phenylpropanamide							0	(38)
Remifentanil*	Methyl 1-(3-methoxy-3-oxopropyl)-4-(n-propanoylanilino) piperidine-4-carboxylate	●	●	●	●	●	●	6	
Sameridine*	n-ethyl-1-hexyl-n-methyl-4-phenylpiperidine-4-carboxamide							0	(39)
Semorphone*	(4r,4as,7ar,12bs)-4a,9-dihydroxy-3-(2-methoxyethyl)-2,4,5,6,7a,13-hexahydro-1h-4,12-methanobenzofuro[3,2-e] isoquinolin-7-one							0	(40)
Spiradoline*	2-(3,4-dichlorophenyl)-n-methyl-n-[(5r,7s,8s)-7-pyrrolidin-1-yl-1-oxaspiro[4.5]decan-8-yl]acetamide					●	●	2	
Sufentanil*	n-[4-(methoxymethyl)-1-(2-thiophen-2-ylethyl)piperidin-4-yl]-n-phenylpropanamide		●	●	●	●	●	5	
Tapentadol*	3-[(2r,3r)-1-(dimethylamino)-2-methylpentan-3-yl]phenol	●	●		●	●	●	5	
Tetrahydrofuranylfentanyl	n-phenyl-n-[1-(2-phenylethyl)piperidin-4-yl]oxolane-2-carboxamide			●				1	
Tetramethylcyclopropylfentanyl	2,2,3,3-tetramethyl-n-(1-phenethylpiperidin-4-yl)-n-phenylcyclopropane-1-carboxamide							0	(41)
Thebacon*	[(4r,4ar,7ar,12bs)-9-methoxy-3-methyl-2,4,4a,5,7a,13-hexahydro-1h-4,12-methanobenzofuro[3,2-e]isoquinolin-7-yl] acetate		●	●	●			3	
Thebaine	(4r,7ar,12bs)-7,9-dimethoxy-3-methyl-2,4,7a,13-tetrahydro-1h-4,12-methanobenzofuro[3,2-e] isoquinoline			●	●			2	
Thiafentanil	Methyl 4-(n-(2-methoxyacetyl)anilino)-1-(2-thiophen-2-ylethyl)piperidine-4-carboxylate							0	(42)
Thiofentanyl	n-phenyl-n-[1-(2-thiophen-2-ylethyl)piperidin-4-yl] propanamide			●				1	

TABLE A1 (Continued)

Index name	IUPAC	BNF	ATC	INCB	Merck	Martindale	GtoP	Total	Other
Tianeptine*	7-[(3-chloro-6-methyl-5,5-dioxo-11 h-benzo[c][2,1] benzothiazepin-11-yl)amino]heptanoic acid				●			1	(43)
Tilidine*	Ethyl (1s,2r)-2-(dimethylamino)-1-phenylcyclohex-3-ene-1-carboxylate		●	●	●	●		4	
Tipp-psi	(2S)-2-[[(2S)-2-[[(3S)-2-[(2S)-2-amino-3-(4-hydroxyphenyl) propanoyl]-3,4-dihydro-1H-isoquinolin-3-yl]methylamino]-3-phenylpropanoyl]amino]-3-phenylpropanoic acid						●	1	
Tonazocine*	1-[(1r,9s,13s)-4-hydroxy-1,10,13-trimethyl-10-azatricyclo [7.3.1.02,7]trideca-2(7),3,5-trien-13-yl]octan-3-one							0	(44)
Tramadol*	(1r,2r)-2-[(dimethylamino)methyl]-1-(3-methoxyphenyl) cyclohexan-1-ol	●	●		●	●	●	5	
Trefentanil*	n-[1-[2-(4-ethyl-5-oxotetrazol-1-yl)ethyl]-4-phenylpiperidin-4-yl]-n-(2-fluorophenyl)propanamide					●		1	
Trimebutine*	[2-(dimethylamino)-2-phenylbutyl] 3,4,5-trimethoxybenzoate		●		●			2	
Trimeperidine*	(1,2,5-trimethyl-4-phenylpiperidin-4-yl) propanoate			●	●	●		3	
u-47 700	3,4-dichloro-n-[2-(dimethylamino)cyclohexyl]-n-methylbenzamide			●				1	
Valerylfentanyl	n-phenyl-n-[1-(2-phenylethyl)piperidin-4-yl] pentanamide			●				1	
Veradoline*	4-[2-(6,7-dimethoxy-1-methyl-3,4-dihydro-1h-isoquinolin-2-yl) ethyl]aniline							0	INN
Volazocine*	10-(cyclopropylmethyl)-1,13-dimethyl-10-azatricyclo [7.3.1.02,7]trideca-2,4,6-triene							0	(45)
Xorphanol*	(1r,9r,10r,11s)-17-(cyclobutylmethyl)-11-methyl-13-methylidene-17-azatetracyclo [7.5.3.01,10.02,7] heptadeca-2(7),3,5-trien-4-ol							0	(46)

*Names identified in the INN search (n = 170); if there was no INN name, the BAN or the name reported in the BNF was selected, otherwise the next most common drug name was selected.
Abbreviations: ATC, Anatomical Therapeutic Classification; BNF, British National Formulary; GtoP, IUPHAR/BPS Guide to Pharmacology; INCB, International Narcotic Control Board; INN, International Non-proprietary Names; IUPAC, International Union of Pure and Applied Chemistry.

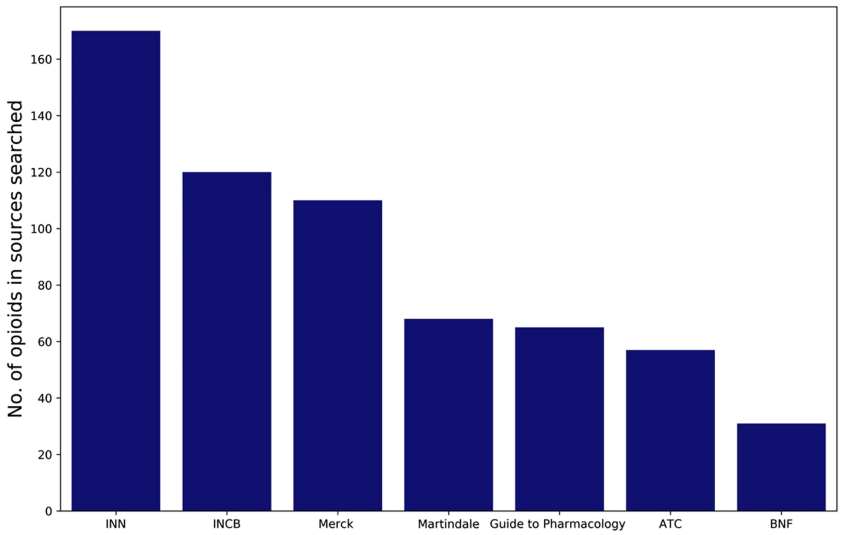

FIGURE A1 The number of opioid drugs identified in the seven databases searched to create phase one of the Oxford Catalogue of Opioids

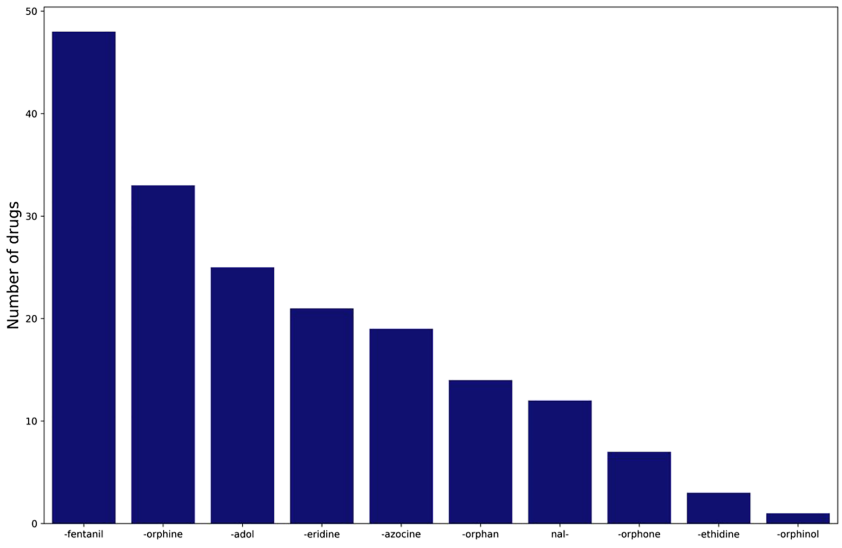

FIGURE A2 Ten stems of the drugs in the Oxford Catalogue of Opioids

REFERENCES FOR APPENDIX

1. Helander A, Bäckberg M, Signell P, Beck O. **Intoxications involving acrylfentanyl and other novel designer fentanyls-results from the Swedish STRIDA project**. Clin Toxicol [Internet]. 2017 Jul 3 [cited 2020 Nov 17];55 (6):589-599.Available from: https://pubmed.ncbi.nlm.nih.gov/28349714/
2. Kudzma LV, Severnak SA, Benyenga MJ, et al. **4-Phenyl- and 4-Heteroaryl-4-anilidopiperidines. A Novel Class of Analgesic and Anesthetic Agents**. J Med Chem [Internet]. 1989 Dec 1[cited 2020 Nov 17];32(12):2534-2542.Available from: https://pubs.acs.org/sharingguidelines
3. Rives ML, Rossillo M, Liu-Chen LY, Javitch JA. **6′-Guanidinonaltrindole (6′-GNTI) is a G protein-biased κ-opioid receptor agonist that inhibits arrestin recruitment**. J Biol Chem [Internet]. 2012 Aug 3[cited 2020 Oct 31];287(32):27050-27054. Available from: https://pubmed.ncbi.nlm.nih.gov/22736766/
4. Barber A, Gottschlich R. **Novel developments with selective, non-peptidic kappa-opioid receptor agonists [Internet]. Vol. 6, Expert Opinion on Investigational Drugs**. Expert Opin Investig Drugs. 1997[cited 2020 Nov 17];1351-1368.Available from: https://pubmed.ncbi.nlm.nih.gov/15989506/
5. Guenther S, Mickle TC, Barrett AC, et al. **Pharmacokinetics and Abuse Potential of Asalhydromorphone, a Novel Prodrug of Hydromorphone, after Intranasal Administration in Recreational Drug Users**. Pain Med (United States) [Internet]. 2020 Mar 1[cited 2020 Oct 31];201(3):511-520.Available from: https://pubmed.ncbi.nlm.nih.gov/30986302/
6. Mustafa AA, Rajan R, Suarez JD, Alzghari SK. **A Review of the Opioid Analgesic Benzhydrocodone-Acetaminophen**. Cureus [Internet]. 2018 Jun 20[cited 2020 Nov 1];10(6). Available from: https://pubmed.ncbi.nlm.nih.gov/30140595/
7. Mickle TC, Guenther SM, Barrett AC, et al. **Pharmacokinetics and abuse potential of benzhydrocodone, a novel prodrug of**

hydrocodone, after intranasal administration in recreational drug users. Pain Med (United States) [Internet]. 2018[cited 2020 Nov 1];19(12):2438-2449.Available from: https://pubmed.ncbi.nlm.nih.gov/29092079/

8. Guenther SM, Mickle TC, Barrett AC, Roupe KA, Zhou J, Lam V. **Relative bioavailability, intranasal abuse potential, and safety of benzhydrocodone/acetaminophen compared with hydrocodone bitartrate/acetaminophen in recreational drug abusers**. Pain Med (United States) [Internet]. 2018 May 1[cited 2020 Nov 1];19(5):955-966.Available from: https://pubmed.ncbi.nlm.nih.gov/29025138/
9. Varshneya NB, Walentiny DM, Moisa LT, Walker TD, Akinfiresoye LR, Beardsley PM. **Opioid-like antinociceptive and locomotor effects of emerging fentanyl-related substances**. Neuropharmacology [Internet]. 2019 Jun 1[cited 2020 Nov 17];151:171-179.Available from: https://pubmed.ncbi.nlm.nih.gov/30904478/
10. Noble C, Weihe Dalsgaard P, Stybe Johansen S, Linnet K. **Application of a screening method for fentanyl and its analogues using UHPLC-QTOF-MS with data-independent acquisition (DIA) in MS ^{E} mode and retrospective analysis of authentic forensic blood samples**. Drug Test Anal [Internet]. 10(4): 2018 Apr 1[cited 2020 Nov 17], 651-662.Available from: http://doi.wiley.com/10.1002/dta.2263
11. Ruangyuttikarn W, Law MY, Rollins DEO, Moody DE. **Detection of fentanyl and its analogs by enzyme-linked immunosorbent assay**. J Anal Toxicol [Internet]. 1990 May 1[cited 2020 Nov 17];14(3):160-164.Available from: https://academic.oup.com/jat/article/14/3/160/752051
12. Moody MT, Diaz S, Shah P, Papsun D, Logan BK. **Analysis of fentanyl analogs and novel synthetic opioids in blood, serum/plasma, and urine in forensic casework**. Drug Test Anal [Internet]. 2018 Sep 1[cited 2020 Nov 18];10(9):1358-1367.Available from: http://doi.wiley.com/10.1002/dta.2393
13. Fogarty MF, Papsun DM, Logan BK. **Analysis of Fentanyl and 18 Novel Fentanyl Analogs and Metabolites by LC-MS-MS, and report of Fatalities Associated with Methoxyacetylfentanyl and Cyclopropylfentanyl**. J Anal Toxicol [Internet]. 2018 Nov 1[cited 2020 Nov 18];42(9):592-604.Available from: https://pubmed.ncbi.nlm.nih.gov/29750250/
14. Hayes AG, Skingle M, Tyers MB. **Evaluation of the receptor selectivities of opioid drugs by investigating the block of their effect on urine output by β-funaltrexamine**. J Pharmacol Exp Ther [Internet]. 1987[cited 2020 Nov 1];240(3):984-988.Available from: https://pubmed.ncbi.nlm.nih.gov/3559988/
15. Verougstraete N, Vandeputte MM, Lyphout C, et al. **First Report on Brorphine: The Next Opioid on the Deadly New Psychoactive Substances' Horizon?** J Anal Toxicol [Internet]. 2020 Aug 3[cited 2020 Nov 18];2020(00):1-10.Available from: https://academic.oup.com/jat/advance-article/doi/10.1093/jat/bkaa094/5879253
16. Ding H, Czoty PW, Kiguchi N, et al. **A novel orvinol analog, BU08028, as a safe opioid analgesic without abuse liability in primates**. Proc Natl Acad Sci U S A [Internet]. 2016 Sep 13[cited 2020 Oct 21];113(37):E5511-E5518.Available from: https://pubmed.ncbi.nlm.nih.gov/27573832/
17. James RW, Heywood R, Crook D. **Reversible suppression of spermiogenesis in Beagle dogs following overdosage with the narcotic analgesic cogazocine lactate**. Toxicology [Internet]. 1980 [cited 2020 Nov 4];16(3):193-203.Available from: https://pubmed.ncbi.nlm.nih.gov/6106974/
18. Wilde M, Pichini S, Pacifici R, et al. **Metabolic pathways and potencies of new fentanyl analogs [Internet]. Vol. 10, Frontiers in Pharmacology**. Frontiers Media SA. 2019[cited 2020 Oct 31]. Available from: /pmc/articles/PMC6461066/?report=abstract
19. Zebala JA, Searle SL, Webster LR, et al. **Desmetramadol Has the Safety and Analgesic Profile of Tramadol Without Its Metabolic Liabilities: Consecutive Randomized, Double-Blind, Placebo- and Active Comparator-Controlled Trials**. J Pain [Internet]. 2019 Oct 1[cited 2020 Nov 4];20(10):1218-1235.Available from: https://pubmed.ncbi.nlm.nih.gov/31005596/
20. Houdi AA, Kottayil S, Crooks PA, Butterfield DA. **3-O-Acetylmorphine-6-O-Sulfate: A potent, centrally acting morphine derivative**. Pharmacol Biochem Behav [Internet]. 1996 [cited 2020 Nov 4];53(3):665-671.Available from: https://pubmed.ncbi.nlm.nih.gov/8866970/
21. Chang T-K, Huang C-W, Su W-C, et al. **Extended-Release Dinalbuphine Sebacate Versus Intravenous Patient-Controlled Analgesia with Fentanyl for Postoperative Moderate-to-Severe Pain: A Randomized Controlled Trial**. Pain Ther [Internet]. 2020 Sep 29[cited 2020 Nov 5]. Available from: https://pubmed.ncbi.nlm.nih.gov/32990938/
22. Lee SO, Huang LP, Wong CS. **Preoperative administration of extended-release dinalbuphine sebacate compares with morphine for post-laparoscopic cholecystectomy pain management: A randomized study**. J Pain Res [Internet]. 2020[cited 2020 Nov 5];13:2247-2253.Available from: https://pubmed.ncbi.nlm.nih.gov/32982387/
23. Spaulding T, Fielding S, Cornfeldt M, et al. **Fluradoline (HP 494), a centrally acting analgesic with antidepressant properties: Antidepressant pharmacology**. Drug Dev Res [Internet]. 1985 Jan 1 [cited 2020 Nov 18];5(3):207-215.Available from: http://doi.wiley.com/10.1002/ddr.430050303
24. Gelders YG, De Ranter CJ, Schenk H. **Structural studies of substituted 6,7-benzomorphan compounds. I. The absolute configuration of (−)-2-cyclopropylmethyl-2′-hydroxy-5-ethyl-9,-9-dimethyl-6,7-benzomorphan (gemazocine) hydrobromide**. Acta Crystallogr Sect B Struct Crystallogr Cryst Chem [Internet]. 1979 Mar 1[cited 2020 Nov 6];35(3):699-703.Available from: //scripts.iucr.org/cgi-bin/paper?a17358
25. Goicoechea C, Sánchez E, Cano C, Jagerovic N, Martín MI. **Analgesic activity and pharmacological characterization of N-[1-phenylpyrazol-3-yl]-N-[1-(2-phenethyl)-4-piperidyl] propenamide, a new opioid agonist acting peripherally**. Eur J Pharmacol [Internet]. 2008 Oct 24[cited 2020 Nov 18];595(1-3):22-29.Available from: https://pubmed.ncbi.nlm.nih.gov/18706410/

26. Watanabe S, Vikingsson S, Roman M, Green H, Kronstrand R, Wohlfarth A. **In Vitro and In Vivo Metabolite Identification Studies for the New Synthetic Opioids Acetylfentanyl, Acrylfentanyl, Furanylfentanyl, and 4-Fluoro-Isobutyrylfentanyl**. AAPS J [Internet]. 2017 Jul 1 [cited 2020 Nov 6];19 (4):1102-22. Available from: https://pubmed.ncbi.nlm.nih.gov/28382544/
27. Telford GL, Caudill A, Condon RE, Szurszewski JH. **Ketocyclazocine, a κ-opioid receptor agonist, and control of intestinal myoelectric activity in dogs**. Am J Physiol - Gastrointest Liver Physiol [Internet]. 1988[cited 2020 Nov 6];255(5). Available from: https://pubmed.ncbi.nlm.nih.gov/2847542/
28. Mannelli P, Janiri L, De Marinis M, Tempesta E. **Lefetamine: new abuse of an old drug - clinical evaluation of opioid activity**. Drug Alcohol Depend. 1989 Oct 1;24(2):95-101.
29. France C, Winger G, Medzihradsky F, Seggel M, Rice K, Woods J. **Mirfentanil: pharmacological profile of a novel fentanyl derivative with opioid and nonopioid effects**. J Pharmacol Exp Ther [Internet]. 1991[cited 2020 Nov 6], 258;(2):502-510.Available from: https://pubmed.ncbi.nlm.nih.gov/1650830/
30. Hayes AG, Sheehan MJ, Tyers MB. **Differential sensitivity of models of antinociception in the rat, mouse and guinea-pig to μ-and κ-opioid receptor agonists**. Br J Pharmacol [Internet]. 1987 Aug[cited 2020 Nov 9];91(4):823-32. Available from: /pmc/articles/PMC1853585/?report=abstract
31. Forrest WH, Shroff PF, Mahler DL. **Analgesic and other effects of nalmexone in man**. Clin Pharmacol Ther [Internet]. 1972 Jul 1 [cited 2020 Nov 9];13(4):520-525.Available from: http://doi.wiley.com/10.1002/cpt1972134520
32. Viscusi ER, Skobieranda F, Soergel DG, Cook E, Burt DA, Singla N. **APOLLO-1: A randomized placebo and activecontrolled phase iii study investigating oliceridine (TRV130), a G protein-biased ligand at the μ-opioid receptor, for management of moderatetosevere acute pain following bunionectomy**. J Pain Res [Internet]. 2019[cited 2020 Nov 9];12:927-943.Available from: https://pubmed.ncbi.nlm.nih.gov/30881102/
33. Leander J. **Evidence that nalorphine, butorphanol and oxilorphan are partial agonists at a κ-opioid receptor**. Eur J Pharmacol. 1983;86(3-4):467-470.
34. Pircio A, Gylys J. **Oxilorphan (l-N-cyclopropylmethyl-3,-14-dihydroxymorphinan): a new synthetic narcotic antagonist**. J Pharmacol Exp Ther [Internet]. 1975[cited 2020 Nov 9]. Available from: https://pubmed.ncbi.nlm.nih.gov/237112/
35. Janssen P A J, Eddy NB. **Compounds Related to Pethidine—IV. New General Chemical Methods of Increasing the Analgesic Activity of Pethidine**. J Med Chem [Internet]. 1960 [cited 2020 Nov 10];2 (1):31-45.Available from: https://pubs.acs.org/doi/abs/10.1021/jm50008a003
36. Loew GH, Jester JR. Quantum Chemical Studies of Meperidine and ProdineJ Med Chem [Internet. 1975 Nov 1[cited 2020 Nov 10];18(11):1051-1056.Available from: https://pubmed.ncbi.nlm.nih.gov/1177250/
37. Hayes A, Birch P. **Reversal by β-funaltrexamine and 16-methyl cyprenorphine of the antinociceptive effects of opioid agonists in the mouse and guinea-pig**. Neuropharmacology. 1988;27 (8):813-816.
38. Meert TF. **Pharmacotherapy of opioids: Present and future developments [Internet]**. Vol 18, Phar Wor Sci Springer. 1996[cited 2020 Nov 10];1-15.Available from: https://link.springer.com/article/10.1007/BF00449683
39. Mulroy MF, Greengrass R, Ganapathy S, Chan V, Heierson A. **Sameridine Is Safe and Effective for Spinal Anesthesia**. Anesth Analg [Internet]. 1999 Apr[cited 2020 Nov 10];88(4):815-821.Available from: http://journals.lww.com/00000539-199904000-00025
40. Behne M, Bremerich D, Heinrich J, Schumacher H, Scherer M. **Respiratory effects and tolerability of Mr 2264 Cl - A new opiate partial agonist in comparison with morphine and placebo**. Eur J Clin Pharmacol [Internet]. 1994 Jul[cited 2020 Nov 10];46(4):301-304.Available from: https://link.springer.com/article/10.1007/BF00194395
41. Åstrand A, Vikingsson S, Jakobsen I, Björn N, Kronstrand R, Gréen H. **Activation of the μ-opioid receptor by alicyclic fentanyls: Changes from high potency full agonists to low potency partial agonists with increasing alicyclic substructure**. Drug Test Anal [Internet]. 2020[cited 2020 Nov 11]. Available from: https://pubmed.ncbi.nlm.nih.gov/32749741/
42. Armenian P, Vo KT, Barr-Walker J, Lynch KL. **Fentanyl, fentanyl analogs and novel synthetic opioids: A comprehensive review**. Neuropharmacology [Internet]. 2018 May 15[cited 2020 Nov 11];134(Pt A):121-132.Available from: https://pubmed.ncbi.nlm.nih.gov/29042317/
43. Samuels BA, Nautiyal KM, Kruegel AC, et al. **The Behavioral Effects of the Antidepressant Tianeptine Require the Mu-Opioid Receptor**. Neuropsychopharmacology [Internet]. 2017 Sep 1 [cited 2020 Nov 11];42(10):2052-2063.Available from: /pmc/articles/PMC5561344/?report=abstract
44. Ward SJ, Pierson AK, Michne WF. **Pharmacological profiles of tonazocine (Win 42 156) and zenazocine (Win 42 964)**. Neuropeptides. 1985;5(4-6):375-378.
45. Lynn R, Smith R, Leger R, Deinzer M, Griffin D, Gerber N. **Identification of glucuronide metabolites of benzomorphan narcotic analgesic drugs in bile from the isolated perfused rat liver by gas chromatography and mass spectrometry**. Drug Metab Dispos [Internet]. 1977[cited 2020 Nov 11];5(1):47-55.Available from: https://pubmed.ncbi.nlm.nih.gov/13975/
46. Howes JF, Villarreal JE, Harris LS, Essigmann EM, Cowan A. **Xorphanol**. Drug Alcohol Depend [Internet]. 1985[cited 2020 Nov 11];14(3-4):373-380.Available from: https://pubmed.ncbi.nlm.nih.gov/4039650/