

Drug Interaction Solutions

Transforming scientific data into clinical knowledge

Who we are

We are a team of pharmaceutical scientists, pharmacists, and clinicians who together bring over 180 years of cumulative expertise in drug metabolism, transport, pharmacokinetics (PK), drug interactions, and clinical pharmacology.

The Metabolism & Transport Drug Interaction Database program (now Drug Interaction Solutions) was founded at the University of Washington in the late 1990s, after recognizing the advances made in the field of *in vitro* to *in vivo* predictions and the need for more widespread knowledge about the risks of drug interactions. The program was acquired by Certara in June of 2023.

The database subscription program started in 2002. Over the years, the database content was expanded with the addition of pharmacogenetics, food-effect studies, organ impairment data, and additional mechanisms of PK-based drug interactions such as absorption-based interactions.

All curation activities and editorial tasks are performed in-house with a team that is dedicated to the overall platform, identified as the Drug Interaction Database (DIDB®), and user support.

MEET THE TEAM DRUG INTERACTION SOLUTIONS

Isabelle Ragueneau-Majlessi, MD, MS, Co-Founder & Senior Director

Jingjing Yu, MD, PhD, Associate Director

Sophie Argon, PharmD, MS, Scientist

Katie Owens, BPharm, PhD, Scientist

Ichiko Petrie, PharmD, Scientist

Jessica Tay-Sontheimer, PhD, Scientist

Yan Wang, MS, Scientist

Christy Watson, MS, Associate Scientist

Cheryl Wu, PhD, Scientist

Marie C. Bodinier, MS, Marketing & Customer Experience

Chris Kinsella, Software Development

DRUG INTERACTION DATABASE LICENSING:

Contact: DIDBase@Certara.com

Our Recent Publications

SEEING WHAT IS BEHIND THE SMOKE SCREEN: A SYSTEMATIC REVIEW OF METHODOLOGICAL ASPECTS OF SMOKING INTERACTION STUDIES OVER THE LAST THREE DECADES AND IMPLICATIONS FOR FUTURE CLINICAL TRIALS

Robert Hermann, Amin Rostami-Hodjegan, Ping Zhao, Isabelle Ragueneau-Majlessi

Clin Transl Sci. 2023 May;16(5):742-758

STRONG PHARMACOKINETIC DRUG-DRUG INTERACTIONS WITH DRUGS APPROVED BY THE US FOOD AND DRUG ADMINISTRATION IN 2021: MECHANISMS AND CLINICAL IMPLICATIONS

Jingjing Yu, Yan Wang, Isabelle Ragueneau-Majlessi

Clin Ther. 2022 Nov;44(11):1536-1544

EVALUATING THE FEASIBILITY OF PERFORMING PHARMACOGENETIC GUIDED-MEDICATION THERAPY MANAGEMENT IN A RETIREMENT COMMUNITY: A PROSPECTIVE, SINGLE ARM STUDY

Lena Chaitesipaseut, Jennifer Wilson Norton, Kristen Trivelli, Sophie M.A. Argon, Ichiko D. Petrie, Isabelle Ragueneau-Majlessi, Tamatha Mikes, Hao Nguyen, Beth Devine

J Am Coll Clin Pharm. 2022;5(3):291-301

PHARMACOKINETIC DRUG-DRUG INTERACTIONS WITH DRUGS APPROVED BY THE U.S. FOOD AND DRUG ADMINISTRATION IN 2020: MECHANISTIC UNDERSTANDING AND CLINICAL RECOMMENDATIONS

Jingjing Yu, Yan Wang, Isabelle Ragueneau-Majlessi

Drug Metab Dispos. 2022 Jan;50(1):1-7

EXPLORING THE RELATIONSHIP OF DRUG BCS CLASSIFICATION, FOOD EFFECT, AND GASTRIC PH-DEPENDENT DRUG INTERACTIONS

Katie H. Owens, Sophie M.A. Argon, Jingjing Yu, Xinning Yang, Fang Wu, Sue-Chih Lee, Wei-Jhe Sun, Anuradha Ramamoorthy, Lei Zhang, Isabelle Ragueneau-Majlessi

AAPS J. 2021 Dec 27;24(1):16

ANALYSIS OF DRUG-DRUG INTERACTION LABELING LANGUAGE AND CLINICAL RECOMMENDATIONS FOR NEWLY APPROVED DRUGS EVALUATED WITH DIGOXIN, MIDAZOLAM, AND S-WARFARIN

Lindsay M. Henderson, Claire E. Steinbronn, Jingjing Yu, Catherine K. Yeung, Isabelle Ragueneau-Majlessi

Clin Ther. 2021 Nov;43(11):2032-2039

What we offer

Drug Interaction Solutions (www.druginteractionsolutions.org) is designed to support research and regulatory scientists in their decision-making when evaluating PK-based drug-drug interactions (DDIs), gene-drug interactions, and drug safety.

- Our main activity is the development of drug interaction content in DIDB®.
- We also provide customized clinical PK datasets to fit specific solutions.

DIDB® has the largest manually curated collection of qualitative and quantitative human *in vitro* and clinical (*in vivo*) information related to various extrinsic and intrinsic factors. These include interacting co-medications, excipients, food products, herbals, tobacco, organ impairment, and genetics, that can affect drug exposure in humans. Its easy-to-use web portal allows users to efficiently retrieve the most relevant and up-to-date information from the large body of publications and regulatory documentation.

Information on drug disposition available in DIDB® encompasses:

- *In vitro* drug metabolism, transport, and DDIs (involving metabolizing enzymes, transporters, and their variants)
- Clinical DDIs and case reports
- Clinical pharmacogenetics
- Other DDI mechanisms including clinical absorption-based interactions (e.g., food-effect, pH-dependence, etc.)
- Clinical hepatic and renal impairment

EXAMPLE OF QUERY

Over 70 queries

23,627 citations with 159,452 entries
496 NDA/BLAs with 14,193 entries

[All queries >>](#)

Resource center

Watch our video "DIDB - Comprehensive Demonstration"

Lists of substrates, inhibitors and inducers, tutorials, regulatory guidances, and more.

[Resources >>](#)

Citations recently published

PubMed 34402088	8 entries	2022 Feb
PubMed 34806331	4 entries	2022 Feb
PubMed 34656072	2 entries	2022 Feb
PubMed 34674222	1 entry	2022 Feb
PubMed 34689023	3 entries	2022 Jan

More recently published citations →

Monographs

Our detailed drug monographs contain summaries for DDI, QT, and PK as well as chemical structure depictions, links to external resources, and relationships to other compounds in DIDB.

[Monographs >>](#)

News

Data Curation and Entry in DIDB – January Summary
2/15/2022

[New Name and Additional Data for the CYP/P-gp Substrates and Perpetrators Lists: 1/18/2022](#)

Data Curation and Entry in DIDB – December Summary
1/18/2022

[Read more news →](#)

NDA/BLAs recently entered

Tralokinumab	2/3/2022
Inclisiran	2/3/2022
Efgartigimod alfa	2/2/2022
Maribavir	1/27/2022
Tezepelumab	1/20/2022

[View all NDA/BLAs entered →](#)

1

2

3

Drug considered as **object (victim)** or **precipitant (perpetrator)**

Monograph Find all studies **Objects** Precipitants Object and Precipitant Pair

Find all citations with **Objects**

Condition

Our expertise

In practice, we review the latest peer-reviewed publications as well as recent NDA/BLA reviews and drug labels from the FDA and select the content that is most relevant to support drug interaction evaluations at various stages of the drug development process.

We create detailed drug monographs that summarize the main mechanistic and quantitative findings including the drug characteristics, PK profile, DDI summary, QT summary, as well as information regarding the overall DDI risk level and label recommendations for clinical use.

We maintain an up-to-date Resource Center containing:

- A DDI Marker Studies Knowledgebase which includes known sensitive and moderate sensitive substrates, weak/moderate/strong perpetrators, based on available clinical evaluations with marker compounds
- A series of tutorial videos and user guides which describe the content and the functionality of the database, and show how to best retrieve the information of interest
- Regulatory guidances from the FDA, EMA, PMDA, and Health Canada

In addition to data curation, we share the results of our own research by contributing to workshops and conferences, and publishing articles and reviews on an ongoing basis.

We work closely with colleagues from various universities, regulatory agencies, and pharmaceutical companies on the most pressing issues and challenges in the field.

We assist the end-users of DIDB® with highly specific and detailed database searches and outputs, breaking down often complex mechanisms of drug interactions to enable efficient problem solving.

We continuously expand the database content and improve its functionality based on user feedback.

DRUG MONOGRAPH

maribavir

- General information
- Characteristics
- Pharmacokinetic profile
- DDI summary
- Main routes of elimination
- Main enzymes and associated interactions
- Main transporters and associated interactions
- Inhibition profile
- Induction profile
- Other DDIs
- QT summary
- Relationship to other compounds
- External resources

maribavir PubChem [PubChem](#) Print / Save as PDF

NDA 215596 43 studies III Study Food-Effect Study approval year: 2021

Therapeutic class: Anti-infective Agents → Antivirals

Brand name: LINTENCITY (tablets)

Indications and usage: LINTENCITY is a cytomegalovirus (CMV) pUL57 kinase inhibitor indicated for the treatment of adults and pediatric patients (12 years of age and older and weighing at least 35 kg) with post-transplant CMV infection/disease that is refractory to treatment (with or without genotypic resistance) with ganciclovir, valganciclovir, cidofovir, or foscarnet.

Clinical recommended dosage: 400 mg orally twice daily with or without food

Molecular weight: 376.24 g/mol

Biopharmaceutics class: Class II; High permeability - Low solubility
reference: NDA 215596 Product Quality Review(s)

[Q All studies containing maribavir](#)

DDI summary last updated 1/31/2022

DDI drug monograph DDI summaries are prepared when the drugs are FDA approved by the FDA and are based on the available toxicity data from clinical and pre-clinical studies. To review all clinical data, including data submitted voluntarily, use the full studies data.

NDA 215596 43 studies III Study Food-Effect Study approval date: 2021

Risk level as subject: Low

Risk level as perpetrator: Low to High

Key Highlights

Maribavir (LINTENCITY) was tested in a cytochrome P450 (CYP) pUL57 kinase inhibitor indicated for the treatment of adults and pediatric patients (12 years of age and older and weighing at least 35 kg) with post-transplant CMV infection/disease that is refractory to treatment with or without genotypic resistance with ganciclovir, valganciclovir, cidofovir, or foscarnet. The recommended dose is 400 mg orally twice daily with or without food (LINTENCITY Product Label).

In vitro studies suggest that maribavir is primarily metabolized by CYP3A4. In vivo, concurrent administration with fentanyl, a strong CYP3A4 substrate, increased maribavir AUC 1.2-fold. Based on in vitro screening and in vivo studies, co-administration with amphotericin B, a known CYP3A4 inhibitor, was predicted to increase maribavir AUC 1.6-fold. However, these changes are not reflected in the clinical data.

QT summary

Sources: ClinicalTrials.gov Clinical Reviews DrugLabel - Product Labels PubMed Central

Preclinical data:
In vitro, maribavir had no effect on QTc interval at 100 µg/mL.

Clinical data:
The QTc prolongation is through QT (QT) study

Measurement	Test	Positive control
Group Region	100 mg oral 1200 mg oral dose	400 mg single dose
Population	healthy volunteers	healthy volunteers
Mean change in QTc (P-R-T) (sec)	100 mg: 1.34 ± 1.22, 1200 mg: 3.11 ± 1.09 mg: 0.10 ± 0.16, 400 mg: 1.9	8.05 ± 0.41, 11.33 ± 3.31
Significance (p-value)	< 0.0001 (p-value) (p = 0.001)	

In a randomized, double-blind, placebo-controlled, four-period crossover through QT study in healthy volunteers, maribavir (100 mg and 1200 mg) did not prolong the QT interval in any clinically relevant manner. The supra-therapeutic dose of maribavir (1200 mg three times high) was not shown to affect QTc interval. The supra-therapeutic dose of maribavir (1200 mg three times high) was not shown to affect QTc interval. The supra-therapeutic dose of maribavir (1200 mg three times high) was not shown to affect QTc interval. The supra-therapeutic dose of maribavir (1200 mg three times high) was not shown to affect QTc interval.

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Characteristics

CYP3A4 weak inhibitor
CYP3A4 weak inhibitor
P-gp clinical inhibitor

In contrast to the DDI summary, which is mainly based on the NDA review at the time of the drug approval, Drug Characteristics are identified based on the most up-to-date information from the literature and/or drug labels, and may change when new information becomes available. Therefore, differences may exist between Drug Characteristics and the DDI summary. For more information on characteristics, see our full list of characteristics for all drugs see all our characteristics →

Pharmacokinetic profile

Accumulation ratio	1.37-1.47; steady state is reached within 2 days
BP	1.37 ± 0.13 (0.005-10 µg/mL)
Biopharmaceutics class	Class II: High permeability - Low solubility
C _{max}	45.72 µmol/L 17.2 (28-2%) µg/mL 400 mg orally twice daily in transplant patients with CMV
Clearance	2.85 L/h (transplant patients with CMV); 0.651 L/h (Llrenal)
Clinical recommended dosage	400 mg orally twice daily with or without food
Dose proportionality	yes - C _{max} and AUC increase approximately dose-proportionally at single doses of 50-1600 mg and at multiple doses up to 2400 mg/day; PK is time-independent
Elimination pathway	extensive metabolism
F _s	0.99
F _a	< 0.02 (oral)
F _{1st in vivo}	0.664 (CYP3A4), 0.336 (CYP1A2) - based on recombinant CYPs
F _{2nd in vivo}	0.25 (CYP3A4) - also a substrate of P-gp, this value back-calculated from the maximum AUCR with ketoconazole may overestimate its as ketoconazole also inhibits P-gp
F _{1st in vitro}	0.73 (human)
t _{1/2}	1.2 h
logP	2.86 at pH 7.4
Molecular weight	376.24 g/mol
Removability	5.6 × 10 ⁻⁴ cm ² /sec (Papp in Caco-2 cells)
pKa	5.2
Plasma protein binding	98% (0.05-200 µg/mL)

How we work



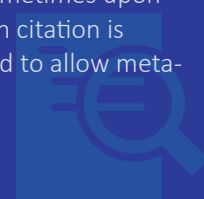
Selection of Citations

We identify the latest, most relevant publications and regulatory documents from NDA/BLA packages for manual curation.



Data Extraction

Prior to integration, the data is carefully and critically evaluated. When appropriate, and sometimes upon discussion with the study authors, comments are attached to the data. The richness of each citation is exploited, generating a highly detailed dataset. The data is formatted for immediate use and to allow meta-analysis of multiple sources.



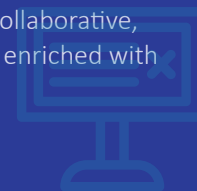
Data Entry and validation

Once entered into the database, the data is validated by a second curator, who thoroughly reviews the studies and citations to make sure all the relevant information has been accurately extracted and represented. Only then, is the data released and accessible to end-users.



Data release

This process, built over more than 20 years, has been mastered by the team, and is highly-collaborative, allowing the database to be updated with new information daily, and the applications to be enriched with new scientific findings as soon as they become available.



Thorough standard operating procedures support the selection, distribution, data entry, and data validation of citations in DIDB[®].

DIDB[®] BY THE NUMBERS

(as of August 2023)

PROGRAM ESTABLISHED

20
years ago

CITATION COVERAGE

1950
to present

OVER **70** queries INCLUDING
450 possible searches

20,000
total compounds

900
DDI summaries

DRUG-DRUG INTERACTIONS
PHARMACOKINETIC DATA FROM OVER

25,000
citations
INCLUDING

180,000
entries

550
NDAs/BLAs
INCLUDING

16,000
entries

Who are our users

PHARMACEUTICAL COMPANIES Preclinical and clinical scientists working in drug development and regulatory groups	REGULATORY AGENCIES	ACADEMIC INSTITUTIONS	PUBLISHERS of DRUG INFORMATION
	CONTRACT RESEARCH ORGANIZATIONS	NON-PROFIT ORGANIZATIONS	PROVIDERS of CLINICAL DECISION SUPPORT SYSTEMS

The worldwide userbase includes organizations of **all sizes**

Benefits

of using DIDB[®]

PROVIDE CONTEXT for the INTERPRETATION of results obtained for candidate compounds	OPTIMIZE and VALIDATE PBPK MODELS and static predictions	ASSIST with PRIORITIZATION and DESIGN of clinical trials
GAIN INSIGHT on DDI RISK and possible clinical outcomes	SUPPORT DRUG LABELING RECOMMENDATIONS and the safe use of medications in various patient populations	PROVIDE CUSTOMIZED CLINICAL DATASETS AND EXPERTISE to support personalized prescription applications

WHY SUBSCRIBE

The data we select and its presentation are unique reflections of our expertise in drug interactions. As a small and fully independent operation, we are flexible and react rapidly. We are able to continuously incorporate new scientific findings and improve the content and functionality of the database.

DIDB® is internationally recognized as an authoritative, unbiased, and transparent research tool. Our users have trusted our database for over 20 years.

FUTURE DIRECTIONS

With its mechanistic and quantitative features, and the breadth of its content, DIDB® has the potential to become a standard in supporting various healthcare applications and complex clinical decision algorithms. We believe that its integration into clinical tools for healthcare providers and patients is a next step in the development of Drug Interaction Solutions and will constitute a pivotal milestone in the management of adverse drug interactions in the clinic. We foresee that DIDB® content will help the emergence of new approaches in personalized medicine that aims at selecting the most appropriate drug and dose for each unique patient.

HONORS and AWARDS

DIDB® and its co-founders: Dr. René Levy and Dr. Isabelle Ragueneau-Majlessi have been selected to receive the 2022 Gary Neil Prize for Innovation in Drug Development.

“
Your exemplary accomplishments and the superb drug interaction resource that you created” were noted by the ASCPT Awards Committee “as an exceptional achievement to facilitate drug development.”
”

Isabelle Ragueneau-Majlessi was also named a University of Washington CoMotion Presidential Innovation Fellow in 2015 for her work on the DIDB®. The prestigious fellowship program debuted in 2011 to foster entrepreneurial thinking across the University of Washington.

About Certara

At Certara, we accelerate medicines to patients, partnering with life science innovators. Together we advance modern drug development with biosimulation, regulatory science, and market access solutions.

For more information visit www.certara.com or email DIDBase@Certara.com