INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

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Review Article

Oral Chemotherapy Therapeutic Drug Monitoring (Tdm): A Pharmacist's Viewpoint

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ARTICLE INFO

Published: 11 Dec 2025
Keywords:
Pharmacokinetics, Patient Safety, Adherence Monitoring, Pharmacovigilance, Oncology Pharmacy, Pharmacist Role, Oral Chemotherapy, And Therapeutic Drug Monitoring
DOI:
10.5281/zenodo.17894510

ABSTRACT

By shifting the burden of administering medication from medical professionals to patients, oral chemotherapy has revolutionized the treatment of cancer. Patients now have more control, and treatment is more convenient, but there are significant drawbacks as well, like individual differences in drug processing, interactions with food or other medications, and issues taking medication as directed. Currently used for antibiotics and immunosuppressive medications, therapeutic drug monitoring is increasingly being used to help control the effectiveness of some cancer medications. From the perspective of a pharmacist, this review examines the use of TDM in oral chemotherapy. It discusses the benefits of TDM, the most effective methods for establishing treatment objectives, the real-world difficulties in applying TDM, and potential future developments such as the use of artificial intelligence to assist in determining the appropriate dosage of medication. The article focuses on how TDM fits into healthcare professionals' daily tasks and demonstrates how pharmacists can assist in determining who should use it, interpreting test results, determining whether patients are taking their medications as prescribed, and suggesting dosage adjustments. Pharmacist-led TDM is becoming more prevalent despite ongoing issues with resources and evidence, thanks to advancements in technology and a greater understanding of how medications affect the body. TDM use in oral chemotherapy treatment may be a crucial component of routine care; personalized cancer treatment is becoming more prevalent.

INTRODUCTION

1.1Variability in Absorption

The drug levels of oral tyrosine kinase inhibitors (TKIs), like imatinib and sorafenib, are highly dependent on stomach pH and whether or not food is consumed with the medication.

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Imatinib levels can rise by about 70% when taken with food, but nilotinib must be taken without food because doing so can significantly raise the drug's maximum level and raise the risk of QT interval prolongation, a heart condition (Clinical Pharmacology & Therapeutics, 2024).

1.2 Polymorphisms in Metabolism

Drugs like tamoxifen and abiraterone are broken down in the liver by the CYP2D6 and CYP3A4 enzymes.

Lower drug effects result from poor metabolizers' inability to effectively convert these medications into their active forms (Nematullah et al., 2023). TDM can assist in identifying patients who may require a higher dosage or alternative treatment because they are not properly metabolizing their medication.

1.3 The Pharmacokinetic Variable of Adherence

The amount of medication in the blood during oral chemotherapy, as opposed to intravenous treatments, is largely dependent on the patient's compliance with the medication. For medications with short half-lives, such as dasatinib, missing doses can lower blood levels by more than 50%, according to studies. This makes it difficult to interpret low levels without verifying that patients are taking their medications as directed (Li et al., 2025).

2. The Function of Pharmacists in TDM Implementation

Because they have access to information about how medications are filled, understand how the body processes drugs, and have the opportunity to speak with patients when they pick up their medication, pharmacists are essential to the success of TDM in cancer care.

2.1 Selection of Patients and Evaluation of TDM

Indications Pharmacists can determine which patients are most likely to benefit from TDM by considering:

• The medication's characteristics (limited range of safe and effective dosages, wide range of bodily processing variations)

• Clinical issues, such as harmful side effects, indications that the medication isn't working, or ineffective treatment

• Interaction risk (using multiple medications that impact the same protein or enzyme in the body)

2.2 Analysis and Suggestions for Dose Modification

Pharmacists examine whether drug levels fall within the desired range after receiving blood test results (e.g., more than 1000 ng/mL for imatinib, more than 5.9 ng/mL for endoxifen). They may then recommend: • Modifying the frequency of medication intake; • Changing the medication's form if different forms are absorbed differently; • Changing the dosage in a manner consistent with the same pattern.

2.3 Adherence safeguarding and patient education

Pharmacists educate patients on the following topics through routine medication discussions: • The significance of taking the medication at the same time each day; • The amount of time that should pass between taking the medication and eating; and • The risks of taking excessive amounts to make up for missed doses.

The objective of the study was to assess how therapeutic drug monitoring can maximize the safety and effectiveness of oral anticancer medications, with an emphasis on pharmacokinetic variability and the pharmacist's role in patient care.

3.1 Comparative Summary of Oral Chemotherapy Agents Suitable For TDM

Drug Name	Class	Known Therapeutic Range (Trough, Cmin)	TDM Justification	Typical Sampling Time
Imatinib	TKI (CML/GIST)	>1,000 ng/mL[9,11,12]	Exposure–response validated[9,12,14]	Pre-dose[9]
Nilotinib	TKI	500–800 ng/mL (proposed)[5,11,14]	QT risk at higher levels[5,11]	Fasting pre-dose[5]
Everolimus	mTOR inhibitor	5–15 ng/mL[5,13,14]	Narrow therapeutic window[5,13]	Steady-state trough[5]
Sorafenib	TKI	>3,500 ng/mL[5,14,15]	Low exposure = progression[5,14]	12-hour trough[5]
Tamoxifen (Endoxifen)	Hormonal	>5.9 ng/mL[10,14]	CYP2D6 metabolism variability[10,15]	Random steady-state[10]
Abiraterone	CYP17 inhibitor	AUC-based[5,14]	Prevent mineralocorticoid toxicity[5,14]	2-hour post-dose[5]

3.2markdown Table Format

Drug Name	Class	Therapeutic Target (Cmin)	Rationale for TDM	Sampling Guidance
Imatinib	TKI	>1,000 ng/mL[9,11,12]	Correlates with remission rates[9,12,14]	Trough before morning dose[9]
Nilotinib	TKI	500–800 ng/mL (tentative)[5,11,14]	QT prolongation above range[5,11]	Fasted trough[5]
Everolimus	mTOR Inhibitor	5–15 ng/mL[5,13,14]	Toxicity risk when >15[5,13]	Steady-state trough[5]
Sorafenib	TKI	>3,500 ng/mL[5,14,15]	Higher levels linked to benefit[5,14]	Trough at 12 h[5]
Tamoxifen (Endoxifen)	Hormonal	>5.9 ng/mL[10,14]	Poor metabolizers underexposed[10,15]	Anytime at steady state[10]
Abiraterone	CYP17 Inhibitor	No fixed range (AUC-based)[5,14]	Correlates with hypokalemia[5,14]	2 h after dose[5]

5. Proof in Favor of TDM in Oral Chemotherapy

Depending on the drug type, the evidence supporting TDM varies. The most conclusive evidence relating drug levels to treatment outcomes among targeted therapies is found for imatinib. When it came to treating chronic myeloid leukemia, patients with lower drug levels—less than 1,000 ng/mL—performed worse than those with higher levels (van der Kleij et al., 2025). Many patients experienced improved outcomes when their dosage was increased when

they were not receiving enough of the medication (Li et al., 2025).

Additionally, tamoxifen is dependent on its active form, endoxifen, which is produced by the CYP2D6 enzyme. Endoxifen levels must be higher than 5.9 ng/mL in order to be effective. and has known adverse effects. Without compromising the medication's efficacy, physicians can reduce the dosage of TDM to lessen adverse effects like mouth sores and elevated blood sugar.

Last but not least, sorafenib is special since its adverse effects frequently cause patients to discontinue treatment. Doctors can carefully adjust the dosage with TDM to find a level that works well without creating too many issues (Smita et al., 2022).

Table 5. Challenges and Limitations of TDM Integration

Challenge	Clinical Impact	Pharmacist Mitigation Strategy
Lack of standardized therapeutic thresholds for many agents[5,14]	Uncertainty in decision-making [5,13]	Advocate for institutional protocols based on available literature [11,14]
High cost and limited access to LC–MS/MS assays [2,5,14]	Delayed turnaround time [2,5]	Centralized sample batching or outsourcing [2,14]
Clinician reluctance due to unfamiliarity with PK interpretation [1,3,13]	Underutilization of TDM [1,5,14]	Pharmacist-led education and case demonstrations [3,13]
Adherence confounding low levels [8,9,10]	Misleading assumptions of underexposure [9,10]	Verify adherence before dose adjustments [8,9]
Reimbursement limitations [2,5]	Institutional resistance [5,14]	Present cost–benefit analyses (toxicity avoidance) [2,14]

6. Prospects For the Future:

MIPD, AI, and Digital Adherence Integration TDM's future extends beyond examining individual test findings. In model-informed precision dosing (MIPD), a single test result is converted into a complete picture of a drug's physiological behavior using Bayesian forecasting. This makes it possible for doctors to recommend dosages that are more effective and tailored to each patient (Rowland & Tozer, 2011). AI systems can integrate data about a drug's physiological effects with other information, such as age, genes, and whether a patient is taking their medication as directed. Before it becomes an issue, this helps identify patients who may be receiving too little or too much of the medication. Information about when doses were taken can be obtained through digital tools such as smart pill bottles or sensors that monitor medication intake. This makes it easier for pharmacists to distinguish between low drug levels that occur naturally and those that result from missing a dose.

8. CONCLUSION

An important development in the management of oral chemotherapy is TDM. TDM accounts for individual differences caused by genetics, medication adherence, and drug

metabolism, as opposed to one-size-fits-all dosing, which assumes that everyone responds in the same way. Pharmacists have a great opportunity to lead TDM initiatives. They can help with test interpretation, managing drug interactions, and making sure patients take their prescriptions as directed. Thanks to new technologies like digital tracking and AI-based dosing systems, TDM can be used in cancer care with ease. Just as crucial to precision medicine as the appropriate drugs are the appropriate dosages.

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HOW TO CITE: A. Zirmire*, S. Futane, R. Kawale, A. Badgire, Oral Chemotherapy Therapeutic Drug Monitoring (Tdm): A Pharmacist's Viewpoint, Int. J. of Pharm. Sci., 2025, Vol 3, Issue 12, 1948-1953 https://doi.org/10.5281/zenodo.17894510