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NL Journal of Medical and Pharmaceutical Sciences

(ISSN: 3108-0502)

Volume 1 Issue 3 December 2025

Editorial

Personalized Medicine through Pharmacogenetics and Therapeutic Drug Monitoring

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doi: 10.71168/NMP.01.03.113

Received Date: November 25- 2025 **Publication Date:** December 01- 2025

The paradigm of medicine is undergoing a profound shift, moving decisively away from the "one-size-fits-all" model towards a future of personalized care. In this evolution, clinical pharmacists stand at a pivotal crossroads, armed with two of the most powerful tools in our therapeutic arsenal: Pharmacogenetics (PGx) and Therapeutic Drug Monitoring (TDM). Historically, these disciplines have often been siloed, with PGx informing the initial prescription and TDM guiding subsequent dose adjustments. It is time we recognize that their true potential is not realized in isolation, but in a powerful, synergistic collaboration that offers a comprehensive, dynamic, and patient-centric approach to pharmacotherapy.

Pharmacogenetics provides the foundational blueprint-a genetic snapshot of a patient's inherent capacity to metabolize and respond to a drug. It answers the critical question: "What is the right drug and starting dose for this patient?" By identifying genetic polymorphisms in enzymes like CYP2C19, CYP2D6, or TPMT, we can pre-emptively avoid therapeutic failure or severe adverse drug reactions. For instance, initiating clopidogrel in a CYP2C19 poor metabolizer or azathioprine in a TPMT-deficient patient without dose modification is no longer just suboptimal care; it is a foreseeable and preventable error. PGx empowers us to make smarter choices at the starting line.

However, the human body is not a static entity. Genetics is the prelude, not the entire story. Physiological changes, drug-drug interactions, disease states, organ function, and adherence all introduce variability that a static genetic test cannot capture. This is where Therapeutic Drug Monitoring excels. TDM provides a real-time, quantitative snapshot of drug exposure, answering the subsequent, equally vital question: "Is the current dose producing the right concentration in this patient, at this time?" For drugs with a narrow therapeutic index, such as vancomycin, tacrolimus, or anticonvulsants, TDM is the indispensable compass that guides us through the dynamic landscape of a patient's clinical journey.

The synergy emerges when we integrate these two data streams. Consider the management of a patient on voriconazole. A PGx test may reveal a CYP2C19 ultra-rapid metabolizer genotype, predicting subtherapeutic levels and treatment failure. This prompts the clinician to select an alternative agent or a significantly higher starting dose. Subsequent TDM then validates this decision and fine-tunes the dose further, accounting for non-genetic factors like drug interactions or fluctuating liver function. Conversely, in a patient with inexplicably high tacrolimus levels despite a standard dose, a PGx test revealing a CYP3A5 non-expresser genotype provides the explanatory "why," transforming empirical dose reduction into a definitive, long-term management strategy.

As clinical pharmacists, we are the natural architects of this integration. Our expertise in pharmacokinetics, pharmacodynamics, and medication management positions us uniquely to interpret both the genetic blueprint and the dynamic serum concentration. We must champion the development of clinical decision support systems that seamlessly integrate PGx results with TDM data within the electronic health record. Furthermore, we have a responsibility to educate our physician and nursing colleagues on the interpretation and clinical application of this combined information.

The path forward requires a concerted effort. We must advocate for broader inclusion of PGx-guided dosing guidelines alongside traditional TDM targets in institutional protocols. Research should focus on validating combined PGx-TDM algorithms for a wider range of drug classes, moving beyond oncology and transplant medicine into psychiatry, cardiology, and infectious diseases.

In conclusion, the future of precision pharmacotherapy lies not in choosing between the genome and the dose, but in weaving them together. Pharmacogenetics sets the stage, and Therapeutic Drug Monitoring directs the play. By embracing their synergistic power, we, as clinical pharmacists, can transition from reactive dose adjusters to proactive architects of truly individualized, safe, and effective therapeutic regimens. Let us lead the charge in bridging these two disciplines to fully realize the promise of personalized medicine for every patient we serve.

Citation: Mohamed E.E. Shams. "Personalized Medicine through Pharmacogenetics and Therapeutic Drug Monitoring". NL Journal of Medical and Pharmaceutical Sciences 1.3 (2025): 01-02.