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PHARMACOLOGICAL APPROACHES TO DRUG REPURPOSING: MECHANISMS, STRATEGIES, AND CLINICAL APPLICATIONS

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ABSTRACT

Drug repurposing has emerged as a strategic approach to accelerate therapy development by identifying novel uses for existing drugs, offering reduced development time, lower costs, and established safety profiles. This review provides a comprehensive analysis of pharmacological approaches to drug repurposing, focusing on mechanisms, strategic paradigms, and clinical applications. A structured literature search was conducted across PubMed, Scopus, Web of Science, and Google Scholar using keywords such as "drug repurposing," "mechanism-based repurposing," and "phenotype-driven repurposing," considering articles published in English from 2015 to 2026. Studies reporting mechanistic insights, computational strategies, preclinical and clinical evidence, and regulatory considerations were included, while non-peer-reviewed or insufficiently detailed studies were excluded. Data were extracted on drug names, original and repurposed indications, mechanisms, strategies employed, and clinical outcomes. The review identified multiple successful repurposing examples, including sildenafil, thalidomide, metformin, and remdesivir, highlighting the role of both phenotype-driven and mechanism-based approaches. Computational methods, such as in silico predictions, network pharmacology, and machine learning, were found to significantly enhance identification of novel indications. Despite regulatory, intellectual property, and safety challenges, repurposed drugs demonstrated meaningful clinical impact across oncology, infectious diseases, and neurodegenerative disorders. These findings underscore drug repurposing as an evidence-driven, translational strategy that expands therapeutic options, informs clinical practice, and guides future pharmacological research.

KEYWORDS: Drug repurposing, Drug repositioning, Mechanism-based strategy, Phenotype-driven strategy, Computational pharmacology, Translational pharmacology.

INTRODUCTION

Drug discovery is a complex, time-consuming, and resource-intensive process, often requiring more than a decade of research and substantial financial investment before a new therapeutic agent reaches the market. Despite significant advances in molecular biology, computational chemistry, and translational medicine, the overall success rate of novel drug development remains low, with many candidates failing during late-stage clinical trials due to lack of efficacy or unforeseen safety concerns.[1] In this context, drug repurposing, also known as drug repositioning, has emerged as a promising and pragmatic strategy to accelerate the development of

effective therapies by identifying new therapeutic uses for existing drugs.

Drug repurposing leverages compounds that have already been approved for clinical use or have passed significant stages of safety and pharmacokinetic evaluation.[2] This approach offers several advantages over traditional de novo drug discovery, including reduced development time, lower cost, and an improved probability of success due to established safety profiles.[3] A well-known example is Sildenafil, which was initially investigated for the treatment of angina pectoris but was later repurposed for erectile dysfunction after its unexpected pharmacological effects were observed during clinical trials.[4] Similarly, Thalidomide, once withdrawn due to teratogenicity, has been successfully repositioned for the treatment of multiple myeloma and other inflammatory conditions, illustrating the transformative potential of this strategy.[5]

Pharmacological approaches to drug repurposing rely on a deep understanding of drug mechanisms of action, disease pathophysiology, and the complex interactions between biological systems.[6] Mechanism-based repurposing focuses on identifying shared molecular pathways between different diseases, enabling a drug originally designed for one condition to be applied to another with a similar underlying mechanism.[1] For instance, drugs targeting inflammatory pathways may be repurposed across autoimmune diseases, cancers, and neurodegenerative disorders due to overlapping signaling cascades such as cytokine modulation and oxidative stress responses.[7,8] Advances in systems pharmacology and network medicine have further facilitated this approach by enabling the mapping of drug–target–disease interactions at a systems level.[9]

In addition to mechanism-driven strategies, several other pharmacological approaches have been developed to support drug repurposing. These include target-based screening, where existing drugs are evaluated against newly identified biological targets, and phenotypic screening, which assesses drug effects on disease-relevant cellular or organismal models without prior knowledge of specific targets.[10] Computational approaches, including molecular docking, machine learning, and big data analytics, have also gained prominence in recent years. These methods integrate diverse datasets such as genomics, proteomics, and electronic health records to predict novel drug–disease associations with high efficiency and accuracy.[11–13]

Clinical observations and real-world evidence play a crucial role in drug repurposing as well. Off-target effects, adverse drug reactions, and unexpected therapeutic benefits observed during clinical use can provide valuable insights into alternative applications of existing drugs.[14] The rapid global response to the COVID-19 pandemic highlighted the importance of repurposing strategies, as several approved drugs were evaluated for potential antiviral and immunomodulatory effects in an urgent effort to identify effective treatments.[15] Although not all candidates proved successful, this approach demonstrated the speed and flexibility of repurposing in addressing emerging public health crises.[16]

Furthermore, regulatory agencies such as the U.S. Food and Drug Administration and the European Medicines Agency have increasingly recognized the value of drug repurposing and have established pathways to facilitate the approval of repositioned drugs.[3] These frameworks often allow for streamlined clinical development processes, particularly when safety data from previous indications are available.[17] However, challenges remain, including intellectual property issues, limited financial incentives, and the need for robust clinical evidence to support new indications.

In recent years, the integration of pharmacogenomics and personalized medicine has further expanded the scope of drug repurposing. By considering genetic variability among individuals, researchers can identify subpopulations that may benefit from specific repurposed therapies, thereby enhancing treatment efficacy and minimizing adverse effects.[18] This precision-based approach aligns with the broader goal of optimizing therapeutic outcomes through tailored interventions.

Given these developments, pharmacological approaches to drug repurposing represent a dynamic and evolving field with significant implications for modern therapeutics. This review aims to provide a comprehensive overview of the underlying mechanisms, key strategies, and clinical applications of drug repurposing, highlighting recent advances and future directions. By synthesizing current knowledge, this work seeks to underscore the potential of repurposing as a cost-effective and innovative solution to the ongoing challenges in drug discovery and development.

METHODOLOGY

This review was conducted through a structured literature search across PubMed, Scopus, Web of Science, and Google Scholar, using keywords such as “drug repurposing,” “drug repositioning,” “mechanism-based repurposing,” “phenotype-driven repurposing,” and “clinical applications.” Articles published in English from 2015 to 2026 were considered, focusing on studies that reported mechanistic insights, computational strategies, preclinical and clinical evidence, and regulatory perspectives. Conference abstracts, non-peer-reviewed content, and studies lacking sufficient pharmacological relevance were excluded. Data were extracted on drug name, original and repurposed indications, mechanism of action, repurposing strategy, and clinical status. Computational methods, including in silico predictions, network pharmacology, and machine learning approaches, were also noted. The collected

information was synthesized qualitatively to provide a comprehensive overview of contemporary pharmacological approaches to drug repurposing, highlighting current trends, challenges, and opportunities for future research.

1. Concept and Types of Drug Repurposing

1.1 Definition

Drug repurposing, also known as drug repositioning, refers to the use of existing or previously studied drugs for new therapeutic indications beyond their original purpose.[19] These drugs may already have established safety and pharmacokinetic profiles, which makes the development process faster, less costly, and less risky compared to traditional drug discovery.[20] The concept is based on the idea that many diseases share common molecular pathways, allowing a single drug to be effective in multiple conditions.[21]

1.2 Types of Drug Repurposing

Drug repurposing can be broadly classified into two main types based on pharmacological mechanisms.

On-target repurposing occurs when a drug is used for a different disease but acts on the same biological target or pathway as in its original indication.[22] This approach is relatively straightforward, as the mechanism of action is already well understood.[23]

Off-target repurposing involves the identification of a new biological target for an existing drug. In this case, the drug produces therapeutic effects through a different mechanism than originally intended.[24] This type often arises from unexpected findings during research or clinical use.[25]

Additionally, the terms drug repositioning and drug reprofiling are sometimes distinguished. Repositioning refers to finding new uses without altering the drug, while reprofiling may involve modifications such as changes in formulation or delivery to improve its effectiveness for the new indication.[26]

Overall, drug repurposing can result from clinical observations or systematic pharmacological investigations, making it a flexible and valuable approach in modern drug development.

2. Pharmacological Basis of Drug Repurposing

2.1 Pharmacodynamics (PD)

Pharmacodynamics plays a central role in drug repurposing by explaining how a drug interacts with biological systems to produce its effects. At the core of this process are drug–receptor interactions, where a compound binds to specific molecular targets such as receptors, enzymes, or ion channels.[27] These interactions determine the drug's mechanism of action and therapeutic outcome. In the context of repurposing, the same drug–receptor interaction may be relevant in different diseases that share similar underlying pathways.[24]

In addition, signal transduction pathways are critical in mediating the downstream effects of drug binding.[28] Many diseases involve dysregulation of common signaling cascades, such as inflammatory or metabolic pathways.[8] A drug that modulates these pathways in one condition may therefore be effective in another.

Off-target effects further expand the pharmacodynamic basis of drug repurposing.[29] Drugs often interact with unintended targets, which can lead to unexpected therapeutic benefits. While such effects were traditionally viewed as undesirable, they are now increasingly recognized as valuable opportunities for identifying new clinical indications.[30]

2.2 Pharmacokinetics (PK)

Pharmacokinetics is equally important in determining the suitability of a drug for repurposing. It describes how the body absorbs, distributes, metabolizes, and excretes a drug. These processes influence drug concentration at the target site and ultimately affect therapeutic efficacy.[31]

For repurposed drugs, existing pharmacokinetic data provide a strong advantage, as information on bioavailability, half-life, and metabolic pathways is often already available.[32] However, different disease conditions may require adjustments in dosing regimens. Dose optimization is therefore essential to ensure that adequate drug levels are achieved for the new indication while minimizing toxicity.[33]

2.3 Polypharmacology

Polypharmacology refers to the ability of a single drug to interact with multiple molecular targets.[34] This property is a key factor underlying the success of drug repurposing. Instead of acting on a single pathway, many drugs influence complex biological networks, which may be involved in multiple diseases.[35]

This multi-target activity increases the likelihood that an existing drug can be applied to different therapeutic areas. As a result, polypharmacology provides a strong scientific basis for identifying new uses of known drugs and supports the growing interest in network-based and systems pharmacology approaches in drug repurposing.[36]

3. Pharmacological Approaches to Drug Repurposing

3.1 Target-Based Approaches

Target-based repurposing focuses on identifying specific interactions between drugs and molecular targets.[37] This approach relies on knowledge of a drug's binding profile, often determined through receptor binding studies or enzymatic assays.[38] By understanding which targets a drug modulates, researchers can match it to diseases where the same targets play a critical role, making this approach highly precise and mechanism-driven.[39]

3.2 Phenotypic Screening

Phenotypic screening evaluates a drug's effect on cells, tissues, or whole organisms without prior assumptions about its specific target.[10] Changes in cell behavior, viability, or disease-related phenotypes are monitored to identify potential therapeutic effects.[40] This strategy is particularly valuable in complex diseases such as cancer and central nervous system disorders, where multiple pathways contribute to pathology, and the drug's overall biological impact is more informative than a single target interaction.[41]

3.3 Mechanism-Based Approaches

Mechanism-based repurposing involves understanding the underlying disease pathways and aligning them with the known mechanism of action of a drug.[20] By identifying overlapping pathways or shared pathological processes, this approach allows drugs to be applied to conditions beyond their original indication.[42] For example, anti-inflammatory drugs may be repurposed for neurodegenerative disorders if they modulate relevant cytokine or oxidative stress pathways.[43]

3.4 Network Pharmacology

Network pharmacology expands the concept of drug action from individual targets to a systems-level perspective. It maps the interactions among drugs, targets, and diseases, providing a holistic view of how a drug influences complex biological networks.[44] This approach helps uncover multi-target effects and indirect relationships that might not be apparent through conventional methods, making it particularly useful for diseases with multifactorial etiology.[45]

3.5 Computational Approaches

Computational methods have become integral to modern drug repurposing. Techniques such as molecular docking, machine learning, and artificial intelligence allow for high-throughput prediction of drug–target interactions and new disease associations.[46] Knowledge graphs and big data analytics integrate diverse datasets—including genomics, proteomics, and clinical records—to identify promising repurposing candidates. Recent studies demonstrate that combining computational modeling with experimental validation significantly improves prediction accuracy and accelerates the discovery of repurposed therapies.[47]

Overall, these pharmacological approaches—ranging from traditional target-based studies to advanced computational strategies—provide a comprehensive toolkit for systematically identifying new therapeutic uses for existing drugs, enhancing both efficiency and success in drug development.

4. Recent Advances in Drug Repurposing (2024–2026)

In recent years, drug repurposing has benefited from significant technological and scientific advances, making it a more systematic and reliable strategy in therapeutic development. One of the most notable trends is the increasing use of artificial intelligence (AI) and machine learning (ML) models. These tools analyze large datasets to predict drug–target interactions, identify potential off-target effects, and propose new indications with higher accuracy than traditional methods.[48]

The integration of genomics and proteomics data has further strengthened repurposing efforts. By examining genetic and protein expression profiles across diseases, researchers can identify shared molecular pathways and potential drug targets.[49] This approach has enabled precision-based repurposing, allowing therapies to be tailored to specific patient populations or disease subtypes.[50]

Knowledge graph–based prediction systems represent another emerging advance. These systems organize complex relationships among drugs, targets, pathways, and diseases into a structured network, enabling rapid identification of novel repurposing opportunities.[51] When combined with AI and experimental validation, these platforms can significantly accelerate drug discovery pipelines.[52]

Additionally, repurposing is no longer limited to small-molecule drugs. Biologics and biosimilars are increasingly being explored for alternative indications, expanding the scope of repurposing to include therapies such as monoclonal antibodies, cytokines, and therapeutic proteins.[53,54]

Recent evidence suggests that drug repurposing has become a stable and integral component of pharmaceutical innovation.[24] By leveraging computational tools, multi-omics data, and experimental insights, repurposing accelerates therapeutic development across a wide range of disease areas, offering an efficient pathway to address unmet medical needs.[55]

5. Clinical Applications of Drug Repurposing

5.1 Oncology

Drug repurposing has made a notable impact in oncology, where complex and heterogeneous tumor biology creates opportunities for existing drugs to be applied in new ways.[56] Thalidomide, once withdrawn due to its teratogenic effects, has been successfully repurposed for multiple myeloma, where it exhibits anti-angiogenic and immunomodulatory activity.[57] Metformin, a widely used antidiabetic agent, has also shown anticancer potential by modulating cellular metabolism, inhibiting tumor growth, and affecting key signaling pathways in preclinical and clinical studies.[58] These examples highlight how drugs with established safety profiles can be redirected to target cancer pathways.

5.2 Infectious Diseases

Repurposing is particularly valuable in infectious diseases, especially during pandemics when time is

critical.[59] Approved antivirals and other therapeutics can be evaluated for activity against emerging pathogens, allowing rapid initiation of clinical trials.[60] The recent global health crises demonstrated that repurposing existing drugs provides a faster route to treatment compared to the development of entirely new agents, helping to mitigate disease spread and severity.[61]

5.3 Neurological Disorders

Neurological disorders such as Alzheimer's disease involve multiple pathological mechanisms, including protein aggregation, oxidative stress, and neuroinflammation.[62] Repurposing strategies in this area focus on drugs that can modulate these pathways, leveraging prior safety and pharmacokinetic data to accelerate clinical evaluation.[63] This approach enables a multi-target strategy, which is often necessary to address the complex etiology of neurodegenerative diseases.[64]

5.4 Cardiovascular Diseases

Cardiovascular drug repurposing has produced several successful examples. Sildenafil, originally developed for angina, was repurposed for erectile dysfunction and later for pulmonary hypertension, based on its effects on vascular smooth muscle and nitric oxide signaling.[4] This demonstrates how understanding a drug's mechanism of action can uncover new therapeutic applications beyond the original indication.

Several drugs have been successfully repurposed for new therapeutic applications, leveraging shared molecular mechanisms and clinical observations from cancer and infectious diseases to neurological and cardiovascular conditions (**Table 1**).

Table 1: Summary of selected drugs repurposed for new therapeutic uses, including original indication, mechanism, and current clinical status.

Drug	Original Indication	Repurposed Indication	Mechanism / Rationale	Clinical Status	Ref
Sildenafil	Angina pectoris	Erectile dysfunction, Pulmonary hypertension	PDE5 inhibition → vasodilation	Approved	4
Thalidomide	Sedative / antiemetic	Multiple myeloma, Leprosy	Anti-angiogenic, immunomodulatory	Approved	57
Metformin	Type 2 Diabetes	Cancer (breast, colorectal)	AMPK activation → inhibits mTOR, reduces proliferation	Clinical trials ongoing	65,66
Remdesivir	Ebola virus	COVID-19	RNA polymerase inhibition	Emergency use / approved in some countries	67,68
Itraconazole	Antifungal	Cancer (anti-angiogenic)	Inhibits hedgehog signaling and angiogenesis	Clinical trials	69,70
Minocycline	Antibiotic	Neurodegenerative diseases	Anti-inflammatory, inhibits microglial activation	Clinical trials	71
Dexamethasone	Anti-inflammatory	COVID-19 (severe cases)	Corticosteroid → reduces cytokine storm	Approved / recommended	72
Raloxifene	Osteoporosis	Breast cancer prevention	Selective estrogen receptor modulator	Approved for prevention	73
Hydroxychloroquine	Malaria / Lupus	COVID-19 (investigated)	Modulates endosomal pH, immune response	Clinical trials; controversial efficacy	74,75
Auranofin	Rheumatoid arthritis	Cancer, viral infections	Thioredoxin reductase inhibition, induces oxidative stress	Preclinical / early trials	76,77

6. Advantages of Drug Repurposing

Drug repurposing offers several clear benefits over traditional drug development, making it an attractive strategy for accelerating therapeutic innovation.

Reduced development time and cost: Since repurposed drugs have already undergone preclinical testing and often early-phase clinical trials, the pathway to approval for a new indication is faster and less expensive than developing a completely new drug.[1]

Known safety and toxicity profiles: Existing safety and pharmacokinetic data provide a strong foundation, reducing the risk of unexpected adverse effects and

allowing researchers to focus on efficacy in the new indication.[24]

Higher success rate compared to new drugs: Because the pharmacological properties and safety of the drug are well established, repurposed drugs have a greater likelihood of progressing successfully through clinical trials and achieving regulatory approval.[3]

Overall, these advantages make drug repurposing a practical and efficient approach for addressing unmet medical needs and bringing effective therapies to patients more quickly.

7. Challenges and Limitations

Despite its advantages, drug repurposing faces several challenges that can affect its development and commercialization.

Regulatory approval complexities: Even though the safety profile of a repurposed drug is often known, approval for a new indication still requires robust clinical evidence. Regulatory agencies may require additional trials to demonstrate efficacy and safety in the new context, which can be time-consuming and costly.[78]

Intellectual property issues: Patents on older drugs may have expired, limiting the ability to secure exclusivity for the new use. This can reduce commercial incentives and discourage investment in clinical development.[79]

Dose adjustment and toxicity in new indications: Different diseases may require different dosing regimens or treatment durations. Adjusting doses can lead to unexpected toxicity or reduced efficacy, necessitating careful pharmacokinetic and pharmacodynamic evaluation.[80]

Limited commercial incentives: Because many repurposed drugs are off-patent or low-cost, pharmaceutical companies may see less financial motivation to invest in expensive clinical trials compared to new chemical entities.[81]

Despite these challenges, regulatory frameworks are gradually evolving to facilitate repurposed drug approvals. Programs that offer accelerated review, data exclusivity, or orphan drug designation are helping to overcome some of these barriers, making repurposing a more viable strategy in modern drug development.[82]

8. Future Perspectives

The future of drug repurposing is closely tied to advances in technology, data science, and personalized medicine. One major trend is AI-driven precision repurposing, where machine learning and artificial intelligence analyze large datasets to predict novel drug–disease associations with high accuracy.[55] These approaches can uncover subtle connections that might be missed by traditional experimental methods.[83]

Integration with pharmacogenomics is another promising direction. By considering individual genetic variations, researchers can identify which patients are most likely to benefit from a repurposed drug, improving both efficacy and safety.[84] This aligns with broader personalized medicine approaches, where treatments are tailored to the unique biological profile of each patient.[85]

The expansion of global drug databases and multi-omics datasets will further enhance repurposing efforts. Comprehensive repositories of chemical structures, drug-target interactions, clinical trial outcomes, and real-world patient data enable systematic identification of repurposing candidates and accelerate the translation from discovery to clinical application.[86]

Together, these developments suggest that drug repurposing will increasingly contribute to addressing unmet medical needs, particularly for rare diseases and conditions with limited therapeutic options. By combining computational tools, molecular insights, and patient-specific data, repurposing is poised to become a cornerstone of innovative and efficient drug development strategies.

DISCUSSION

Drug repurposing has emerged as a compelling strategy in contemporary pharmacology, driven by the need to reduce the time, cost, and risk associated with traditional de novo drug development. The increasing complexity of disease biology and the substantial attrition rates in clinical trials have prompted researchers and clinicians to reconsider approved and shelved compounds for new therapeutic uses. This review has highlighted key pharmacological mechanisms, strategic paradigms, and clinical successes that define the current landscape of repurposing. In this discussion, we integrate these insights, examine underlying challenges, and identify opportunities that could shape future research and clinical translation.

At the mechanistic level, drug repurposing leverages an expanding understanding of disease pathways and molecular targets. Many successful repurposing cases share a common theme: the original and new indications converge on shared biological mechanisms.[87,88] For example, agents with anti-inflammatory properties such as non-steroidal anti-inflammatory drugs have been explored in neurodegenerative disorders due to overlapping cytokine dysregulation.[89] Similarly, drugs originally developed for metabolic disorders have shown promise in oncology by exploiting effects on cellular energetics and signaling pathways.[90] These examples underscore the value of systems pharmacology and pathway mapping, which enable researchers to identify pleiotropic effects and latent therapeutic potential beyond the drug's initial indication.

The strategic approaches to repurposing broadly fall into two categories: phenotype-driven and mechanism-based

strategies. Phenotype-driven repurposing involves screening existing compounds in disease models or clinical phenotypes without prior assumptions about the target.[10] High-throughput screening (HTS) platforms and phenotypic assays have been instrumental in this context. Such approaches have uncovered unexpected activities of drugs like sildenafil, initially developed for angina and later repurposed for erectile dysfunction and pulmonary hypertension due to observed vasodilatory effects.[4] Mechanism-based repurposing, on the other hand, starts with a defined target implicated in multiple diseases.[20] Bioinformatic analyses, chemoproteomics, and in silico target prediction tools now allow for systematic identification of drugs that bind to these targets.[91] Mechanism-based strategies can be exceptionally efficient when backed by robust biological evidence, yet they depend on accurate target annotation and comprehensive understanding of disease biology.

Computational methods have increasingly become central to repurposing efforts. Advances in artificial intelligence, machine learning, and network pharmacology have enabled integration of diverse data types, including genomic, proteomic, phenotypic, and clinical datasets.[92] These tools can predict drug–disease associations with increasing accuracy and provide mechanistic hypotheses that can be validated experimentally. For instance, network-based algorithms can identify drugs that modulate disease modules within biological networks, while machine learning classifiers can rank repurposing candidates based on clinical and molecular features.[93] The integration of real-world data (RWD) from electronic health records and post-marketing surveillance adds another dimension, allowing observational evidence to suggest off-target benefits or safety profiles that support repurposing hypotheses.[94]

Despite these advances, several challenges persist in translating repurposing discoveries into clinical impact. One major challenge is intellectual property and commercialization. Repurposed drugs often lack strong patent protection, reducing financial incentives for pharmaceutical companies to invest in expensive confirmatory trials.[82] Regulatory frameworks, while evolving, still pose hurdles for labeling and approval for new indications.[95] These challenges have led to a reliance on public funding, academic partnerships, and innovative business models that share financial risk. Another challenge relates to safety and efficacy. Although approved drugs have established safety profiles in their original indications, repurposing may involve different dosing regimens, patient populations, or disease contexts, creating new safety considerations that must be rigorously evaluated.[3]

Clinical applications of repurposed drugs illustrate both the promise and complexity of this approach. In infectious diseases, repurposing has had notable successes. For example, remdesivir, initially developed for Ebola virus disease, was rapidly assessed and authorized for COVID-19 treatment based on antiviral activity against SARS-CoV-2.[68] Similarly, itraconazole, an antifungal agent, has shown anti-angiogenic activity in cancer models and is under investigation in oncology.[96] These case studies affirm that strategic repurposing can yield clinically meaningful therapies, particularly when preclinical evidence is strong and regulatory pathways are navigated proactively.

From a public health perspective, drug repurposing offers a scalable model for addressing unmet medical needs, particularly in rare diseases and neglected conditions where traditional R&D investment is limited. The repurposing model enables faster clinical translation, harnesses existing safety data, and can rapidly add therapeutic options in emergent health crises.[97] However, maximizing this potential will require continued refinement of repurposing methodologies, greater collaboration among academic, industry, and regulatory stakeholders, and policies that balance innovation incentives with broad access.

In summary, drug repurposing stands at the intersection of pharmacology, systems biology, and data science. Its success relies on mechanistic insight, strategic screening approaches, computational prediction, and adaptive clinical and regulatory frameworks. As biological data becomes richer and analytical tools more sophisticated, repurposing will likely play an ever-greater role in expanding the therapeutic arsenal. Addressing current challenges through multidisciplinary collaboration and thoughtful policy could accelerate the translation of repurposing discoveries into safe, effective, and accessible treatments.

CONCLUSION

Drug repurposing represents a transformative approach in modern pharmacology, offering a faster, cost-effective, and lower-risk alternative to traditional drug development. By exploiting shared molecular pathways, pleiotropic drug effects, and advanced computational methods, repurposing strategies have demonstrated significant potential across diverse therapeutic areas, from infectious diseases to oncology and neurodegeneration. While challenges remain, including regulatory hurdles, intellectual property issues, and context-specific safety considerations, ongoing advances in systems pharmacology, bioinformatics, and clinical data integration are poised to overcome these barriers. Strategic collaboration between academia, industry, and regulatory bodies will be essential to fully realize the clinical and public health benefits of repurposed drugs. Ultimately, drug repurposing not only expands treatment options but also exemplifies a pragmatic, evidence-driven model for accelerating the translation of pharmacological discoveries into meaningful patient care.

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Conflict of Interest
Nil.

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