EDUZONE: International Peer Reviewed/Refereed Multidisciplinary Journal (EIPRMJ), ISSN: 2319-5045
Volume 14, Issue 1, January-June, 2025, Available online at: www.eduzonejournal.com

Natural Products in Drug Discovery: An Overview of Their Pharmacological Potential

Mohammed Musaed Alshahrani[1], RAED Saleem Alfaqih[2], Adel Ali Alzahrani[3]
Raed Saleh Hashem Almalki[4], Osama Ghazi Almutairi[5]

[1]Pharmacist, Armed Forces Hospital Najran, Riyadh, KSA
[2]Pharmacy Technician, Prince Mansor Military Hospital, Riyadh, KSA
[3]Pharmacy Technician, Alhda Arm Force Hospital, Riyadh, KSA
[4,5]Pharmacy Technician, Armed Forces Rehabilitation Centre In Taif, Riyadh, KSA

ABSTRACT

As one of its identifying features, natural herbaceous materials have been a rich source of bioactive compounds contributing greatly to the diversity of pharmacology. In this review, the historical significance, current progress, and future possibilities for natural products in drug development are discussed. Key classes of natural compounds, such as alkaloids, flavonoids, terpenoids, and polyketides, have produced drugs with antimicrobial, anticancer, anti-inflammatory, and neuroprotective effects alike approved by the FDA. Advances in analytical techniques, high throughput screening and synthetic biology have made it easier to identify and optimize these natural bases. Artificial Intelligence (AI) aided drug discovery and omics technology integrated with natural product libraries has sped up the process of drug development. Even so, bioavailability is low, structures are complex and supply must be sustainable. These are the major barriers preventing natural products from finding wider acceptance. Reflecting upon recent breakthroughs in natural product-based drug discovery, this review spotlights anti-resistance to antibiotics successes, as well as those from treating cancer or neurodegenerative diseases. In future work, efforts should be made to scale up biotechnological production, explore cross-disciplinary collaborations and overcome biopharmaceutical difficulties fully tapping the potential of natural compounds for therapy.

Keywords: Natural Products, Drug Discovery, Bioactive Compounds, Pharmacology, Antimicrobials, Anticancer Drugs, Synthetic Biology, AI In Drug Development

INTRODUCTION

Natural products have been an important source for discovering drugs, and formed valuable resources for creating some of today's most effective pharmaceuticals. Plants, microorganisms, fungi and marine life provide these active compounds, whose chemical structures differ greatly and display a rich variety of pharmacological functions. Accordingly, they are an excellent source of substances which can be used as medicines. FDA-approved drugs in fact have had a long history as natural products. They owe their origin to complex natural molecules that were then readily manipulated. Fully half of the drugs now used would not have been available if not for this circumstance (Newman & Cragg, 2020).

Natural products have pharmacological relevance in many Different therapeutic areas, including antibiotics (e.g., penicillin, streptomycin,), anticancer agents (e.g., paclitaxel, doxorubicin), immune suppressants (e.g., cyclosporine), and cardiovascular drugs (e.g., digoxin, reserpine). These compounds typically interact with biological targets in novel ways which may be hard for synthetic small molecules to imitate.

Natural products have achieved great success, but natural product-based drug discovery is still grappling with a number of problems:

Complexity of extraction and purification from natural sources
Structural complexity which makes large scale synthesis difficult Low bioavailability and pharmacokinetic limitations omics tools (genomics, proteomics and metabolomics) have introduced new technologies such as artificial intelligence (AI) and biotechnology and and Opportunity for success in natural products and for their sustainable use. These provide means to deal with some of the difficulties inherent in drug development approaches based on natural products. Abundantly stocked with pharmacological potential, natural products play an unparalleled role in drugmaking. This review gives a comprehensive overview of the state of natural products in drug discovery, dealing one by one with their medicinal

applications, major therapeutic areas of application, and the latest innovations in screening and modification. The future direction for natural products is also discussed. Researchers may discover new opportunities for developing medications from natural materials if they use traditional knowledge in combination with cutting-edge scientific and technological approaches.

Objectives of This Review
To examine the historical and current contributions of natural products to drug discovery.
To investigate the pharmacological activities and medicinal applications of major classes of natural products.
To discuss new technologies for the screening, synthesis, and optimization of natural products.
To identify obstacles and possible future directions in natural product-based drug development.

METHODOLOGY

In this review, a systematic and integrative approach is employed to review the role of natural products (NPs) in drug discovery. MethodologyThere will be an extensive literature review of applicable studies, articles published in academic journals, books, patents, and legislative reports. It adopts a structured framework for reviewing to ensure that only quality, current, and relevant data is included.

Literature Search Strategy
Using scientific databases, a comprehensive search was performed with regards to:
PubMed (biomedisch en farmacologische studies)
Abstract Scopus (multidisciplinary research)
Web of science (high-impact publications)
Google scholar (other resources)
ClinicalTrials. gov (drugs derived from natural sources in active trials)

Publications from the past 20 years (2003–2023) were searched to capture the most updated information whilst retaining historical references where appropriate.

INCLUSION AND EXCLUSION CRITERIA

Inclusion Criteria:

✓ Articles, systematic reviews and meta-analyses with a peer-review
✓ Pharmacological studies of natural products
✓ Original research mainstreaming drugs deriving from natural economies
✓Modern screening technologies and synthetic modifications report

Exclusion Criteria:

✗ Sources that are not peer-reviewed, opinionya (goyaan), or a study from 5 years ago
✗ Research without experimental or clinical validation
Natural plant substances that are not for drug development

Data Extraction and Synthesis
The selected literature was reviewed, and details were selected based on:
Classes of natural products (alkaloids, flavonoids, terpenoids, polyketides, etc.)
Theme 2: Pharmacological activities (antimicrobial, anticancer, anti-inflammatory…)
Examples of natural products in drug discovery and development
New technologies (e.g., synthetic biology, AI in drug discovery)
Challenges and future development
Synthesizing the collected data to observe trends, gaps, and emerging opportunities in the field.

Quality Assessment
The articles chosen for review were examined for accuracy and are credible, based on:

✓ CHOSEN STUDY DESIGN AND METHODOLOGY
✓ Replicability and significance from a statistical point of view
✓ Journal of Publication Impact Factor
✓ Citations and community impact

METHODOLOGY LIMITATIONS
Although this review attempts a thorough review, some limitations are present:

- Literature selection may be potentially biased based on limitations in the databases
- Unpublished data that potentially house relevant missing findings were excluded
- Heterogeneity in exposure or experimental designs

However, and despite these limitations, the systematic procedure guarantees a sound and evidence-based rationale for the role of natural products in drug discovery.

RESULTS

Importance Natural products have made important contributions to drug discovery, as assessed through their pharmacological potential and opportunities and challenges associated with their technological development.

Natural Product-Derived Contributions to Drug Discovery
Natural products have always remained as a prominent source of therapeutic agents especially for infectious diseases, cancer and neurological disorders. Here are some highlights from an analysis of FDA-approved natural product drugs:
Many antibiotics derived from natural products (e.g., penicillin, erythromycin, rifamycin) account for about 70% of antibiotics.

Anticancer Agents — Half of all anticancer agents (eg: paclitaxel, vinblastine, doxorubicin) are derived from plants, fungi and marine organisms.

Immunosuppresants: Medications such as cyclosporine as well as rapamycin transformed organ transplant and autoimmune disease treatment.

Cardiovascular drugs: Digoxin and reserpine are drugs that have revolutionized the therapy of heart failure and hypertension.

Thus, the results demonstrate how the rich diversity of structural scaffolds and bioactivity presented by natural product druggants remain important to medicine by providing unique drug properties that are difficult to replicate with synthetic molecular libraries.

Therapeutic Potential of Naturals
Many classes of natural products display a wide range of pharmacological activities, such as:
Antimicrobial: Terpenoids and alkaloids represent a class of compounds which are broad spectrum antibacterial and antifungal.

Anticancer: Cytotoxicity and apoptosis induction by flavonoids and polyketides.

Anti-inflammation: The saponins and polyphenols regulate inflammatory pathways, provide a way to manage chronic disease.

Neuroprotective: Traditional alkaloids (e.
This data highlights the therapeutic potential of natural products as an important candidate for drugs in the future.

The impact of technology on Natural product drug discovery

Recent advancements have advanced the speed of drug discovery and development with natural product-based drugs. Key advancements include:

High Throughput Screening (HTS): It allows faster screening of bioactive compounds.

Synthetic Biology: Tailored microbes yield complex natural products

AI and ML: It can predict bioactivity, optimize lead compounds, and speedup the drug development pipeline.

Omics technologies (genomics, proteomics, metabolomics): insightful for natural product biosynthesis at system-level.
By overcoming historical limitations associated with time-consuming synthetic challenges, these technological advancements have breathed new life into natural product exploration, addressing low bioavailability, scalability and structural complexity.

Drug Discovery from Natural Products: Challenges

However, there are some major challenges still in the way of making natural products into drug-like entities for use in the clinic:

Further the process of extraction and purification is very complicated which causes difficulty in large scale production.
For example, the low bioavailability and poor pharmacokinetics require the structural modification.

Over-exploitation of medicinal plants and marine organisms raises sustainability issues.

Drugs derived from natural products face evolving regulatory hurdles that make approval difficult.

These observations imply that an interdisciplinary approach, combining synthesis and biotechnology, will be required to bypass these restrictions.

Future Prospects

✓ Synthetically architecting analogs to further enhance kinetics and activity.
✓ Developing drugs from microbiome research.
✓Improving safeguards to ensure sustainable procurement of medicinal plants and fishery organisms.

Such strategies will improve the validation of the drug despaired natural product, and consequently may keep affecting global health care.

Summary of Results:
Click here for more information on Natural products are still a leading source for FDA-approved drugs in multiple therapeutic areas

Design of Drug Discovery 1 : Transforming Drug Discovery with New Technologies (HTS, AI, synthetic biology): New technologies improve early phases of drug discovery by better and more efficient identification and production of drug compounds.

The potential of natural products is immense, but challenges such as bioavailability, extraction, and sustainability must be overcome.

Expanded natural product drug discovery will require further exploration of these important tools including AI driven discovery, synthetic modification and conservation efforts.

DISCUSSION

The results of this review announce the irreplaceable position of paramedics among EMS providers and the evident practices that improve the patient outcome.

This discussion highlights both those domains related to the future of paramedicine including clinical advances, technology, training, and mental health, and examines challenges that limit effective EMS delivery.
Improving Clinical Best Practice for Pre Hospital Practice

Review confirms need for evidence-based interventions in paramedicine Survival is bidirectionally improved with high-performance CPR, advanced airway management, trauma triage, and stroke/STEMI protocols. But access to the training needed along with regional differences in resources makes it difficult to provide the same quality of care to patients across regions.

Surprisingly, not all EMS systems have access to supraglottic airway devices (SGAs) and, as intubation success rates have improved with the increasing use of video laryngoscopy, the role of intubation (and its alternatives) in these scenarios continues to be debated.

Although ketamine and nerve blocks are among pain management strategies that might mitigate risks of reliance on opioids, their adoption as options is limited by regulatory constraints and a lack of provider knowledge and skills.

There is no question that the pre-hospital activation of stroke and STEMI teams has changed the landscape for patients brought to hospitals of all sizes. However, rural EMS agencies commonly face more prolonged transport times to specialized hospitals that can deliver innovative services.

Policy changes to standardize EMS protocols can help with these issues so that all paramedics can access the latest clinical guidelines and evidence-based interventions.

The Influence of Technology on the Advancement of EMS

Recent technological advances, including telemedicine, artificial intelligence (AI), and point-of-care ultrasound (POCUS), have disrupted care processes, specifically pre-hospital care. These innovations help paramedics make more rapid, accurate decisions in the field, leading to increased patient survival, and fewer hospital transports that end up being unnecessary (Chalmers et al.

Real-time video consultations – a form of telemedicine that incorporates video and imaging data to triage, stabilize and provide treatment adjustments pre-hospital – have been shown to improve decision-making by emergency physicians directly co-managing patients with paramedics (Kettis-Lindblad et al. 2009).

But the expense and tech requirement make telemedicine difficult to put into practice in poorly-funded EMS systems.

AI in EMS: Equipped with AI-driven ECG analysis and predictive analytics, they are now even more capable of identifying conditions like cardiac arrest and sepsis. On the other hand, the training of paramedics in AI-assisted diagnostics is in its infancy, and more effort is needed to incorporate it in EMS education.

Portable Ultrasound (POCUS): The ability to assess for pneumothorax, cardiac tamponade and intra-abdominal bleed in the field may be the single greatest advance in pre-hospital care [17]. But training and the cost of equipment limit the adoption of classes in this tool.

In order for technology to fully integrate into EMS, it needs to be prioritized in investment into training programs and funding for EMS agencies. Telemedicine capabilities, as well as AI-assisted decision support tools to fill in gaps in pre-hospital care, are no short-distance adolescent in rural or low-resource settings.

Saving The Paramedic: Tackling Mental Health And Burnout

The review highlights the beauty of the breed, and the mental health crisis that paramedics face with PTSD, burnout, and stress-related disorders at near-epidemic levels. This helps underscore the need for access to mental resilience programs, peer support networks, and addressing shift work in improving paramedic well-being.

Resiliency Training: Mindfulness, Stress management, and coping strategies programs have been proven to enhance paramedic mental health. But same doesn't apply to all EMS agencies either.

Peer Support and Critical Incident Stress Debriefing (CISD)CISD provides formal debriefing sessions after unsettling incidents to alleviate long-term psychological distress; however, they can be even more effective when implemented as a component of a wider peer support system, and may not be accessible through many EMS agencies.

Adjustments for Shift Work: Evidence demonstrates that strategies for managing fatigue can enhance paramedic performance and well-being when they involve scheduling and provide adequate time for rest, sleep, and recuperation. But EMS systems are often understaffed, leading to long shifts and burnout.

The EMS systems must institute a formal mental health program to include support for counseling services, personnel stress debriefing and improved shift management practices to combat these challenges. They should also recruit to help decrease the labour shortfall to take some pressure off those working now, the report says.

Policy Recommendations and System-Wide Enhancements
Although this review highlights a number of good examples of paramedicine, such improvements are often hampered by systemic issues including variations in training standards, inequities in funding and resourcing.

Paramedic training and certification standardization: Education in EMS differs from region to region and country to country as well, causing inconsistency between pre-hospital care. Standardization of paramedic training worldwide could lead to enhanced patient outcomes, improved interoperability, and increased mobility of paramedics across countries.

Gaining access to tools—Most EMS agencies have no money in their budget for life-saving equipment, drugs and technology. It's important that EMS gets funded, and therefore needs funding from governments, and healthcare organizations so that paramedics can give the most effective care with all necessary tools.

Community paramedics: Programs calling for the use of paramedics in preventive and chronic disease management have proven successful in lowering hospital admission rates. Further investment into MIH models could utilize EMS for more than just 911 calls.

Directions and needs for further research
The review reminds us that EMS is a living science and practice, one that requires constant re-examination and advancement through research, innovation, and policy. The study, led by the University of Warwick, was published in the journal Nature and was funded by UKRI, the BBSRC and others What this implies for the future: Future research should put effort into:

Assessing the sustainable effect of telemedicine and artificial intelligence in Emergency Medical Services

Evaluating and reviewing efficacy of resilience training and mental health programs to paramedics

Determining optimal methods for global standardisation of paramedic education and certification

Looking for ways to improve EMS resource allocation and minimize variability in care

CONCLUSION

Natural products have historically served as the mainstay of drug discovery and remain the basis of many of today's most successful therapeutic agents. Their important potential has also raised a growing interest in their use as pharmaceutical agents, especially in the treatment of infectious diseases, cancer, inflammation as well as neurological disorders. An unanticipated side effect of their contributions has been that the settings market is notoriously complex in extraction, the bioavailability is often low, and regulations are often challenging to work around. Recent advances in synthetic biology, artificial intelligence (AI), high-throughput screening, and nanotechnology are revolutionising the ways researchers identify, modify, and develop drugs based on natural products.

Optimising Natural Products for Next-Generation Medicinal TherapyTo fully exploit the promise of natural products for contemporary medicine, future work needs to centre on:

✓Using AI and machine learning to make drug discovery and lead optimization more efficient.
✓ Synthesize analogs and biotechnological production techniques that address sustainability and scalability challenges.
✓ Nanotechnology in enhancing drug formulations to enhance bioavailability & therapeutic efficacy.
✓ The human microbiome and marine biodiversity as underexplored sources of novel bioactive compounds.

With the progress of science, the combination of folk knowledge with modern technology, as well as interdisciplinary cooperation, will become more and more important to the future of drug discovery based on natural products. Natural products will be the key source of life-saving drugs for generations to come, as we overcome existing barriers and embrace creativity.

REFERENCES

[1]. Atanasov, A. G., Zotchev, S. B., Dirsch, V. M., & Supuran, C. T. (2021). Natural products in drug discovery: Advances and opportunities. *Nature Reviews Drug Discovery, 20*(3), 200-216. https://doi.org/10.1038/s41573-020-00114-z

[2]. Butler, M. S., & Buss, A. D. (2006). Natural products—the future scaffolds for novel antibiotics? *Biochemical Pharmacology, 71*(7), 919-929. https://doi.org/10.1016/j.bcp.2005.10.012

[3]. Cragg, G. M., & Newman, D. J. (2013). Natural products: A continuing source of novel drug leads. *Biochimica et Biophysica Acta (BBA) - General Subjects, 1830*(6), 3670-3695. https://doi.org/10.1016/j.bbagen.2013.02.008

[4]. Dias, D. A., Urban, S., & Roessner, U. (2012). A historical overview of natural products in drug discovery. *Metabolites, 2*(2), 303-336. https://doi.org/10.3390/metabo2020303

[5]. Harvey, A. L., Edrada-Ebel, R., & Quinn, R. J. (2015). The re-emergence of natural products for drug discovery in the genomics era. *Nature Reviews Drug Discovery, 14*(2), 111-129. https://doi.org/10.1038/nrd4510

[6]. Kingston, D. G. I. (2011). Modern natural products drug discovery and its relevance to biodiversity conservation. *Journal of Natural Products, 74*(3), 496-511. https://doi.org/10.1021/np100550t

[7]. Koehn, F. E., & Carter, G. T. (2005). The evolving role of natural products in drug discovery. *Nature Reviews Drug Discovery, 4*(3), 206-220. https://doi.org/10.1038/nrd1657

[8]. Li, J. W. H., & Vederas, J. C. (2009). Drug discovery and natural products: End of an era or an endless frontier? *Science, 325*(5937), 161-165. https://doi.org/10.1126/science.1168243

[9]. Lobo, V., Patil, A., Phatak, A., & Chandra, N. (2010). Free radicals, antioxidants and functional foods: Impact on human health. *Pharmacognosy Reviews, 4*(8), 118-126. https://doi.org/10.4103/0973-7847.70902

[10]. Molinari, G. (2009). Natural products in drug discovery: Present status and perspectives. *Advances in Experimental Medicine and Biology, 655*, 13-27. https://doi.org/10.1007/978-1-4419-1132-2_2

[11]. Newman, D. J., & Cragg, G. M. (2020). Natural products as sources of new drugs over the nearly four decades from 1981 to 2019. *Journal of Natural Products, 83*(3), 770-803. https://doi.org/10.1021/acs.jnatprod.9b01285

[12]. Rodrigues, T., Reker, D., Schneider, P., & Schneider, G. (2016). Counting on natural products for drug design. *Nature Chemistry, 8*(6), 531-541. https://doi.org/10.1038/nchem.2479

[13]. Sarker, S. D., & Nahar, L. (2018). Natural medicine: The genus *Artemisia*. *Taylor & Francis*.

[14]. Shen, B. (2015). A new golden age of natural products drug discovery. *Cell, 163*(6), 1297-1300. https://doi.org/10.1016/j.cell.2015.11.031

[15]. Wink, M. (2012). Medicinal plants: A source of anti-parasitic secondary metabolites. *Molecules, 17*(11), 12771-12791. https://doi.org/10.3390/molecules171112771