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Editor's Corner

Dear readers,

The spring issue of ***EPPAD Bulletin*** (Volume 5, Number 1) is here. The issue covers a lot of grounds. On November 2, 2024, EPPAD held a one-day successful conference in which various podium presentations were made.

In the News and Highlights Section, EPPAD president Dr. Ermias Tilahun writes a summary of the activities of the Association in 2024. In this section, other topics are also highlighted. A Memorandum of Understanding was signed between the Ethiopian Food and Drug Authority (EFDA) and EPPAD. Dr. Alex Akalu, the team leader of EPPAD Regulatory/Policy Working Group, provides details of the event where the MOU was signed. In early February, Ato Aklile G. Giorgis was at hand in Nazareth (Adama), Ethiopia to attend the unfurling of the first Ethiopian Herbal Pharmacopoeia and traditional medicine strategic brainstorming sessions at the gathering. It is to be noted that EPPAD played a pioneering role in the Pharmacopoeia Project, with the Traditional Medicine Desk, Ethiopian Ministry of Health spearheading the actual writing of the document. Ato Aklile presents a concise summary of the meeting.

In this issue, EPPAD Board member Dr. Helen HaileSelassie is featured. This is a continuation of introducing a Board Member, one at a time, that was started with the last issue of the ***Bulletin*** (Volume 4, Number 2, 2024). In the Pioneers of Pharmacy and Related Fields, we are profiling the illustrious career of the plant systematist Dr. Mesfin Tadesse, who also happens to be a member of EPPAD Traditional Medicine Working Group. Ato Aklile has compiled the monumental contribution of Dr. Mesfin towards initiating, writing and playing a leading role in the Ethiopian Flora Project, which culminated in the production of 10 voluminous issues of the Flora of Ethiopia and Eritrea. His other contributions in the field of botany and related fields are also presented.

One of the themes of the 2024 EPPAD Conference focused on the application of Artificial Intelligence (AI) in drug discovery/development and pharmacy practice. Drs. Bisrat and Solomon gave talks at the conference on this topical issue. The ***Bulletin*** extended invitations to them to write reviews on the subject. In his article, Dr. Solomon eloquently outlines the advantages of AI over traditional approaches in drug discovery and development. In an article entitled *Generative AI in Pharmacy Practice: Applications, Benefits and Ethical Considerations*, Professor Bisrat reviews the application of various AI modalities in pharmacy practice including, among others, clinical decision-making processes. In this issue, the ***Bulletin*** also carries an article penned by Kebedech Tekleab, who is a poet, painter, sculptor and an educator. In her write-up which has a poetic tenor, she shares her rich and vivid notes from the early days of the COVID-19 pandemic in New York. It is a powerful health-related article written by a non-healthcare professional and it reflects the human side, among others, of a COVID pandemic and a cholera epidemic.

EPPAD Bulletin hopes you enjoy reading this issue.

Fekadu Fullas, PhD
Editor-in-Chief, ***EPPAD Bulletin***

EPPAD News and Highlights

A Year of Growth and Impact

Ermias Tilahun, PhD (EPPAD President)

The **Ethiopian Pharmacists and Pharmaceutical Scientists Association in Diaspora (EPPAD)** has made significant strides in 2024, strengthening its role in advancing pharmaceutical sciences, fostering professional collaboration, and contributing to healthcare development both in the U.S. and Ethiopia.

Strengthening Global Partnerships

- **MOU with Ethiopian FDA & Debre Berhan University**: EPPAD successfully **signed Memorandum of Understanding (MOU)** with the **Ethiopian Food and Drug Authority (EFDA) and a pending MOU with Debre Berhan University** to enhance collaboration in regulatory science, pharmaceutical education, and research initiatives.
- **Helping Publish Ethiopia's First Pharmacopeia**: EPPAD played a key role in supporting the **Ethiopian Ministry of Health (MoH) in publishing the country's first-ever pharmacopeia document**. This milestone enhances pharmaceutical quality standards, ensuring safer and more effective medicines for patients.
- **Establishment of a CRO in Ethiopia**: EPPAD has taken a bold step toward strengthening clinical research capacity in Ethiopia by **establishing a Contract Research Organization (CRO)**. This initiative aims to support pharmaceutical research, clinical trials, and regulatory compliance, fostering innovation in the healthcare sector.

Annual Conference & Professional Development

- **5th Annual Conference – November 2, 2024, Alexandria, VA**
  - Focused on **advanced technology in cancer treatment and oncology research**.
  - Featured esteemed speakers from leading institutions, fostering knowledge exchange and collaboration.
- **Continuing Education (CE) Sessions**:
  - **Two CE sessions** were conducted—one during the annual conference and another outside of it, thus helping pharmacists stay updated on cutting-edge advancements in pharmaceutical sciences.

Research & Funding Initiatives

- **Collaboration with Howard University**: EPPAD submitted a joint application for **Pfizer's RFP on Metastatic Breast Cancer (MBC) Care**, aiming to improve access to quality care and innovative treatment solutions for MBC patients.

Recent Visit to Ethiopia

- EPPAD's President, **Dr. Ermias**, made a productive visit to Ethiopia, strengthening partnerships with key stakeholders in the pharmaceutical and regulatory sectors.

- Our board members during their Ethiopia visit engaged with **healthcare professionals, universities, and government agencies** to explore opportunities for collaboration and capacity-building.

Community Engagement & Professional Networking

- Expanded **networking opportunities** for Ethiopian pharmacists and pharmaceutical scientists across the U.S. and globally.
- Organized **webinars and panel discussions**, fostering education, collaboration, and mentorship.

As we reflect on 2024, EPPAD remains committed to **empowering professionals, advancing research, and strengthening global healthcare collaborations**.

For more updates, visit our website: [Ethiopian Pharmacists and Pharmaceutical Scientists Association in Diaspora]

EPPAD News and Highlights

EFDA and EPPAD Sign MoU to Strengthen Pharmaceutical Regulation in Ethiopia

Alemayehu Akalu, PharmD

Addis Ababa, Ethiopia (January 28, 2025) – The Ethiopian Food and Drug Authority (EFDA) and the Ethiopian Pharmacists and Pharmaceutical Scientists Association in the Diaspora (EPPAD) have formalized their collaboration with a Memorandum of Understanding (MoU) aimed at strengthening Ethiopia's pharmaceutical regulatory system. This partnership will enhance regulatory capacity, facilitate knowledge exchange, and support the development of high-quality medicines and medical products.

Strengthening Regulatory Oversight

This MoU builds on years of collaboration between EFDA and EPPAD, with a shared goal of advancing Ethiopia's pharmaceutical sector. Key areas of focus include:

- **Regulatory Capacity Building**: Supporting EFDA in achieving internationally recognized regulatory standards, including Maturity Level 3.
- **Training and Expertise Development**: Enhancing the skills of EFDA's regulatory workforce, including GMP inspectors and dossier evaluators.
- **International Engagement**: Facilitating EFDA's participation in the European Pharmacopoeia Commission and fostering partnerships with the U.S. FDA.
- **Quality Control and Laboratory Support**: Strengthening Ethiopia's national medicines laboratory by mobilizing resources and technical expertise.
- **Medical Devices and Bioequivalence**: Improving oversight of medical devices and advancing bioequivalence regulations for generic medicines.
- **Education and Policy Development**: Partnering with universities to support regulatory science education and contribute to policy improvements.

A Partnership with Purpose

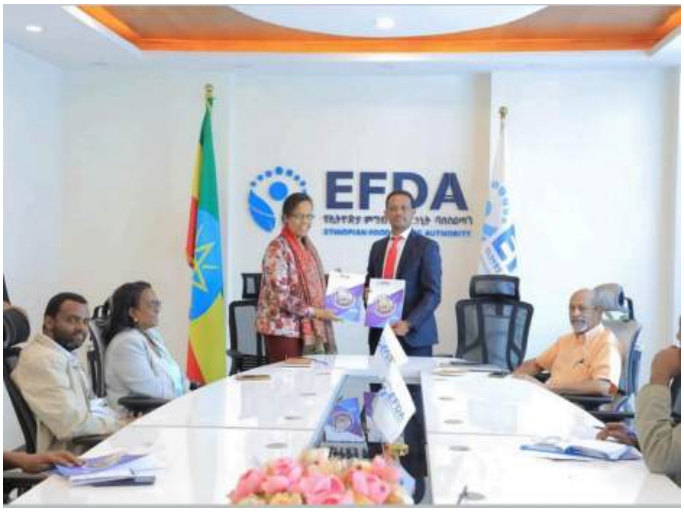
At the signing ceremony, **Heran Gerba**, EFDA's Director General, highlighted the broader impact of this agreement. "This MoU represents more than just a partnership—it is a commitment to safeguarding public health through strong regulatory oversight," she said. "With EPPAD's support, we are building a foundation for a more robust pharmaceutical sector in Ethiopia."

Dr. Alex Akalu, EPPAD's Regulatory Team Leader, reflected on the role of diaspora professionals in supporting Ethiopia's healthcare system. "Many of us have spent years working in global regulatory environments, and we are eager to contribute our expertise," he stated. "This agreement provides a structured way for us to give back and support EFDA's critical mission."

Looking Ahead

The MoU provides a framework for ongoing collaboration and allows for future expansion based on evolving regulatory needs. Both EFDA and EPPAD are committed to ensuring that this

partnership leads to tangible improvements in Ethiopia's pharmaceutical landscape, benefiting patients and the broader healthcare system. This agreement is a testament to the power of collaboration—uniting local expertise with global experience to create a stronger, safer, and more efficient regulatory system.



Pictures from the discussion and signing event of the MOU between EFDA and EPPAD Regulatory Team

Pioneers of Ethiopian Pharmacy and Related Fields

Prepared by Gabriel Daniel (aka-Aklile G Giorgis)

Professor Mesfin Tadesse

EPPAD Bulletin is featuring Prof. Mesfin Tadesse, an accomplished plant biologist with specialization in the taxonomy (the science of naming and classification of plants) and systematics (the science studying diversity and evolutionary relationships of organisms) with extensive experience in teaching, research and administration in Ethiopia and the USA.

EPPAD Bulletin is pleased to have Prof. Mesfin as a member of its Traditional Medicine Working Group. In this role, he has contributed his botanical/taxonomical expertise in supporting the Ethiopian Ministry of Health's effort in developing the first National Herbal Pharmacopeia.

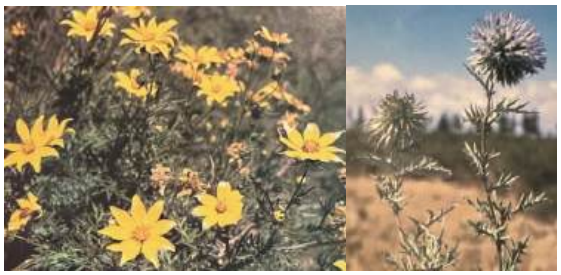
Prof. Mesfin is internationally recognized for finding and naming over 60 new species of flowering plants independently as well as in collaboration with his colleagues, e.g., *Bidens macroptera Mesfin* **(አደይ አበባ)**, *Echinops kebericho Mesfin* **(ቀበሪቾ)**. The name "Mesfin" is now part of the binomial of these as well as many other plant species. Just to mention a few more, Mesfin is the author of about 12 species of *Bidens*, 13 species of *Vernonia*, 3 species of *Echinops*, 22 species of *Electranthera* where he has jointly, with two colleagues, renamed species correctly, i.e., corrected hitherto wrongly named plant species, etc.

He is credited for monographic works on the plant family, the Asteraceae (Compositae) as it occurs in Ethiopia, as well as the genera ***Bidens*** and ***Echinops*** (in Africa), ***Coreopsis*** and related genera (worldwide).

(A botanical name or scientific name is used by botanists, plant growers and managers, and others to avoid the confusion that is often caused by common names. Professional plant taxonomists assign a unique scientific name to each plant species which is given a first name and a second name followed by the name of the author. It is generally based on botanical Latin and is unique to species.)

Botanical Expeditions: Mesfin and team from Germany (trip from Dinsho to Fincha Habera, Bale [upper image], 1990; and Sweden, Sof Omar, Bale, 1979 with guards and support staff [lower image]). ©Mesfin Tadesse.

The plant species that Mesfin named, *Bidens macroptera* Mesfin, is the beautiful, yellow-flowered Adey Abeba or Meskel Abeba, native to Ethiopia. Adey Abeba ushers the beginning of the Ethiopian New Year, the end of the rainy season and also the beginning of the "Spring" season. Adey Abeba, which is also displayed as the symbol of peace, love and joyfulness, is offered as gifts to friends and relatives during this time. Another species also known as Adey Abeba, *Bidens prestinaria*, is common in Ethiopia at mid- and lower altitudes while *Bidens macroptera* is common at higher altitudes.



Bidens macroptera Mesfin (አደይ አበባ), left and ***Echinops kebericho*** Mesfin, (ቀበሪቾ), right. ©Mesfin Tadesse, 1991.

Another plant of medicinal value in Ethiopia that is credited to Mesfin is Kebericho, a plant endemic to Ethiopia and used to treat infectious and non-infectious human diseases. At first it had only a genus name but not a species name. It was the effort of Mesfin that resulted in the new species to be internationally known as ***Echinops kebericho*** Mesfin.

Dr Mesfin started his university education at Haile Selassie 1st University, Ethiopia – BSc. - Biology (1973). His MSc was from the University of Minnesota USA in Botany & Ecology (1976). With support from the Ethiopian Flora project, Mesfin headed to the University of Uppsala, Sweden where he obtained a PhD. in Systematic Botany (1984).

Mesfin, in his half century of academic life beginning in 1973, has risen through the academic ladder from graduate assistant to professor. In his 50 years of knowledge transfer, he has lectured to and transferred skills to over 10,000 students in Ethiopia, East Africa and the United States. He taught undergraduate and graduate courses in plant, human and animal biology, medicinal plants, taxonomy, ecology, conservation, invasive plants etc.

Mesfin has served as advisor and supervisor of both national and international graduate and post graduate students both in Addis Ababa University and The Ohio State University, USA, where he was also a curator and administrator of The Herbarium (2002-2024).

Drs. Tewolde-Berhan Gebre-Egziabher and Mesfin Tadesse, (Photo 1991, ©SAREC).

He served as External examiner at Moi University, Kenya; Dar-es-Salaam University, Tanzania; and Addis Ababa University. He was a Guest Lecturer at Oslo University, Norway; Royal Botanic Gardens, Kew; Missouri Botanical Garden, Missouri; The Ohio State University, USA.

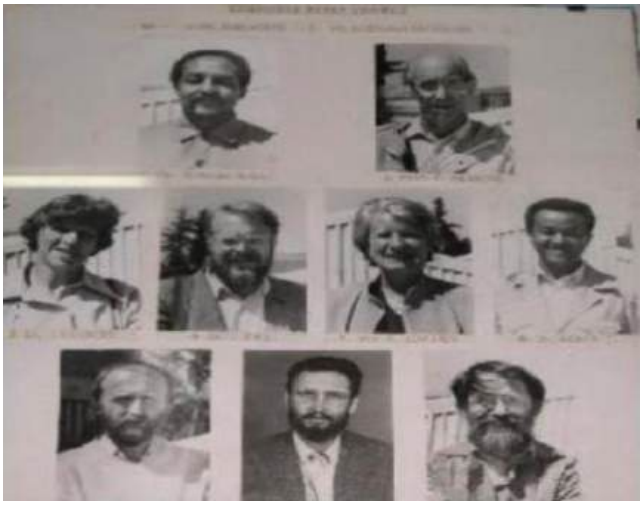
Mesfin was a young professional in the early days of the establishment of the Ethiopian Flora Project, under the leadership of the late Prof. Tewolde-Berhan Gebre Egziabher, where he started as secretary of the ad-hoc Ethiopian Flora Committee (1976-1980). Upon the initiation of the Project in 1980, he became associate leader/leader (1984-1993), and liaison officer of the project at the Royal Botanical Gardens, Kew (1993). He was also the Keeper of the Ethiopian National Herbarium from 1976 to 1980 and 1984 to 1993, nearly 15 years.

About The Ethiopian Flora Project

The Ethiopian Flora Project was initiated in 1980 as a bilateral agreement between the Ethiopian and Swedish governments, implemented through the then Ethiopian Science and Technology Commission and administered by both the Addis Ababa and Uppsala Universities.

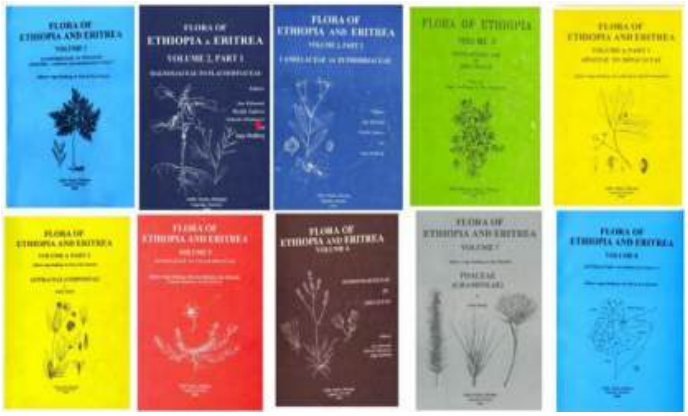
The objectives of the Ethiopian Flora Project (EFP) were to write up a Flora of Ethiopia, to strengthen the National Herbarium and establish a related library to be used as a reference center for pharmacognosists, agriculturists, foresters, wild-life specialists and others. It was also set up to train Ethiopians for promoting scientific activities in taxonomic botany, economic botany, forestry, plant ecology, plant physiology and other botanical fields.

The leaders of the project were Prof. Tewolde-Berhan Gebre-Egziabher on the Ethiopian side, assisted by an Ethiopian secretariat under the Director of the National Herbarium, Mesfin Tadesse, also associate leader of the project, and Prof. Inga Hedberg coordinator on the Swedish side as well as a European counterpart secretariat, headed by Prof. Olov Hedberg.



Flora of Ethiopia - Founders. **Top row** (left): Tewolde-Berhan Gebre-Egziabher (Ethiopia): (right): Olov Hedberg (Sweden). **Middle row** (left to right): Inga Hedberg (Sweden), Ib Friis (Denmark), Sue Edwards (Ethiopia), Mesfin Tadesse (Ethiopia). **Bottom row** (left to right): Kay Vollesen (Denmark), Christian Puff (Austria), M. G. Gilbert (United Kingdom). (Photo 1986, ©Mesfin Tadesse).

By the end of the project, 2009, all the intended 8 volumes (10 issues) of the Flora of Ethiopia and Eritrea (see images below) were published documenting over 6,000 plant species, with about 12% endemism. The volumes are available for purchase at Addis Ababa University bookstore (*Sidst Kilo* campus), or at the National Herbarium, College of Natural Sciences (*Arat Kilo* campus), Addis Ababa, Ethiopia.



Contributions to the project came from over 20 countries and 90 scientists from Africa, Europe, and North America. The efforts of the Swedish nationals Dr Inga Hedberg and Prof. Olov Hedberg in coordinating the activities of the Flora Project in Europe and Scandinavia were monumental. In Ethiopia, plant family accounts were produced mainly by Mesfin Tadesse writing the 408-page account for about 440 species in the Asteraceae in Volume 4(2); over 200 species in the Family Acanthaceae written by Ensermu Kelbessa; and about 130 species in the Family Convolvulaceae by Sebsebe Demissew, both latter families are in Volume 5 of the Flora of Ethiopia and Eritrea (FEE).

Mesfin Tadesse is an avid literary person who has published numerous articles on tropical plants in reputed botanical journals, written several popular books and articles of value to the public (in English and Amharic) in online and print media.

He served as editor, and editor-in-chief of SINET, the peer-reviewed biannual Ethiopian Journal of Science published by the College of Natural and Computational Sciences, formerly Faculty of Science at Addis Ababa University, from its inception in 1978 to 1989. Mesfin has published books entitled ***"Some Endemic Plants of Ethiopia"*** which featured 30 endemic plants some of which are medicinal; ***"Trees and Shrubs from some hillside closures in Wello"*** with 106 graphic presentation

with vernacular names and botanical descriptions (in concert with Beyene Sebeko and Anders Tivell); ***A revision of Bidens for Africa***; ***Asteraceae (Compositae), Flora of Ethiopia and Eritrea (FEE),*** *Vol 4(2);* ***Ethiopia – Home of Arabica Coffee: Early Use, Folklore, Coffee Ceremony***; ***Origin and Biology; and A Monograph of Coreopsis s.s., Burnellia, Gyrophyllum, Pseudoagarista, and Silphidium (Coreopsideae – Compositae).*** He has also contributed accounts of families and genera of plants to other volumes of FEE, Flora of Somalia, Flora of East Africa and Flora Mozambiqensis**.**

Dr Mesfin has served on different committees in Ethiopia as well as abroad including being a member and later Chairman - Coordinating Committee for Traditional Medicine, Ministry of Health, Ethiopia (1978-1981); member of the Natural Resources Subcommittee, Ethiopian Science & Technology Commission; National Committee for M.A.B. (Man and the Biosphere), Ethiopia, and member of a team of a delegation on M.A.B. Ethiopia to Kenya, and various departmental committees in AAU and OSU.

Mesfin provided consultancy services to: the Disaster Prevention and Preparedness Unit of the Ethiopian Red Cross Society, in environmental work - studies in rehabilitation of degraded areas in northern Ethiopia; Ethiopian Tourism Commission, Ethiopia - production of a booklet and calendars on indigenous and endemic plants of Ethiopia; Ministry of Coffee and Tea Development, Ethiopia - exploration of wild coffee plants in south and south-western Ethiopia; and studies associated with cultivated coffee and coffee production.

As part of fulfilling his social obligations, Mesfin served as Chairperson of the Ethiopian Community Organization, Inc., Columbus, Ohio, USA (2003-2006); consultant and advisory board member for Abay Scientific Technologies, Inc., Tennessee, U.S.A; advisor - LUCY - Mother and Child Care, Ethiopia (NGO); and advisor to The Ohio Plant Germplasm Center, Columbus, Ohio, USA (2013-2014).

Dr Mesfin has been recognized for his work with Awards that included: MAB (Man and the Biosphere Program – UNESCO, 1987); SAREC (SIDA, Sweden, 1980-1993) within EFP , NSF (USA, 1993-1999) with D.J. Crawford, Pioneer Botanist in Ethiopia (Department of Plant Biology and Biodiversity Management, Addis Ababa University, 2019); Certificate of Appreciation, 25 Years of Service (Columbus Community College, USA, 2018); Certificate of Appreciation, 25 Years of Service (The Ohio State University, USA, 2019).

Meet our EPPAD Members

In this issue, we would like to introduce you to one of our Board members, Dr. Helen HaileSelassie.

Helen HaileSelassie, PharmD, is a residency-trained and board-certified pharmacist with significant experience working in the healthcare and pharmaceutical industry. In her current role as an assistant director of market access, she oversees the development of formulary submission documents for managed care decision makers in formulary and coverage evaluations. She participates in health economics and outcomes research engagements and strategic planning for commercialization of pharmaceutical products. She also serves as a reviewer and strategic oversight resource for healthcare research.

In her previous role, she practiced as a clinical pharmacist and pharmacy leader, overseeing operational and clinical services for the safe delivery of pharmacy services in an institution-based setting. She has expertise in a wide array of clinical areas delivering patient care and maximizing therapeutic regimens, as well as developing clinical protocols for Pharmacy & Therapeutics committees using evidence-based medicine.

She graduated cum laude from Virginia Commonwealth University with a Doctor of Pharmacy degree and completed her Post Graduate Year One (PGY-1) pharmacy practice residency training. She was the recipient of the Phi Lambda Sigma Pharmacy Leadership Award. She is a member of the Academy of Managed Care Pharmacy and the International Society for Pharmacoeconomics and Outcomes Research.

The Application of Artificial Intelligence in Drug Discovery and Development

Solomon Tadesse Zeleke
Department of Biomedical and Pharmaceutical Sciences, L. S. Skaggs College of Pharmacy, Kasiska Division of Health Sciences, Idaho State University, Pocatello, ID, 83209, USA

Abstract

The integration of artificial intelligence (AI) into drug discovery and development has revolutionized the pharmaceutical industry. AI-driven approaches expedite the identification of drug targets, optimize drug design and lead compounds, and enhance clinical trial efficiency. This review explores the transformative role of AI in various stages of drug discovery, including target identification, compound screening, drug design, and clinical trials. Specific examples and case studies are provided to illustrate the impact of AI, alongside a discussion of challenges and future directions.

Introduction

The traditional drug discovery and development process is notoriously lengthy, expensive, and fraught with high failure rates. On average, it takes 10–15 years and costs over $2.6 billion to bring a new drug to market, with a success rate of less than 10% of potential drug candidates making through to market approval (DiMasi et al., 2016). Artificial intelligence (AI), particularly machine learning (ML) and deep learning (DL), has emerged as a powerful tool to address these challenges. By leveraging large datasets, AI can identify patterns, predict outcomes, and optimize processes, thereby reducing costs and timelines. This review highlights the applications of AI in drug discovery and development, supported by specific examples and recent advancements (Tables 1 and 2). Further discussion is provided under the following subheadings.

1. AI in Target Identification and Validation

Target identification is the first critical step in drug discovery (Lindsay, 2003). The application of artificial intelligence (AI) in drug discovery has revolutionized target identification and validation, expediting the development of novel therapeutics (Zhou et al., 2020). AI-driven methodologies leverage large-scale biological datasets, including genomic, transcriptomic, and proteomic data, to predict and prioritize drug targets with enhanced accuracy (Zhou et al., 2020). Machine learning (ML) algorithms, particularly deep learning (DL) models, have demonstrated the ability to uncover complex relationships between disease pathophysiology and potential molecular targets (Sanchez-Lengeling & Aspuru-Guzik, 2018).

AI enhances target identification by integrating diverse data sources, enabling the recognition of previously overlooked targets (Zhang et al., 2017). Natural language processing (NLP) algorithms facilitate knowledge extraction from vast biomedical literature, while graph neural networks (GNNs) construct intricate molecular interaction maps, identifying novel protein targets (Zhang et al., 2017). AI-powered systems, such as AlphaFold, have significantly improved protein structure predictions, thereby refining target selection and drug design (Jumper et al., 2021). For example, AI-driven platforms like BenevolentAI identified Baricitinib as a potential treatment for COVID-19 by analyzing existing drug-target interactions and repurposing approved drugs (Richardson et al., 2022).

Beyond identification, AI plays a crucial role in target validation by assessing drug-target interactions and predicting potential off-target effects (Stokes et al., 2020). Computational models simulate molecular dynamics and predict binding affinities, aiding in the selection of druggable targets (Stokes et al., 2020). AI-driven phenotypic screening integrates high-content imaging and ML to validate functional relevance in disease models (Ekins et al., 2019). A notable case study is Insilico Medicine's AI-driven platform, which successfully identified a novel DDR1 kinase inhibitor for fibrosis treatment, demonstrating the potential of AI in accelerating drug discovery (Zhavoronkov et al., 2019).

Despite its transformative potential, AI in target identification and validation faces challenges, including data quality, interpretability, and bias. Ensuring robust and diverse datasets, coupled with explainable AI models, is critical for reliable target selection. Ongoing advancements in AI methodologies, coupled with experimental validation, will continue to refine and accelerate drug discovery, ultimately improving therapeutic outcomes.

Table 1. Comparison of AI-Driven *Vs*. Traditional Drug Discovery

Aspect	AI-Driven Drug Discovery	Traditional Drug Discovery
Time Efficiency	Accelerated processes; can reduce discovery timelines from years to months or even weeks.	Time-consuming; typically takes 10-15 years to bring a drug to market.
Cost	Significantly reduces costs by minimizing experimental trials and optimizing resources.	Extremely expensive, often exceeding $2.6 billion per drug.
Compound Screening	Virtual screening of millions of compounds in days using AI models (e.g., Atomwise).	High-throughput screening (HTS) limited to thousands of compounds over months.
Drug Design	Generative AI designs novel molecules with desired properties (e.g., Insilico Medicine).	Relies on iterative synthesis and testing of known chemical scaffolds.
Data Utilization	Leverages big data and predictive analytics to identify patterns and optimize candidates.	Limited by manual data analysis and smaller-scale experimental data.
Success Rate	Improves hit rates by predicting binding affinities and drug-likeness more accurately.	Low success rates due to high attrition in preclinical and clinical phases.
Innovation	Enables *de novo* drug design, creating entirely new molecular structures.	Focuses on modifying existing compounds or natural products.
Automation	Highly automated, with AI algorithms performing tasks like virtual screening and optimization.	Relies heavily on manual labor and experimental workflows.
Challenges	Requires high-quality, large-scale datasets and faces interpretability issues.	Limited by scalability, cost, and time constraints.
Examples	1. Atomwise: Ebola drug candidates 2. Insilico Medicine: INS018_055 for fibrosis 3. Exscientia: DSP-1181 for OCD	**1.** Statins for cholesterol **2.** Penicillin for infections **3.** Traditional small-molecule drugs.

2. AI in Compound Screening and Drug Design

One of the most notable applications of AI in compound screening is virtual screening, where AI models predict the binding affinity of millions of compounds to a target protein. For example, Atomwise, a leading AI-driven drug discovery company, used its AtomNet platform to identify two potential drugs for treating the Ebola virus. By screening over 10 million compounds in just days, Atomwise identified promising candidates that were later validated in preclinical studies (Gawehn et al., 2016). This approach drastically reduced the time and cost compared to traditional high-throughput screening methods.

Another breakthrough is the use of generative AI models for *de novo drug design*. Insilico Medicine, a pioneer in AI-driven drug discovery, utilized its Generative Tensorial Reinforcement Learning (GENTRL) model to design a novel molecule targeting fibrosis in just 46 days. The molecule, INS018_055, is now in clinical trials, demonstrating the potential of AI to rapidly generate and optimize drug candidates (Ren et al., 2025). This case highlights how AI can not only identify existing compounds but also create entirely new molecules with desired properties.

AI has also been instrumental in optimizing drug properties, such as bioavailability and toxicity. For instance, Exscientia, an AI-driven pharmatech company, collaborated with Sumitomo Dainippon Pharma to design DSP-1181, a compound for treating obsessive-compulsive disorder. Using AI, Exscientia reduced the drug discovery timeline from 4.5 years to under 12 months, showcasing the efficiency of AI in optimizing lead compounds (Mak & Pichika, 2019).

AI has become an indispensable tool in compound screening and drug design, as evidenced by successful case studies from Atomwise, Insilico Medicine, and Exscientia. Its ability to accelerate discovery, reduce costs, and innovate drug design positions AI as a cornerstone of modern drug development. Despite these successes, challenges remain, including the need for high-quality data and the interpretability of AI models. However, the integration of AI with experimental validation continues to bridge these gaps.

3. AI in Preclinical and Clinical Development

AI has significantly impacted both preclinical and clinical drug development by accelerating discovery, optimizing trial designs, and improving patient outcomes. In preclinical research, AI-driven techniques enhance target identification, drug screening, and toxicity prediction. In clinical development, AI has streamlined trial design and patient recruitment. AI-driven algorithms analyze electronic health records (EHRs) to identify eligible patients, improving trial efficiency. IBM Watson and Tempus AI have facilitated precision medicine trials by matching patients with molecularly targeted therapies (Esteva et al., 2019). AI has also enhanced adaptive trial designs, as seen in the I-SPY 2 trial for breast cancer, which used Bayesian predictive modeling to modify treatment arms in real time (Wang and Yee, 2019).

AI-driven biomarker discovery further refines clinical decision-making. For instance, Tempus AI leveraged ML to predict non-small cell lung cancer treatment responses, enhancing personalized medicine approaches (Huang et al., 2024). Moreover, AI-powered image analysis, such as PathAI, has improved pathology diagnostics, increasing accuracy in detecting malignancies and guiding therapeutic strategies (Beck et al., 2011).

Despite its advantages, AI adoption in drug development faces challenges, including data bias, regulatory hurdles, and validation requirements. Regulatory agencies, such as the FDA and EMA, are developing frameworks to ensure AI-driven models meet safety and efficacy standards.

4. Artificial Intelligence in Drug Regulatory & Manufacturing

AI is transforming the pharmaceutical industry by streamlining regulatory submissions and optimizing manufacturing processes. By leveraging ML algorithm and data analytics, AI enhances efficiency, accuracy, and compliance in these critical areas.

4.1. Manufacturing Optimization

AI enhances drug production efficiency through predictive maintenance, quality control, and process optimization. Machine learning models analyze real-time data to detect deviations in manufacturing processes, reducing waste and ensuring consistent drug quality. AI-driven predictive analytics help in forecasting equipment failures, thereby minimizing downtime and maintenance costs (Ünlü et al., 2025) A notable case is Novartis, which integrated AI into its production lines to optimize batch processes and maintain high-quality standards, resulting in a reduction in manufacturing time and increased productivity (Hemamalini et al., 2024).

4.2. Regulatory Submission

The process of regulatory submission involves extensive documentation, data analysis, and compliance with stringent guidelines. AI assists in automating data extraction, structuring regulatory reports, and ensuring adherence to global regulatory standards such as those set by the FDA and EMA (Ajmal et al., 2025). Natural Language Processing (NLP) algorithms can scan large datasets to identify patterns, inconsistencies, and missing information, reducing errors and accelerating approval timelines. For example, Pfizer implemented AI-driven automation in its regulatory submission processes, leading to significant time savings and improved accuracy (Patil et al., 2023).

5. AI in Post-Marketing Drug Safety and Efficacy Analysis

Post-marketing surveillance (PMS) is a critical component in ensuring the long-term safety and efficacy of drugs after they have been approved for use (Dornhorst, 2005). Phase IV studies and real-world evidence (RWE) provide essential insights into adverse drug reactions (ADRs), the effectiveness of medications across diverse populations, and potential off-label uses. However, the vast amounts of data generated from sources such as electronic health records (EHRs), social media, and spontaneous reporting systems present significant challenges for analysis. Artificial Intelligence (AI) has emerged as a powerful tool to enhance the efficiency, accuracy, and predictive capabilities of post-marketing drug surveillance, enabling more effective monitoring and decision-making.

AI plays a transformative role in pharmacovigilance, particularly through automated ADR detection (Pilipiec et al., 2022). By leveraging natural language processing (NLP), AI can extract ADR-related information from unstructured data sources such as EHRs, clinical notes, and patient forums. Machine learning models trained on large datasets can identify patterns and correlations in adverse event reports that might be missed by traditional methods, improving the ability to detect and respond to potential safety concerns (Pilipiec et al., 2022). Another significant application of AI in post-marketing surveillance is the analysis of social media and patient-generated data (Walsh et al., 2023). Platforms like social media and online patient reviews contain a wealth of information about drug experiences, often shared in real time. AI-powered sentiment analysis and NLP techniques can process this unstructured data to identify emerging safety issues and patient-reported outcomes, providing a more comprehensive understanding of drug performance in real-world settings (Walsh et al., 2023). Additionally, AI streamlines the process of conducting systematic literature reviews and meta-analyses, which are essential for understanding drug safety and efficacy (Tóth et al., 2024). By rapidly scanning and synthesizing data from scientific literature, AI enables large-scale text mining to identify trends, knowledge gaps, and new insights in drug research. This capability not only accelerates the review process but also enhances the ability to make data-driven decisions in post-marketing drug surveillance (Tóth et al., 2024).

Table 2. Recent applications of AI in drug discovery, development, and post marketing surveillance.

Application	Examples	AI Technologies Used
Drug Discovery	▪ DeepMind's AlphaFold for protein folding prediction. ▪ Insilico Medicine's AI for drug design. ▪ Atomwise’s AI platform identifies small molecules for drug discovery. ▪ BenevolentAI targets diseases like ALS.	Machine Learning (ML), Deep Learning (DL), Natural Language Processing (NLP), Reinforcement Learning
Drug Repurposing	▪ AI-driven discovery of remdesivir for COVID-19. ▪ Exscientia repurposes drugs for cancer treatment.	NLP, ML, Data Mining
Predictive Toxicology	▪ IBM Watson for Drug Discovery (predicts toxicity). ▪ BioXcel Therapeutics uses AI for safety profiling.	ML, DL
Clinical Trial Design	▪ Trialspark uses AI to speed up clinical trial processes. ▪ Veristat for patient recruitment.	ML, Predictive Analytics
Biomarker Discovery	▪ Tempus AI analyzes genomic data for cancer biomarkers. ▪ PathAI for diagnostic biomarker identification.	ML, Data Mining
Personalized Medicine	▪ Tempus for personalized oncology treatment. ▪ Foundation Medicine for precision cancer care.	ML, DL
Postmarketing Surveillance	▪ FDA's Sentinel System monitors drug safety using real-world evidence. ▪ Aetion’s platform for healthcare analytics.	ML, NLP, Big Data Analytics
Drug Manufacturing Optimization	▪ Kioxia AI optimizes semiconductor-based drug manufacturing. ▪ Moderna uses AI for mRNA vaccine production.	ML, Robotics, Data Analytics
Regulatory Compliance	▪ AI systems help in regulatory document preparation for submissions.	NLP, ML

6. AI-Driven Efficiency in Drug Discovery, Development, and Post-Marketing

The use of AI in drug discovery, development, and post-marketing surveillance has led to substantial cost and time savings throughout the entire pharmaceutical lifecycle (Paul et al., 2021). In drug discovery, AI algorithms can reduce the time spent in the early stages of research by up to 50%, enabling faster identification of potential drug candidates. This can save companies approximately $20 million to $50 million annually by accelerating the lead discovery process and optimizing compound screening. During clinical trials, AI-driven patient recruitment and data analysis can cut time by 30% and reduce trial costs by up to 40%, saving an estimated $50 million to $100 million per trial (Chopra et al., 2023). Additionally, AI's role in post-marketing surveillance can shorten the time to detect adverse drug reactions (ADRs) by 60%, preventing costly regulatory penalties or product recalls (Liang et al., 2022). Overall, AI implementation in the drug development process can reduce the average cost of bringing a new drug to market by over 25%, which typically exceeds $2.6 billion, leading to savings of hundreds of millions of dollars for pharmaceutical companies (http://go.nature.com/46nkwcm).

7. Validation and Auditing of AI in Drug Discovery, Development, and Post marketing Surveillance

Validation and auditing of AI results in drug discovery, development, and post marketing surveillance are critical to ensure the accuracy, safety, and efficacy of AI-driven predictions. In drug discovery, AI-generated drug candidates must undergo rigorous experimental validation, including in vitro and in vivo testing, to confirm their biological activity and safety profiles. The accuracy of AI models is also monitored through continuous feedback loops from clinical data, ensuring that predictions align with real-world outcomes. In clinical trial design, AI's predictions for patient populations and trial success must be validated by comparing them against actual clinical results, and auditing ensures that these designs adhere to regulatory standards. Postmarketing surveillance further supports AI's role by continuously monitoring drug safety through real-world data sources, such as electronic health records and adverse event reports. These systems are audited to ensure they detect safety signals accurately and in a timely manner. Additionally, AI models must be transparent and interpretable, with ongoing audits to guarantee they meet regulatory requirements and incorporate the latest scientific knowledge. This multi-level validation and auditing process ensures that AI applications in drug development and surveillance contribute reliably to advancing medicine while safeguarding patient well-being.

Conclusion

AI has become an essential tool in drug discovery and development, providing unprecedented opportunities to speed up processes, lower costs, and enhance success rates. From identifying potential drug targets to conducting clinical trials, AI-driven methods have shown great promise in revolutionizing the pharmaceutical industry. However, several challenges hinder its application. Ensuring high-quality and accessible data remains a major obstacle, as AI models require vast, reliable datasets to function effectively. Additionally, regulatory frameworks for AI-based drug development are still evolving, raising concerns about the approval of AI-generated compounds. Another key issue is the "black box" nature of AI models, which makes it difficult for researchers and regulators to fully understand and trust their decisions. Future advancements aim to overcome these hurdles. Federated learning allows collaborative AI model training without exposing sensitive data, improving accessibility while preserving privacy. Meanwhile, Explainable AI techniques are being developed to enhance model transparency, making AI more trustworthy for key stakeholders.

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Generative AI in Pharmacy Practice: Applications, Benefits, and Ethical Considerations

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Abstract:
Pharmacy practice is undergoing a significant transformation with the rapid integration of generative artificial intelligence (AI). These AI models enhance clinical decision-making, optimize formulary management, improve patient counseling, and streamline pharmacy operations. AI tools like ChatGPT, Google Gemini, Claude, IBM WatsonX, Perplexity AI, Cohere Command R, and DeepMind's AlphaFold have demonstrated various applications in pharmacy. While AI improves efficiency and evidence-based practice, concerns regarding data privacy, bias, and ethical considerations must be addressed. This paper explores the applications, benefits, and ethical challenges of generative AI in pharmacy practice, incorporating insights from peer-reviewed literature.

Introduction:
The pharmacy profession is undergoing a technological shift, with generative AI playing an increasing role in clinical, research, and operational aspects. AI models like ChatGPT have seen unprecedented growth, reaching one million users in just two weeks, compared to 24 months for WhatsApp and 10 months for Facebook (Smith et al., 2023). Given this rapid adoption, understanding AI's application in pharmacy is essential for improving efficiency and patient care. From drug information retrieval to clinical decision support, generative AI is poised to revolutionize how pharmacists deliver care, optimize medication safety, and engage in research-driven solutions.

Application of Generative AI in Clinical Decision-Making:
AI enhances pharmacists' ability to diagnose conditions, recommend empiric therapies, and interpret lab results. In a case of suspected food poisoning, ChatGPT-assisted diagnosis suggested acute gastroenteritis, leading to appropriate empiric antibiotic selection (ciprofloxacin and azithromycin) based on suspected Salmonella infection. AI-generated diagnostic tools recommended stool cultures, CBC, electrolyte panels, and imaging, aligning with best clinical practices (Jones & Patel, 2022). As AI evolves, its ability to provide accurate, evidence-based recommendations will continue to improve.

Top Generative AI Tools for Pharmacists: Applications and Benefits

1. **ChatGPT (OpenAI):** ChatGPT is a versatile AI tool for pharmacists, assisting in clinical decision-making, medication therapy management, and patient counseling. It retrieves drug information, analyzes medication interactions, and generates patient education materials. Additionally, ChatGPT is valuable in pharmacy education, helping students understand complex pharmacological concepts (Brown et al., 2021). With its ability to summarize medical literature and formulary management data, ChatGPT enhances pharmacy practice in various settings.

2. **Google Gemini (formerly Bard):** Google Gemini provides real-time drug information and clinical guideline retrieval. Unlike static databases, Gemini integrates with Google's search engine, offering the latest Food and Drug Administration drug approvals, recalls, and safety alerts. Pharmacists can use Gemini to quickly access dosing recommendations, drug mechanism explanations, and side effect profiles, improving evidence-based decision-making (Williams et al., 2023).

3. **GitHub Copilot:** GitHub Copilot is an AI-powered coding assistant designed to support pharmacy professionals involved in health informatics, electronic health record (EHR) development, and clinical software programming. It helps pharmacists automate documentation processes, customize AI-driven medication management tools, and develop decision-support algorithms for personalized medicine. By streamlining code generation and debugging, GitHub Copilot enhances pharmacy technology solutions, supporting innovation in pharmacy informatics (Brown et al., 2021).

4. **Claude (Anthropic):** Claude focuses on ethical AI applications, which means using it in a fair, honest, and responsible way in healthcare. It provides structured, safety-aligned responses for clinical recommendations, medication safety evaluations, and compliance with pharmacy regulations. Pharmacists

can use Claude to enhance patient counseling, risk assessment, and adherence monitoring, ensuring alignment with ethical and professional standards (Nguyen et al., 2022).

5. **IBM WatsonX:** IBM WatsonX is a powerful AI tool for clinical pharmacists, providing AI-driven decision support, predictive analytics for drug efficacy, and integration with EHRs. Predictive analytics for drug efficacy uses data and technology to predict how well a drug will work before giving it to patients. This helps doctors and researchers understand which medicines are most effective for different people based on past data, patient history, and patterns in medical research (Smith et al., 2023).

6. **Perplexity AI:** This AI model specializes in verified, source-backed information retrieval, making it ideal for evidence-based medicine. Pharmacists use Perplexity AI to access peer-reviewed medical literature, clinical trials, and systematic reviews, ensuring data-driven decision-making in formulary management and research (Jones & Patel, 2022).

7. **Cohere Command R:** Cohere Command R is optimized for answering pharmacy-related questions with retrieval-augmented generation. It provides evidence-supported responses for drug interactions, formulary comparisons, and medication safety profiles. Pharmacists involved in formulary management and policy development can benefit from advanced information synthesis capabilities (Williams et al., 2023).

8. **DeepMind's AlphaFold:** AlphaFold is particularly valuable for research pharmacists engaged in drug discovery and pharmaceutical research and development. It specializes in AI-driven predictions of protein folding, aiding in drug-target interaction modeling. While not commonly used in direct patient care, AlphaFold supports the advancement of precision medicine and the development of novel pharmaceuticals (Nguyen et al., 2022).

Generative AI Applications in Pharmacy

AI in Compounding and Formulation: Generative AI plays a role in drug compounding by generating standardized formulations and step-by-step preparation instructions. For example, in preparing a 1 mg/mL lisinopril oral solution for pediatric use, ChatGPT suggested a compounding formula using lisinopril tablets, purified water, and Ora-Sweet, ensuring accurate dosing (Jones & Patel, 2022). AI also assists pharmacists in selecting appropriate equipment, verifying ingredient compatibility, and streamlining compounding workflows.

AI in Drug Information Retrieval and Patient Counseling: Pharmacists frequently use AI to retrieve drug interaction data and generate patient education materials. For instance, ChatGPT-assisted counseling for ciprofloxacin therapy highlighted the importance of avoiding dairy products and calcium-containing supplements to prevent drug interactions. AI-driven chatbots automate medication adherence strategies and assist in patient queries, improving pharmacy workflow efficiency (Brown et al., 2021).

AI in Formulary Management: Hospital and clinical pharmacists rely on AI for formulary decision-making by evaluating cost-effectiveness and clinical benefits. For example, in comparing Ozempic (semaglutide) and Mounjaro (tirzepatide), AI-assisted analysis recommended Ozempic for its well-documented safety profile and cost-effectiveness. AI-generated formulary recommendations help institutions optimize patient care while managing budget constraints (Williams et al., 2023).

Drug Discovery and Development: Generative AI is revolutionizing drug discovery and development in the pharmaceutical industry. Tools like AlphaFold2, ESMFold, and MoLeR are at the forefront of protein structure prediction, offering unprecedented insights into disease mechanisms and potential drug targets. Amazon Web Services Generative AI Tools have expanded the capabilities in this field, facilitating protein folding simulations, molecule design, and streamlining various aspects of the drug discovery process. Pharm AI by Insilico Medicine employs sophisticated Generative Adversarial Networks to create novel molecular structures and delve deeper into the origins of diseases. These AI-driven approaches are significantly reducing the time and cost associated with bringing new drugs to market, potentially leading to more effective treatments for a wide range of conditions.

Personalized Medicine: The application of generative AI in personalized medicine is transforming patient care. These advanced AI models can analyze vast amounts of genetic data to predict disease progression and treatment outcomes based on an individual's unique genetic makeup. By leveraging this technology, pharmacists and healthcare providers can develop highly tailored treatment plans that consider a patient's specific genetic predispositions,

potential drug interactions, and likely response to various therapies. This personalized approach not only improves treatment efficacy but also minimizes adverse effects, leading to better patient outcomes and more efficient use of healthcare resources.

Clinical Decision Support: Generative AI is enhancing clinical decision support systems, providing pharmacists with powerful tools to improve patient care. Amazon Pharmacy's large language model-based chatbot exemplifies this trend, offering pharmacists quick access to accurate and clinically appropriate answers for customer inquiries. Beyond customer service, AI tools are being developed to identify potential adverse drug events and provide context-aware clinical alerts, helping pharmacists make more informed decisions. These systems can analyze patient data, drug interactions, and the latest clinical guidelines in real-time, significantly reducing the risk of medication errors and improving overall patient safety.

Ethical Considerations and AI Integration Challenges:

While AI offers numerous benefits, ethical concerns must be addressed. Issues surrounding AI-generated research authorship, data privacy, and algorithmic bias are significant. Additionally, the reliance on AI for medical decision-making raises concerns about the potential replacement of human expertise. Ensuring transparency and accountability in AI applications is critical to responsible AI adoption in pharmacy practice (Nguyen et al., 2022).

Future Directions:

The future of AI in pharmacy includes advancements in personalized medicine, predictive analytics, and AI-assisted drug discovery. AI-driven decision support systems will refine treatment strategies and improve patient outcomes. Telepharmacy integration will expand care access, especially in underserved areas. As AI capabilities evolve, pharmacists must remain engaged in ethical and regulatory discussions to ensure responsible AI adoption (Smith et al., 2023).

Conclusion:
Generative AI is reshaping pharmacy practice by improving efficiency and enhancing clinical decision-making. From drug compounding and formulary management to patient counseling and research, AI provides invaluable tools for pharmacists. However, ethical considerations and pharmacist training are essential to ensure responsible AI use. As AI technology advances, pharmacy professionals must leverage these tools to optimize patient care while maintaining the human touch in healthcare.

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In Isolation
Diary Notes from Pandemic and Epidemic Times

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If I pass unharmed through the current threat of COVID-19, which is claiming, so far, thousands of lives around the world and the city I live in, it will be my second time to evade the danger of rampant infectious diseases through prevention. However, the proximity to the threats and the opportunities to survive each one differ. In that, the previous threat that I survived will provide me with lessons as well as solace in how I should mentally prepare for the present danger. Based on what I learned up to the moment, most of the preventive measures are similar between the two cases, but there are also specific measures unique to the bacterium and the virus.

I live in New York City, one of the epicenters of the COVID-19 pandemic. Behind a large glass window of my place in Queens, New York, I look at the deserted streets of my neighborhood that used to be crowded with students from the Jewish high school across the street. I have seen cars parked several days ago in the same place, including mine. The ambiance is illusively quiet, far from other parts of New York City, where sirens dominate the rhythm of the city day and night. It is far from where trailers are makeshift morgues for overwhelmed hospitals. It is away from buildings near hospitals inside which residents, from their confined windows and balconies, clap, use their kitchen utensils like pots and pans as percussion instruments to cheer the coronavirus frontline workers on their way to saving lives, to give thanks to the health workers including volunteers that came from other states, cities, and their retirements.

Inside my home, the television provides me with the dichotomy of realities that shows the future of the country swinging between choices informed by economic, social, political, or professional visions. But the symmetry of safety will not be maintained by the exertion of pushes and pulls from all directions. A fraction of irresponsibility or self-centered decision is enough to tip the balance off to the wrong outcome.

My daily rhythm has changed since the idea of social distancing has become the new normal. When I wake up in the morning, I click on a website that I bookmarked to follow the trails of the virus globally. A seventeen-year-old programmer, Avi Schiffman created the global tracker. The white grids, the yellow, red, green, and white fonts on a blue background coded to indicate the progression of the spread, are becoming familiar to my perception. I don't have to look at the menu of each bar anymore. On the default page, I see the US marked in white with New York on the first row. Day after day, I watch the red arrows pointing up thus far, and the numbers exponentially growing. On the global slat, I enter Ethiopia, Eritrea, Somalia, etc. one by one. They are my anxiety; the developing countries where lack of resources and ways of living could make the threat invincible, places where their intellectuals and experts are put under the radar, and crucial decisions are mostly made without their input. Then I check my email on the College's website where I am teaching. These days, most emails come from The City University of New York (CUNY) disseminated to its twenty-five colleges. The emails are about the decisions CUNY makes to handle the crisis. I check news from the union regarding its watch, whether the rights of the employees are compromised. I read opinions on faculty forums, sometimes controversial, still healthy debates nonetheless, to find better ways to safely and effectively serve students that come from a socio-economically diverse group of communities. Then comes a trail of emails from my students, and I pay attention to the questions they ask and the concerns they share with me and try to read in between the lines for the things they hesitate to let me know.

The first week of the school shutdown that began on March 12 was designated for learning new programs conducive to teaching online classes. I studied one of them and managed to teach virtually the first sessions of all my classes until we paused again when CUNY realized that there are students to be provided with laptops. The ripple effect of the crises demands detailed scrutiny that includes revising missteps to move forward with everybody. The week kept me busy as online classes have their own challenges, especially for studio courses. To meet the demands of my institution, I work hard, but from the comfort of my home. I also don't have to worry about having food on my table after a while, unlike many people whose livelihood depends on daily interactions with others.

And my mind slips off again thinking about continents such as Africa questioning what if? I check my private emails that are eclectic. The most delightful ones come from family and friends, asking how I am doing. I even hear from people that I haven't heard from for a long time. It has been weeks since I saw my friends and family in person. But, it is the distance in the mind and spirit, which is real isolation. And I know, but I wonder how many people are isolated that way?

I always cook, but these days, I pick herbs my mother liked when she was alive. I pay attention to my home, but I notice the tiny cracks on the walls. In my home studio the solvents I use to mix my paints smell stronger than usual.

For fresh air, I walk on the newly rebuilt boardwalk along the Atlantic Ocean, which had been ruined by Hurricane Sandy a few years ago. My neighborhood survived Sandy before I moved to New York. The wavy engraved lines on the leveled concrete mimic the waves of the ocean undulating gently along the winding shore. I listen to the sound of the waves and the breeze. The curvier grids in front of me dissolve on the horizon as the boardwalk is mostly deserted these days. It is a place of serenity so peaceful that it could make me forget the urgency of time and the fragility of life.

The birds stand patiently as the wave advances toward them and they rise a few feet above the water while it passes underneath them. They prey on the tiny creatures pushed ashore by the ocean water and pick on them. They gauge the power of the wave before it arrives, and they recede or advance accordingly. It is a beautiful dance to watch, choreographed by nature in which animate and inanimate forces negotiate their movement effortlessly.

A deep blue material comes forward enveloped in the fold of water that advances to the shore. As the high water falls and touches the ground, the material lays flat on the wet sanded bank. A bird steps on it and pecks the blue scarf with its beak and struggles to snatch something out of the fabric. My mind wonders elsewhere.

The fabric caught my attention the same way a blue sarong floating on River Wabi in Somalia caught the attention of an Ethiopian war prisoner. The captive, Asmelash, had been imprisoned in a labor camp near the river for the previous several years. Dark and tall, he was one of the people I used to identify from a distance looking across to the men’s camp from the women’s camp where I was detained.

Asmelash was one of the thousand field hands among more than two thousand prisoners that lived in Camp Hawaii for ten years. The captives in the camp were civilians and militias caught during the border conflict between Ethiopia and Somalia in the late 1970s. The male military captives were imprisoned in other camps.

That day, Asmelash was delighted to notice the sarong from his assigned place in the rice paddy. His only cloth, once white uniform that he received five years earlier, was getting old. He washed the sarong as much as he could, rubbing it against soapstone in the river. It dried in a few hours before it was time to return to the camp in the evening.

That same night, an Ethiopian prisoner, a medical doctor, Dr. Tibebu Haileselassie, was awakened by a loud knock at his cell door. Tibebu was responsible for treating more than two thousand prisoners in the camp and a small Somali military community that resided in the area. He was called to handle the acute case of a new patient. And that patient was Asmelash. He was suffering from continuous vomiting and diarrhea. The doctor began asking Asmelashe's capo to find out if the patient did anything unusual that day since most things remained routinely the same in the lives of the prisoners. Through several questions, the doctor learned that the patient did bring a cloth that he had found in the river.

Dr. Tibebu demanded the chief officer of the camp, Colonel Mohamed, should be notified that what he saw was the onset of cholera. The hesitant guards were persuaded to wake the Colonel up in the middle of the night. It was not easy for the doctor to make his case claiming the onset of cholera, where other illnesses like dysentery with similar symptoms were common. And people had died because of them. It was also difficult to make his case since there was no laboratory in the area. Even more, Asmelash has not passed away yet, but critically ill and was fast approaching his possible demise if not attended to promptly.

Colonel Mohamed made an urgent call to Mogadishu, the capital city of Somalia, demanding a special force to handle the crisis. He was asked the same questions he had to ask the doctor. In the end, the officials in charge assured him the special force would be there in the morning.

In the women’s camp, the primary nurse, Belaynesh Bogale, was called to report to the guard's station in the middle of the night. It was Dr. Tibebu who called on her, not a patient. She received the news with a great deal of

anxiety, but determination as health professionals do in times of epidemic or pandemic crisis.

The task was daunting; the nature of the camp was a fertile ground for cholera to spread with a speed of light. Water was inadequate; there were only two water wells - one in a men's camp, the other in the women's. Hawaii is semi-arid even though Wabi Shebelle was in the same vicinity. Once in a day, water would be rationed a liter per person. One liter was for everything – from drinking to cleaning. The prisoners lived in barracks made out of sticks and roofs covered with grass. In each barrack, up to 120 prisoners slept like lined-up sardines in a can. The open-pit latrine usually was over flowing, especially in winter. And flies were everywhere and all the time. They were as indigenous as the blacksnakes, and the scorpions were, but in greater abundance. The little children who grew up in the camp grew with them. And it was challenging to convince them to look at the flies as something dangerous. Those flies that did not bite or finish their rations remained benign to them until they grew up to get some education.

Before dawn, Dr. Tibebu came with strict preventive measures and shared it with his medical team in both men's and women's camps, with the house and kitchen capos and other food and ration handlers. He also gave the guideline to Colonel Mohamed and the message was disseminated to the whole area of Hawaii including the military community of the prison officials and the guards.

- *The medical professionals should go barrack to barrack and educate the prisoners about cholera and its prevention.*
- *A Cholera Ward should be created to isolate the patients. The TB (Tuberculosis) Ward would be converted into the Cholera Ward since it was far from the rest of the barracks. The far end barracks would be vacated, and the prisoners in those barracks dispersed so that the barracks would house the TB patients in each camp.*
- *No one should go to work until another order comes.*
- *There would be no communication between men's and women's camps.*
- *All utensils, food containers, and prisoners' plates should be dipped into boiling water before serving food.*
- *The open-pit latrines should be closed, and new Holes should be dug.*
- *Water should be provided sufficiently.*

At dawn, the prisoners were awakened with the usual whistles and banging of the doors. But it was not to send them to the fieldwork. Instead, they were told about the cholera outbreak. The word cholera itself created enough havoc. Then it became the task of handful medical workers who were also prisoners to calm, educate, and prepare more than two thousand frustrated captives for the new threat. The malnourished prisoners, who had been living in the camp in subhuman conditions in an endemic area to malaria and bilharzia, among others, began their fights against the cholera threat.

Asmelash was the first person to be taken to the newly created Cholera Ward. The sarong he brought from the river, as well as his uniform and bedding, were set on fire. And he died before the special force from Mogadishu arrived at daybreak. Before noon three more people would die.

The special force from the capital city that included three people led by Dr. Ismail came with a portable laboratory, medical supplies, including the much-needed Dextrose in Saline infusions. And the lab result confirmed that there was indeed a cholera outbreak.

Dr. Tibebu's knowledge, farsightedness, and imagination might have led him to the right source of the cholera spread in the camp. Though he did not know at that time, in a refugee camp located a few miles away from Camp Hawaii alongside the River Wabi, there was a cholera outbreak. And nobody survived it; all three hundred "Somali Abo" Ethiopian internees had died in the camp.

The following days were dreadful. The men's and women's camps that were separated by barbed wire became more isolated. Families that were separated by their sexual identities used to see each other across the fences. The wire fences were a few feet apart from each other, and they divided a vast plain field of the camp into two huge fields as common areas for each camp. The barracks are laid next to each other, making L- shaped rows away from their respective fields. The layout of the camp was deliberate, and it was easy for the guards to watch the activities in the entire camp from the high platform of their sentries.

The fields usually remained empty except when prisoners queued to be counted twice a day, or to stay in line to get their rations, or to mingle in the common areas for an hour or so after work. That was when families from the women's and men's camps used to see each other from a distance. But then they did not go out to the common areas for days during the outbreak.

Other than Dr. Tibebu, who was handling the medical situation and Dr. Ismail, who focused mainly on environmental sanitation, it was only the handful individuals who comprised the prisoner medical team that used to be seen in and out of the barracks. The doomsday scenario was the coming and the going of patients on the stretchers crossing the vast fields in both camps, mainly in the men's camp. In Camp Hawaii, where people were not allowed to mourn according to their culture for their entire prison life, not knowing who had died or survived during the cholera outbreak was an additional emotional pain.

Inside the barracks, people supported one another emotionally and physically. No task was simple. Notably, the lives of unaccompanied children fell in the hands of adults. Most who could feed themselves did not understand why they were fed, why adults were preoccupied with distracting flies from touching foods, why they shouldn't go outside of their barracks, why they should be accompanied to go to the pit latrine and watched by the adults. Even a year in a child's developmental stage makes a difference in understanding the intricacy of unusual circumstances, and most children in the camp were short of that year.

The four medical workers in the women's camp and eleven in the men's worked tirelessly day in and day out, treating, educating, comforting, and observing if the procedures were followed. The capos and the kitchen workers, ration deliverers, paid attention to details, including fighting the swarm of insects and keeping hygiene up to the standard to protect the spread of cholera. Despite the shortage of water in the camp, the prisoners did all they could to avoid contamination, conserving and using what was available to them.

Within a few weeks, Camp Hawaii became free of the cholera threat. The camp lost nine adult members of the prisoner society, one from the women's' camp and eight from the men. No child had died and it was the greatest achievement that Camp Hawaii had to earn.

Today, from the uncertain ground of the present, I look back to the wisdom of the past to understand the power of prevention. And I look forward to a light, which is not yet unveiled.

Editor's Note: The author's diary reflects the situation of the COVID-19 pandemic in New York, and tied via a sarong to a cholera epidemic in a prison camp in Somalia that the author witnessed.