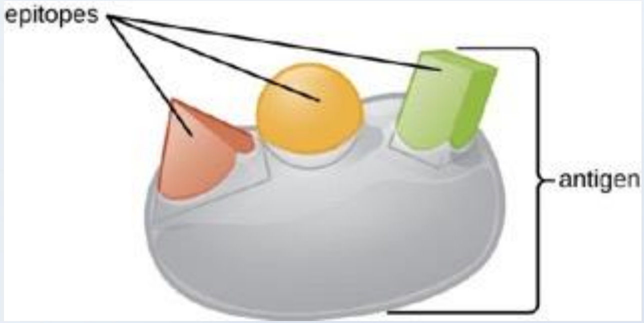
Yapay Zeka & Aşılama

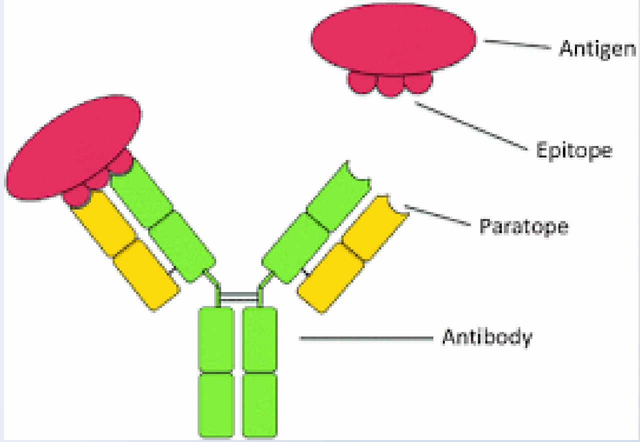
Özlem Güler

Kocaeli Üniversitesi
Enfeksiyon Hastalıkları ve
Klinik Mikrobiyoloji

Aşı Geliştirme Süreci

- Hedef patojen ve Antijen analizi
  - Genom ve protein yapısı
- Bağışıklığın tanımlayabileceği
  - Antijenlerin belirlenmesi
  - Epitop belirleme ve seçimi
- Aday aşı tasarımı





Aşı Geliştirme Süreci

- Preklinik hayvan çalışmaları
- Klinik çalışmalar faz I-III
- Ruhsatlandırma ve onay
- Faz IV ve izlem

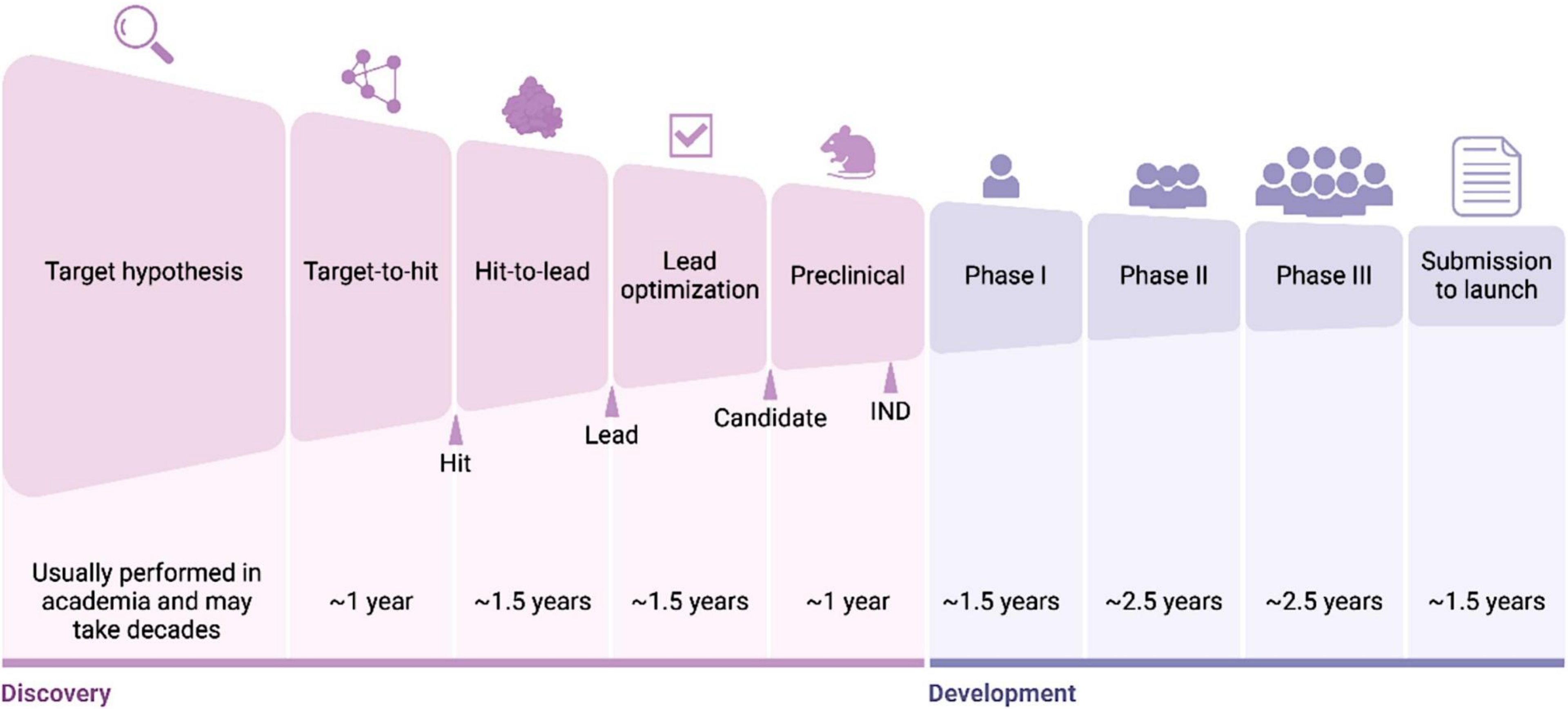
A. Cunningham et al. "Vaccine development: From concept to early clinical testing.." *Vaccine*, 34 52 (2016):

Aşı Sürecinde Zorluklar

- Zaman alır
- Maliyeti fazla
- Antijenin tanımlanması karmaşık bir süreç
  - Kompleks patojenlerin çok antijeni var (tüberküloz)
- Aşı üretim ve erişimdeki zorluklar

Olawade et al. 2024. "Leveraging Artificial Intelligence in Vaccine Development: A Narrative Review." *Journal of Microbiological Methods* 224 (September): 106998.

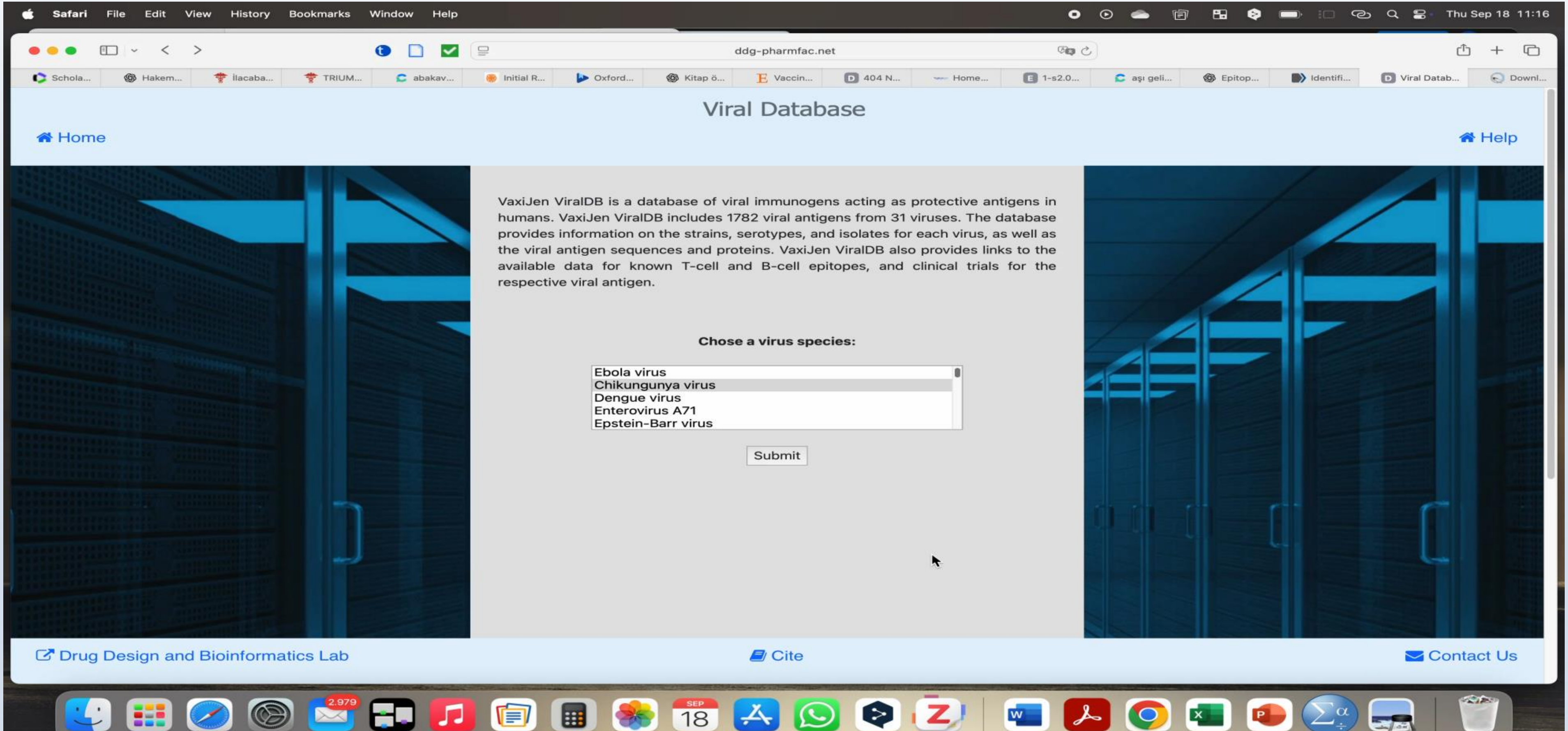
Phases of Preclinical & Clinical Drug Discovery



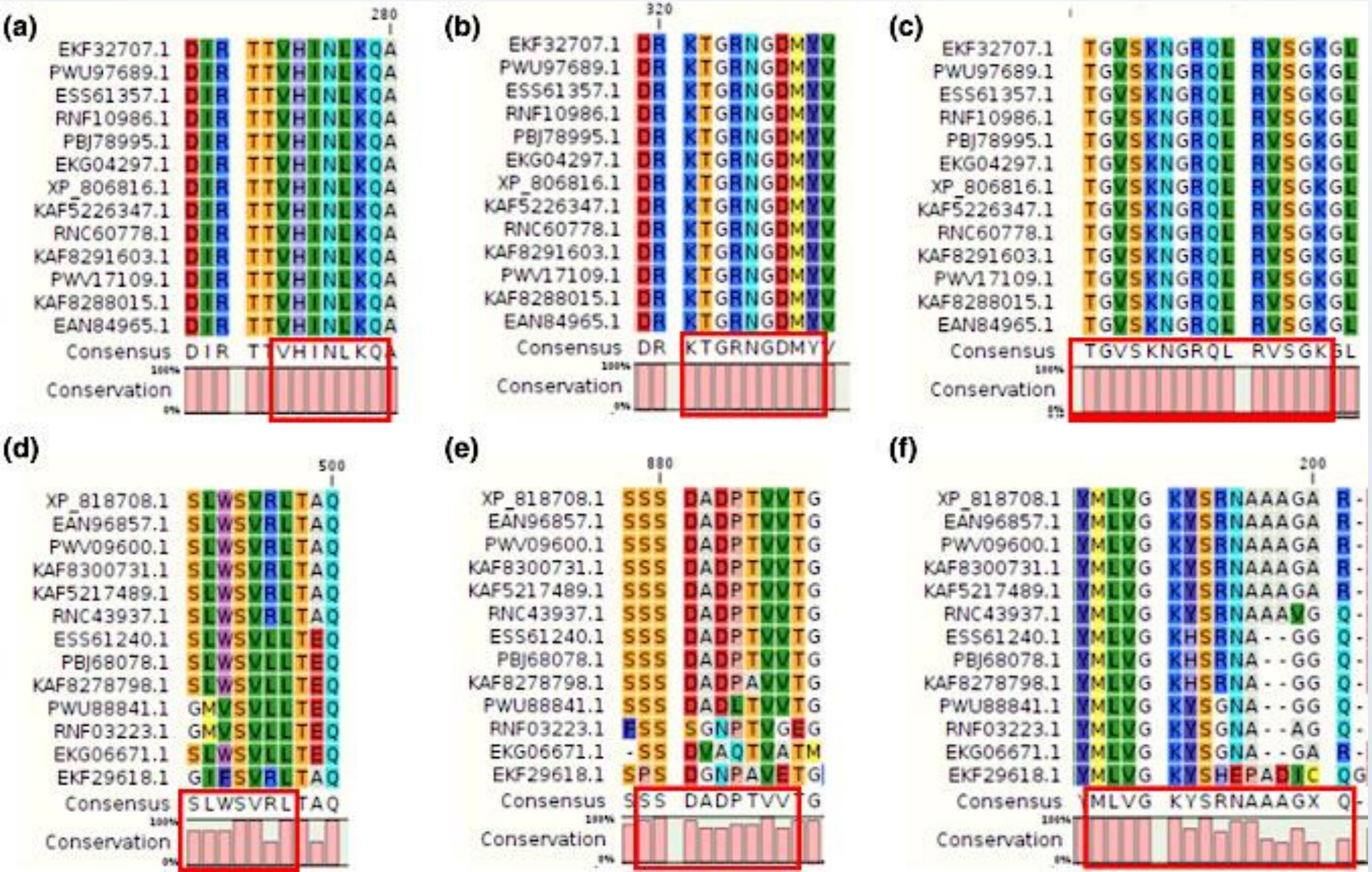
Yapay Zeka ve Aşılama

- Antijenin tanımlanması
- Aşı dozlarının kararı
- Epitop tahmini
- Tedarik zinciri
- Adjuvan, koruyucu, taşıyıcı
- İnfoepidemiyoloji

Proteomik ve genomik analiz ile antijen tahmini (Vaxijen)



Proteomik ve genomik analiz ile antijen tahmini



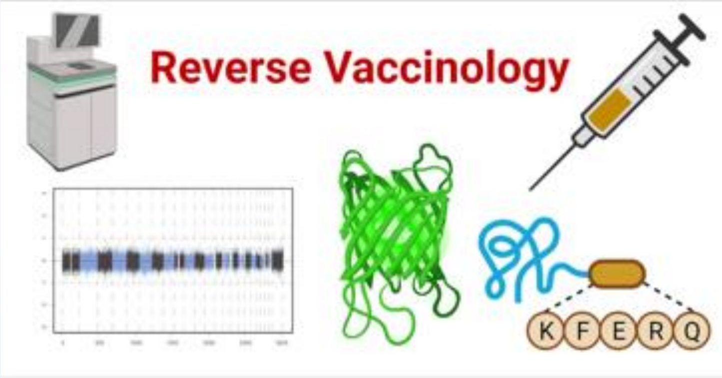
Farklı *T.cruzi* suşlarının epitopları

Rawal. et al. 2021. “Identification of Vaccine Targets in Pathogens and Design of a Vaccine Using Computational Approaches.” *Scientific Reports* 11 (1): 17626..

Reverse vaksinoloji (RV)

- Genom dizisinden başlayarak olası antijenleri arar
- Kültür ve lab adımlarını atlar
- Deneysel olarak antijenleri dener (in silico-bilgisayar destekli)

- İlk büyük başarısı **Bexsero/4CMenB**

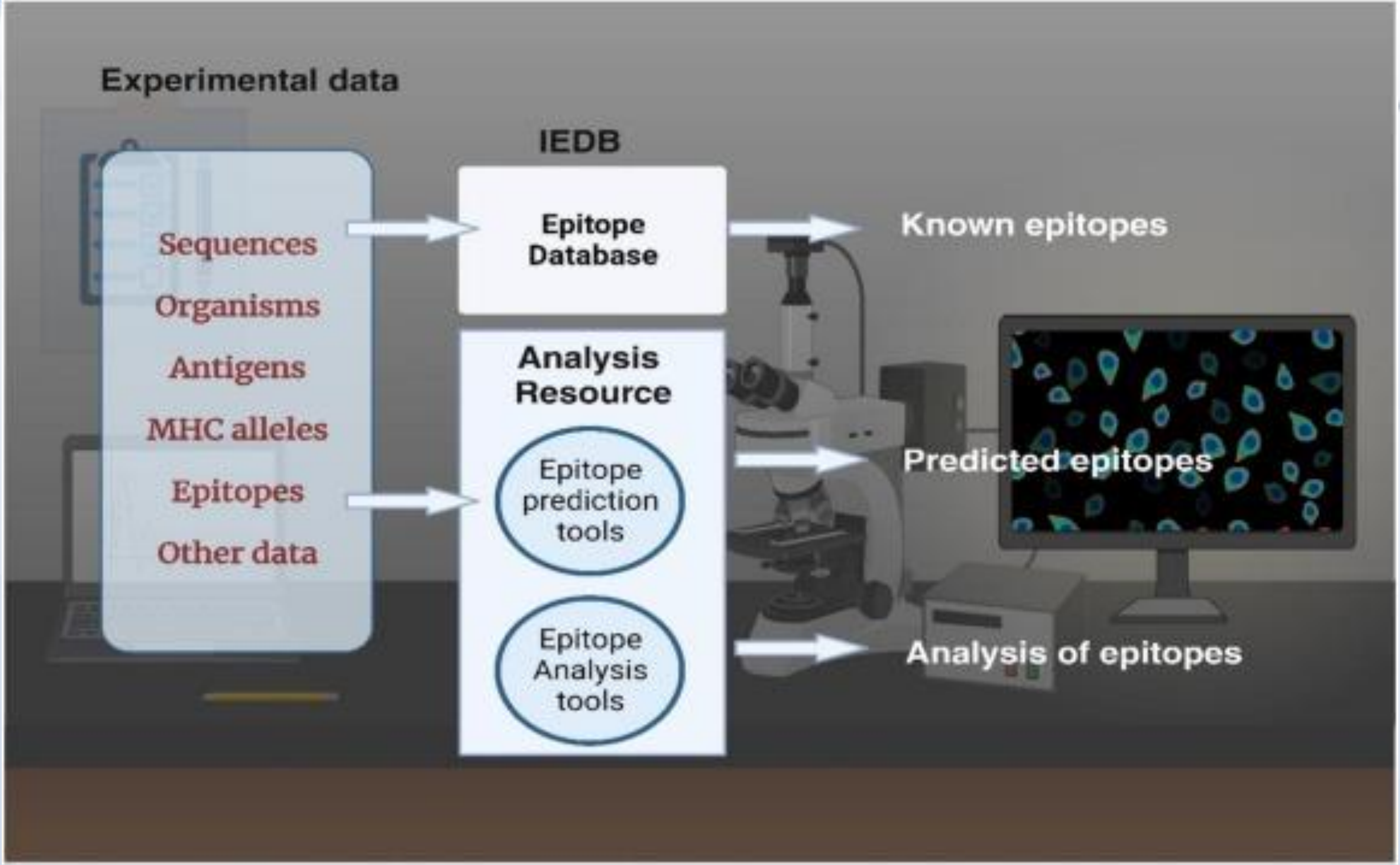


Kaushik et al., 2023. “Artificial Intelligence in Accelerating Vaccine Development - Current and Future Perspectives.” *Frontiers in Bacteriology* 2 (October): 1258159.

Epitop Haritalama

- Epitoplar, antijenlerin B ve T hücreleri tarafından özgül olarak tanınan bölgelerdir.
- Epitop haritalaması, antijen üzerindeki bölgelerin belirlenmesi
- Epitop bazlı aşılar, daha az yan etkiyle koruyuculuk sağlar

Yurina et al., 2022. "Predicting Epitopes for Vaccine Development Using Bioinformatics Tools." *Therapeutic Advances in Vaccines and Immunotherapy* 10 (January): 25151355221100218.



Experimental data
IEDB
Sequences
Organisms
Antigens
MHC alleles
Epitopes
Other data
Epitope Database
Analysis Resource
Epitope prediction tools
Epitope Analysis tools
Known epitopes
Predicted epitopes
Analysis of epitopes

Table 2. T-cell epitope prediction tools.

Tool	Description	URL
EpiMatrix	Based on protein binding efficiency with MHC class I and II	http://www.epivax.com/
FRAGPREDICT	Based on proteasome cleavage site binding score	http://www.mpiib-berlin.mpg.de/MAPPP/cleavage.html
Immune Epitope Database and Analysis Resource (IEDB)	Prediction based on analysis of proteasomal processing, TAP transport, and MHC class I and II binding	http://www.immuneepitope.org/
MHCPred	Based on the binding value of MHC/peptide or TAP/peptideIC50	http://www.jenner.ac.uk/
MMBPred	Determination of high-affinity MHC binding peptide that undergoes mutations	http://www.imtech.res.in/raghava/mmbpred/
NetChop	Based on the immunoproteasome cleavage site	http://www.cbs.dtu.dk/services/NetChop/
NetCTL	Based on the combination of MHC subtype binding values, Tap transport and proteasome	http://www.cbs.dtu.dk/services/NetCTL/
NetMHC	Based on the binding propensity of peptides to different HLA alleles using ANN	http://www.cbs.dtu.dk/
ProPred-1	Based on peptide binding efficiency with MHC I	http://www.imtech.res.in/raghava/propred1
SYFPEITHI	Based on motif binding to MHC class I and II	http://www.syfpeithi.com/
TAPPred	Based on binding affinity with TAP protein	http://www.imtech.res.in/raghava/tappred/
RANKPEP	Predicts peptide binders to MHC I and MHC II molecules using position specific scoring matrices (PSSMs)	http://imed.med.ucm.es/Tools/rankpep.html
Epijen	Based on the immunoproteasome cleavage site and TAP binding affinity	http://www.ddg-pharmfac.net/epijen/EpiJen/EpiJen.htm
nHLAPred	Based on the hybrid approach of artificial neural networks (ANNs) and quantitative matrices (QMs)	http://crdd.osdd.net/raghava/nhlapred/

Mod

Welcome

The Immune Epitope Database (IEDB) is a freely available resource funded by NIAID. It catalogs experimental data on antibody and T cell epitopes studied in humans and other animal species in the context of infectious disease, allergy, autoimmunity and transplantation. The IEDB also hosts epitope prediction and analysis tools, and has a companion site, CEDAR (funded by NCI), which houses cancer epitopes.

Learn More

Upcoming Events & News

Virtual User Workshop * recordings here	Nov 5-7, 2024
AACR 2025	Apr 25-30, 2025
Immunology 2025	May 3-7, 2025

Summary Metrics

Peptidic Epitopes	1,628,339
Non-Peptidic Epitopes	3,327
T Cell Assays	560,544
B Cell Assays	1,426,869
MHC Ligand Assays	4,892,378
Epitope Source Organisms	4,695
Restricting MHC Alleles	1,016
References	26,317

START YOUR SEARCH HERE

Epitope ?

- Any
- Linear peptide
  Exact M | Ex: SIINFEKL
- Discontinuous
- Non-peptidic

Assay ?

- T Cell
- B Cell
- MHC Ligand

Ex: neutralization | Find

Outcome: Positive Negative

Epitope Source ?

Organism

Ex: influenza, peanut | Find

Antigen

Ex: core, capsid, myos | Find

MHC Restriction ?

- Any
- Class I
- Class II
- Non-classical
- Ex: HLA-A*02:01 | Find

Host ?

- Any
- Human
- Mouse
- Non-human primate
- Ex: dog, camel | Find

Disease ?

- Any
- Infectious
- Allergic
- Autoimmune
- Ex: asthma | Find

Reset | Search

Epitope Analysis Resource

T Cell Epitope Prediction ?

Scan an antigen sequence for amino acid patterns indicative of:

- MHC Class I Tools Suite (Immunogenicity, Processing, Binding/Elution)
- MHC Class II Tools Suite (Immunogenicity, Binding/Elution)

B Cell Epitope Prediction ?

Predict linear B cell epitopes using:

- Antigen Sequence Properties

Predict discontinuous B cell epitopes using antigen structure via:

- Discotope
- ElliPro

Epitope Analysis Tools ?

Analyze epitope sets of:

- Population Coverage
- Conservation Across Antigens
- Epitope Cluster Tool

Supported by a contract from the National Institute of Allergy and Infectious Diseases, a component of the National Institutes of Health in the Department of Health and Human Services.

CORE TRUST SEAL

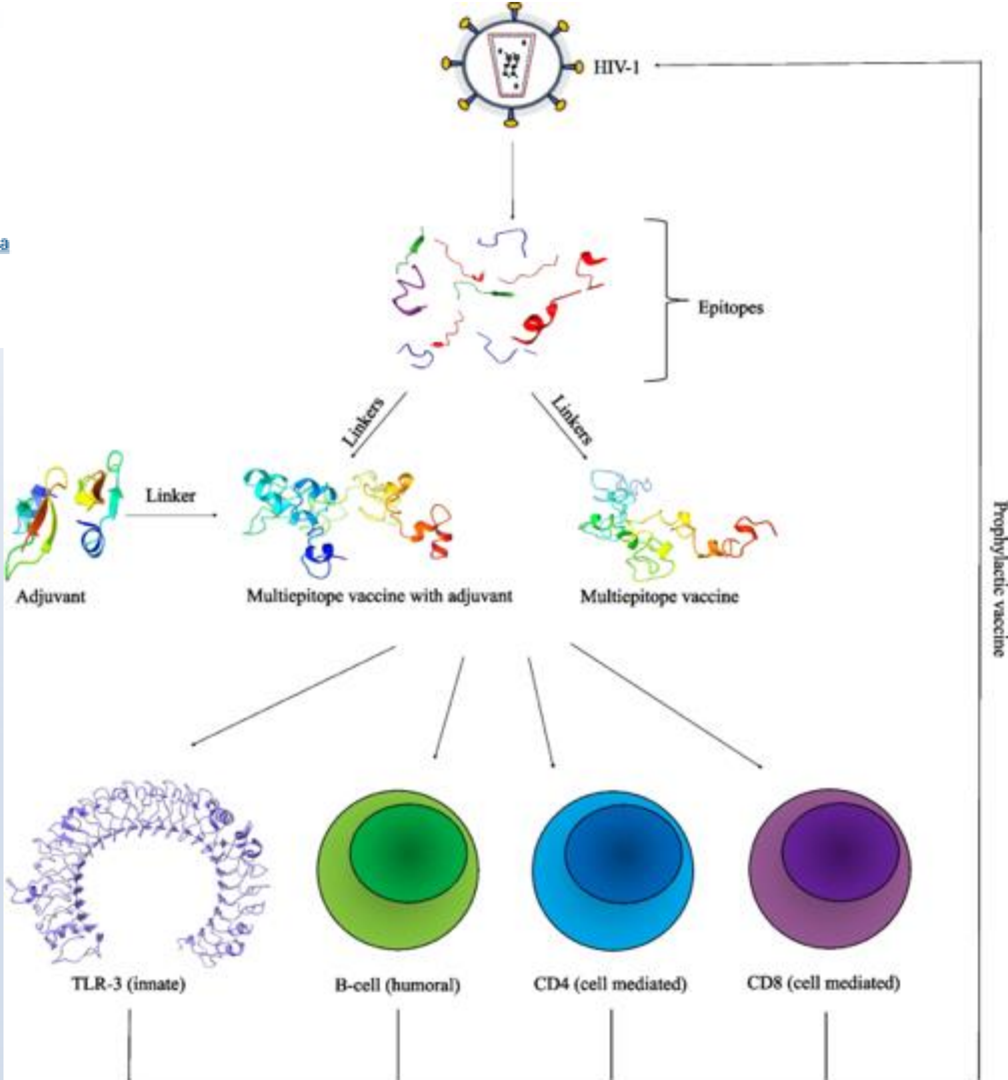
Last Updated: September 14, 2025

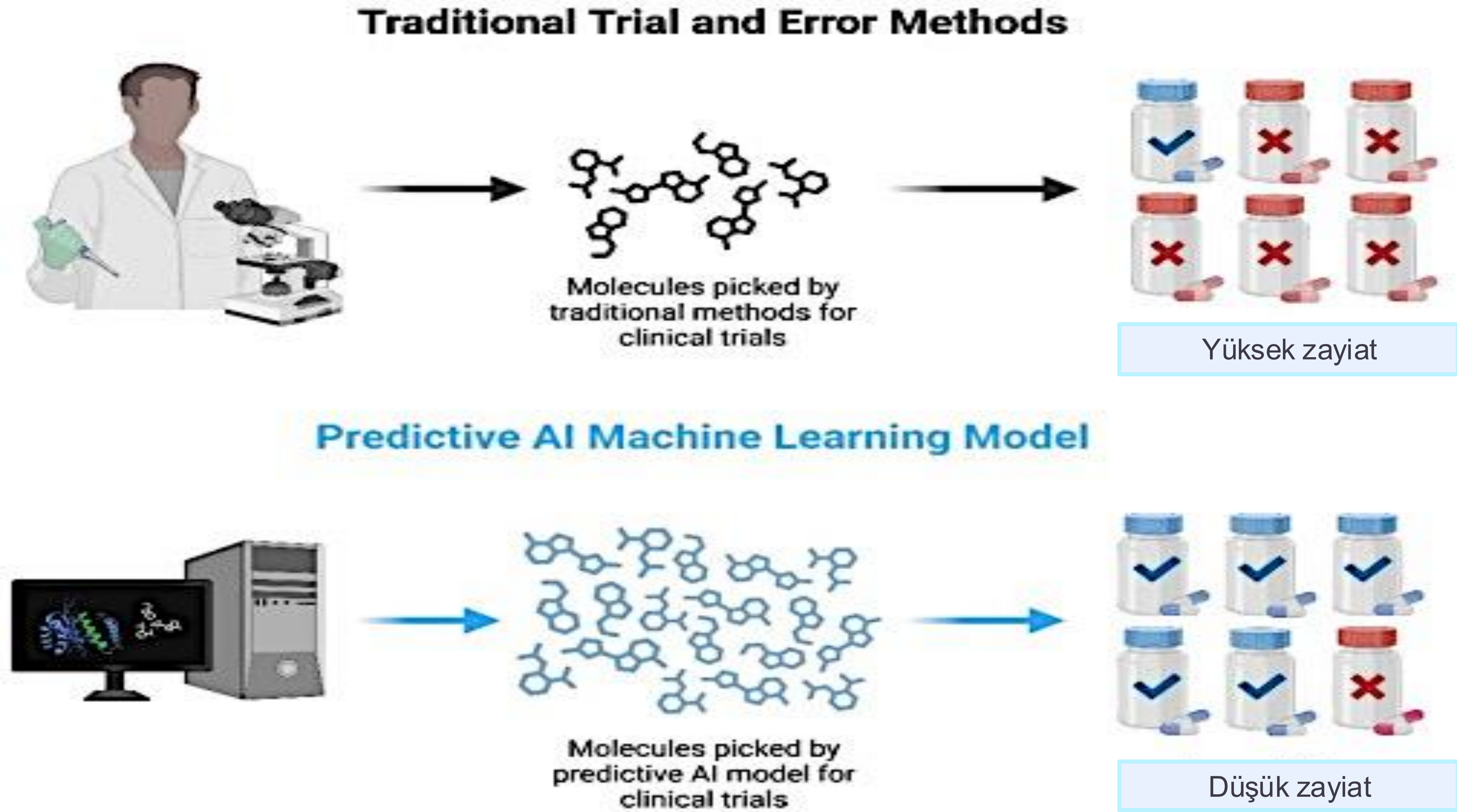
Research | Open access | Published: 24 May 2023

Employing computational tools to design a multi-epitope vaccine targeting human immunodeficiency virus-1 (HIV-1)

Hamza Sher, Hafsa Sharif, Tahreem Zaheer, Sarmad Ahmad Khan, Amjad Ali, Hasnain Javed & Aneela Javed

BMC Genomics 24, Article number: 276 (2023) | Cite this article

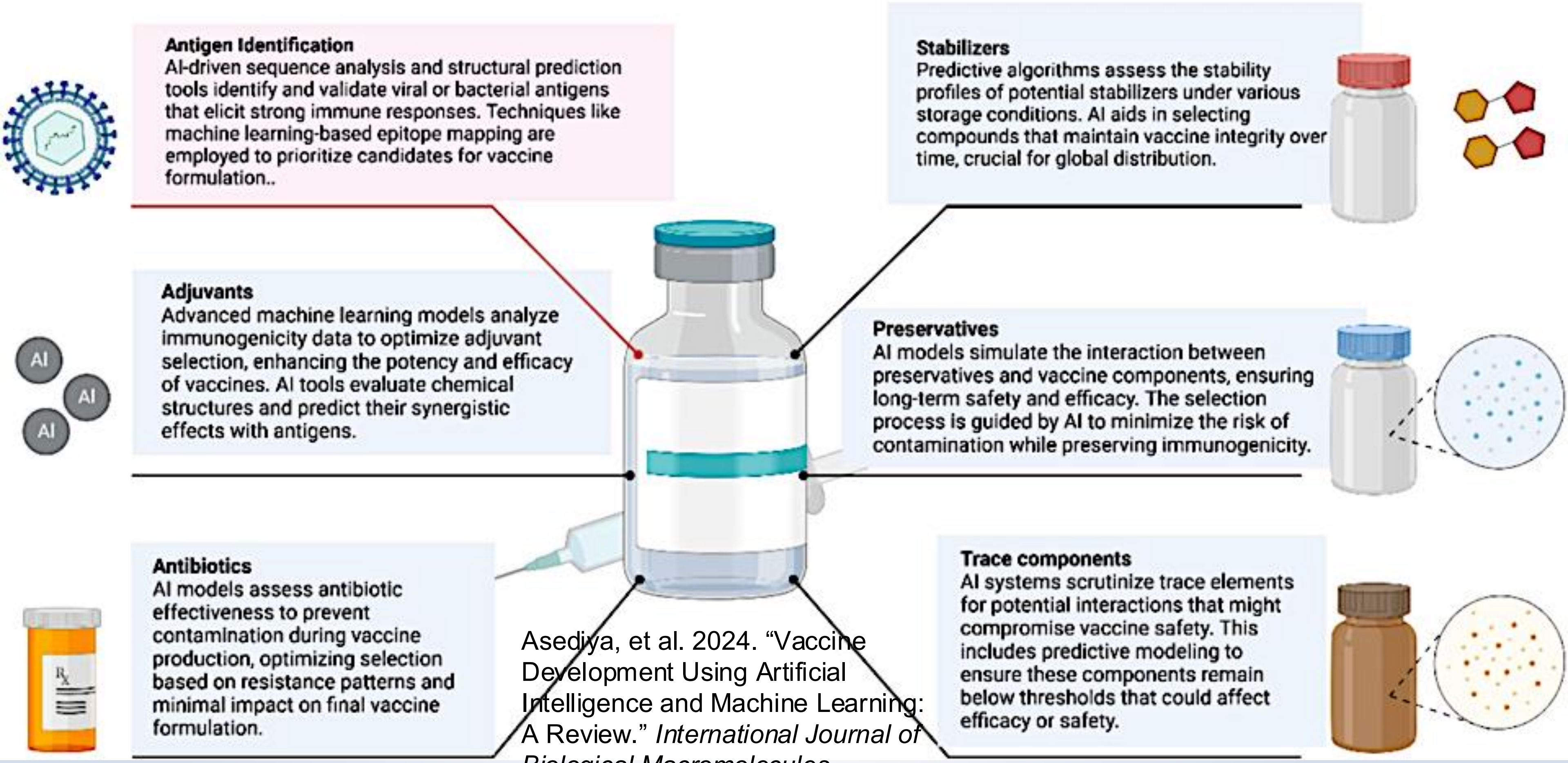




Yüksek zayiat

Düşük zayiat

AI-Driven Components of Vaccine Design and Development



Asediya, et al. 2024. “Vaccine Development Using Artificial Intelligence and Machine Learning: A Review.” *International Journal of Biological Macromolecules*

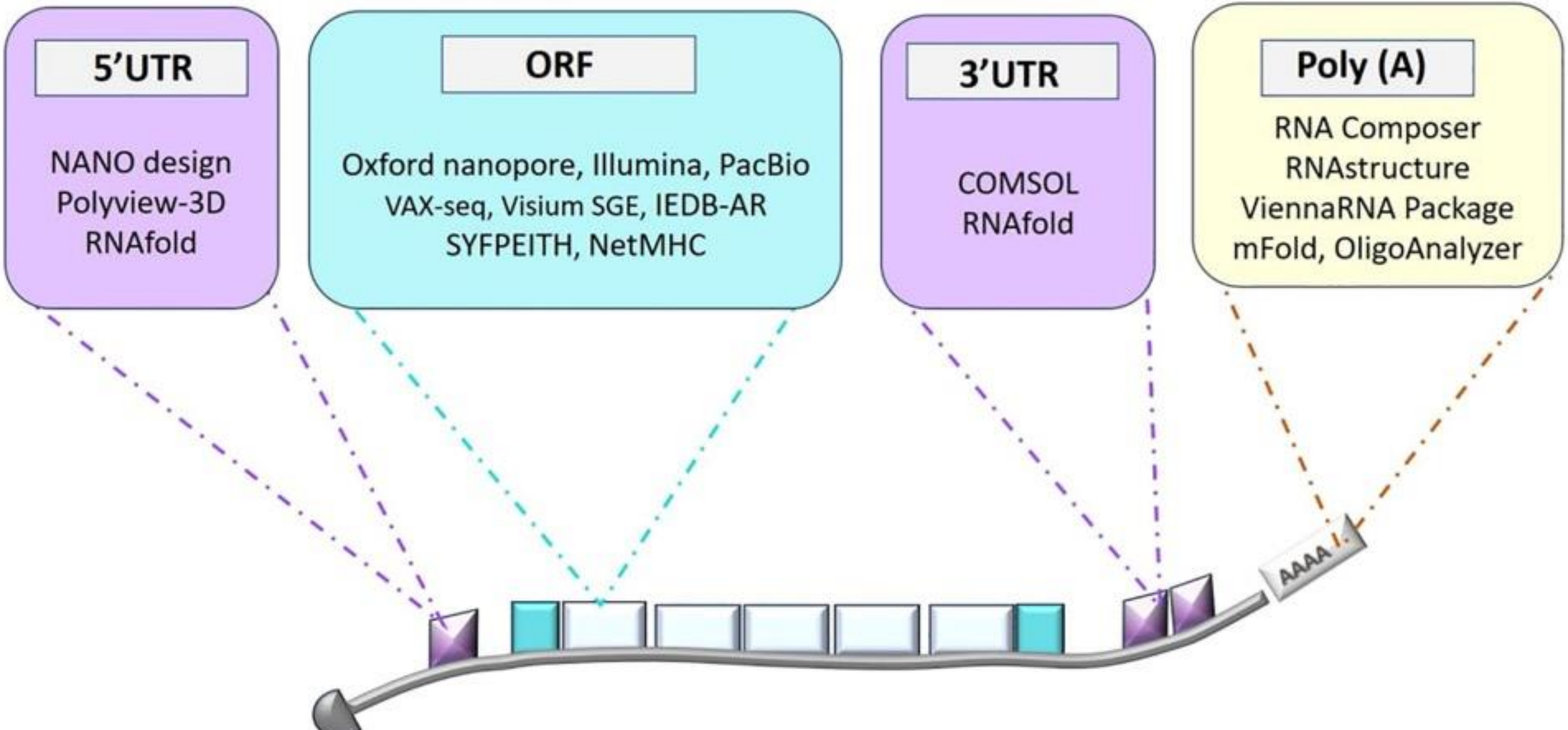
Adjuvan Geliştirme ve Yapay Zeka

- Veri kaynaklarını analiz ederek, potansiyel adayları saptayabilir
  - Moleküler yapıları
  - İmmünolojik aktivite
  - Toksisite analizi

- Sıfırdan da dizayn edebilir

Asediya, et al. 2024. “Vaccine Development Using Artificial Intelligence and Machine Learning: A Review.” *International Journal of Biological Macromolecules*

Aşının Optimizasyonu-mRNA



Aşı Optimizasyonu

- **5′UTR (5′ Untranslated Region)** Tasarımı; ribozom bağlanması, mRNA stabilitesi için kritik olan 5′UTR bölgesinin optimizasyonu
- **ORF / CDS (Open Reading Frame veya Coding Sequence);** antijen kodlayan dizinin optimize edilmesi.
- **3′UTR (3′ Untranslated Region);** mRNA sitoplazmada yıkımı geciktiren 3′UTR'nin optimize edilmesi.
- **Poly(A) Kuyruğu** ;mRNA stabilitesini artırmak ve translasyon verimini yükseltmek için poly(A) kuyruğunun uzunluğunu ve düzenini tasarlamak.

Imani, et al. 2025. "Computational Biology and Artificial Intelligence in mRNA Vaccine Design for Cancer Immunotherapy." *Frontiers in Cellular and Infection Microbiology* 14 (January).

Tedarik Zinciri Ve Dağıtımda Yapay Zeka

Aşı tedarik zinciri

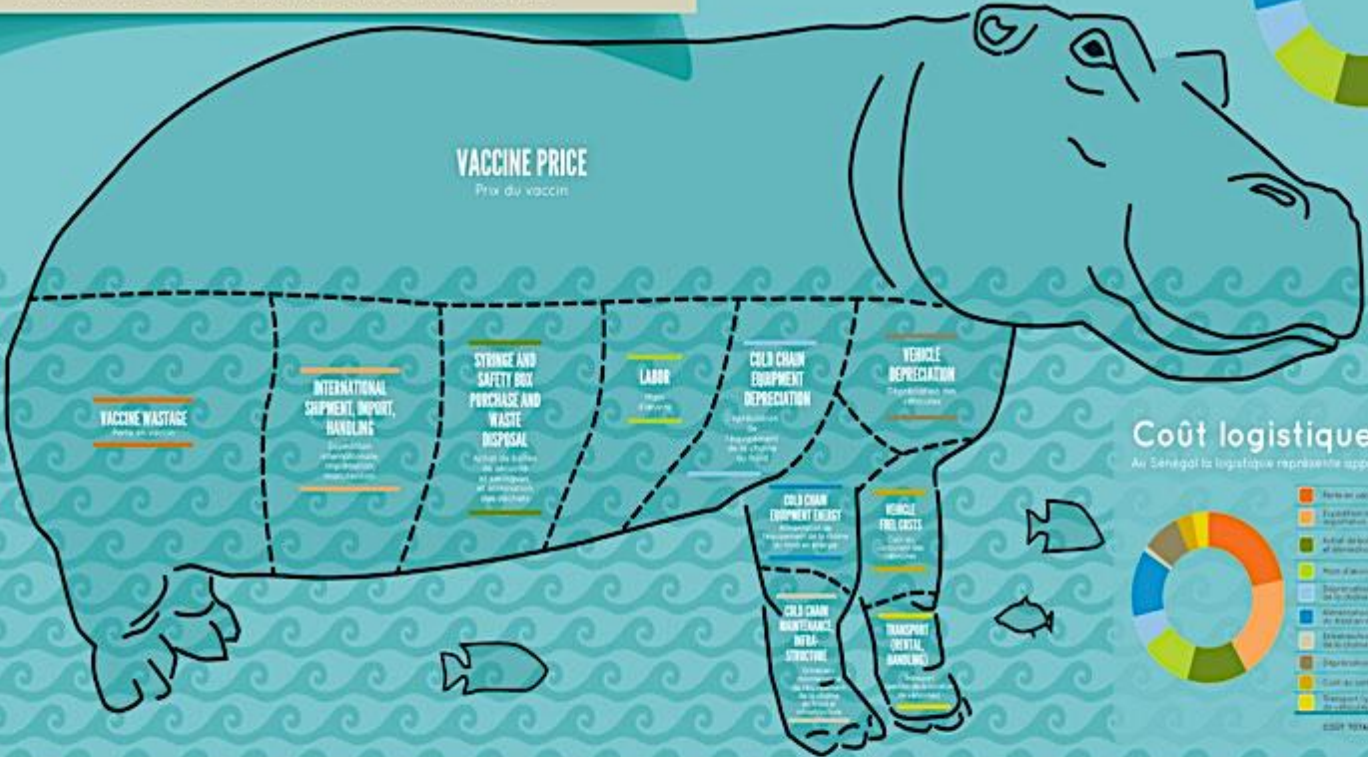
- Üretim
- Nakliye
- Tahsis

Güçlükler

- Arz ve talepte belirsizlik
- Maliyet
- Soğuk zincire uyumsuzluk

SOME VACCINE COSTS ARE HIDDEN BELOW THE SURFACE

Certains coûts liés aux vaccins sont cachés



AVERAGE LOGISTICS COST PER DOSE

In Senegal, logistics comprise approximately 50% of the total average cost per dose delivered.

Vaccine wastage	0.200	22.1%
International shipment, import, handling	0.180	19.9%
Syringe and safety box purchase and waste disposal	0.120	13.2%
Labor	0.106	11.6%
Cold chain equipment depreciation	0.049	5.4%
Cold chain equipment energy	0.115	12.7%
Cold chain maintenance, infrastructure	0.003	0.4%
Vehicle depreciation	0.070	7.7%
Vehicle fuel, insurance, and maintenance	0.032	3.6%
Other	0.031	3.5%
TOTAL SYSTEM COST PER DOSE	0.906	100.0%

VACCINES CURRENTLY USED IN SENEGAL:

VACCINE	WASTAGE
Bacille Calmette-Guerin (BCG)	50%
Pentavalent (Diphtheria, pertussis, tetanus, hepatitis B, Haemophilus influenzae type b)	1%
Oral polio	10%
Measles	25%
Tetanus toxoid	10%
Yellow fever	25%

Coût logistique moyen par dose

Au Sénégal la logistique représente approximativement 50% du coût total par dose livrée.

Perte en vaccin	0.200	22.1%
[illegible]	[illegible]	19.9%
[illegible]	[illegible]	13.2%
Main d'œuvre	[illegible]	11.6%
[illegible]	0.049	5.4%
[illegible]	[illegible]	12.7%
[illegible]	0.003	0.4%
Dépréciation des véhicules	0.070	7.7%
[illegible]	0.032	3.6%
[illegible]	0.031	3.5%
COÛT TOTAL DU SYSTÈME PAR DOSE	0.906	100.0%

Vaccins actuellement utilisés au Sénégal

Vaccin	Pertes
[illegible]	50%
[illegible]	1%
[illegible]	10%
[illegible]	25%
[illegible]	10%
[illegible]	25%

Source: Senegal, Project Optimize, 2012

OPTIMIZE · World Health Organization · PATH

Tedarik Zinciri Ve Dağıtımda Yapay Zeka

- Dünya Sağlık Örgütü,
- Ulaşım, tesis ve depolama maliyetlerini azaltan
- “WHO-EPI (Essential Programme on Immunization) vaccine distribution network”
- Yapay zeka modelini hâlihazırda kullanmaktadır

Effective Vaccine Management (EVM)

Guidance

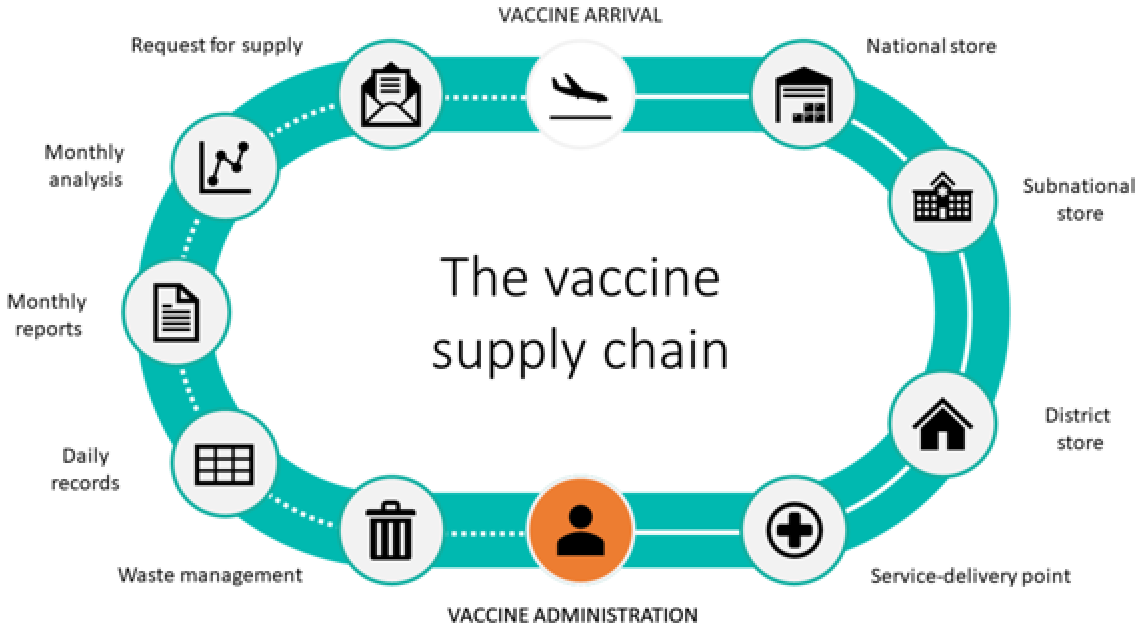
Tools

Controlled temperature chain (CTC)

TechNet-21

Project Optimize

Use the side menu to access key WHO tools, resources and guidance on immunization supply chains.



Supply chain and logistics and IA2030

Effective Vaccine Management (EVM)

Global Data Analysis

2009-2020

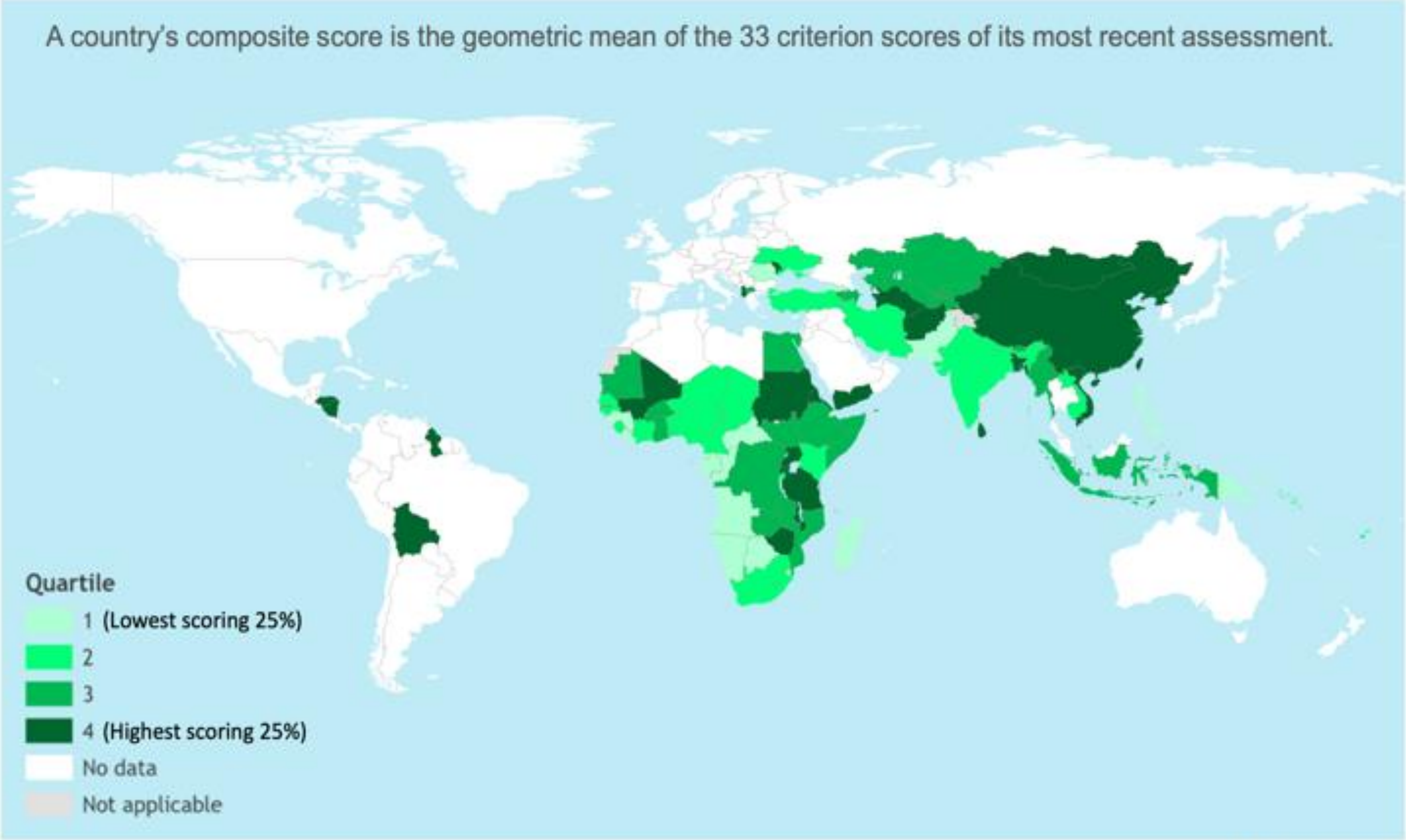
Update: WHO EVM1 database, July 2021

EVM – *setting a standard for the vaccine supply chain*

World Health Organization

unicef

Composite Scores (2009-2020)



The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of WHO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: EVM Assessments 2009-2020
Map Production: WHO GIS Centre for Health, DNA/DDI

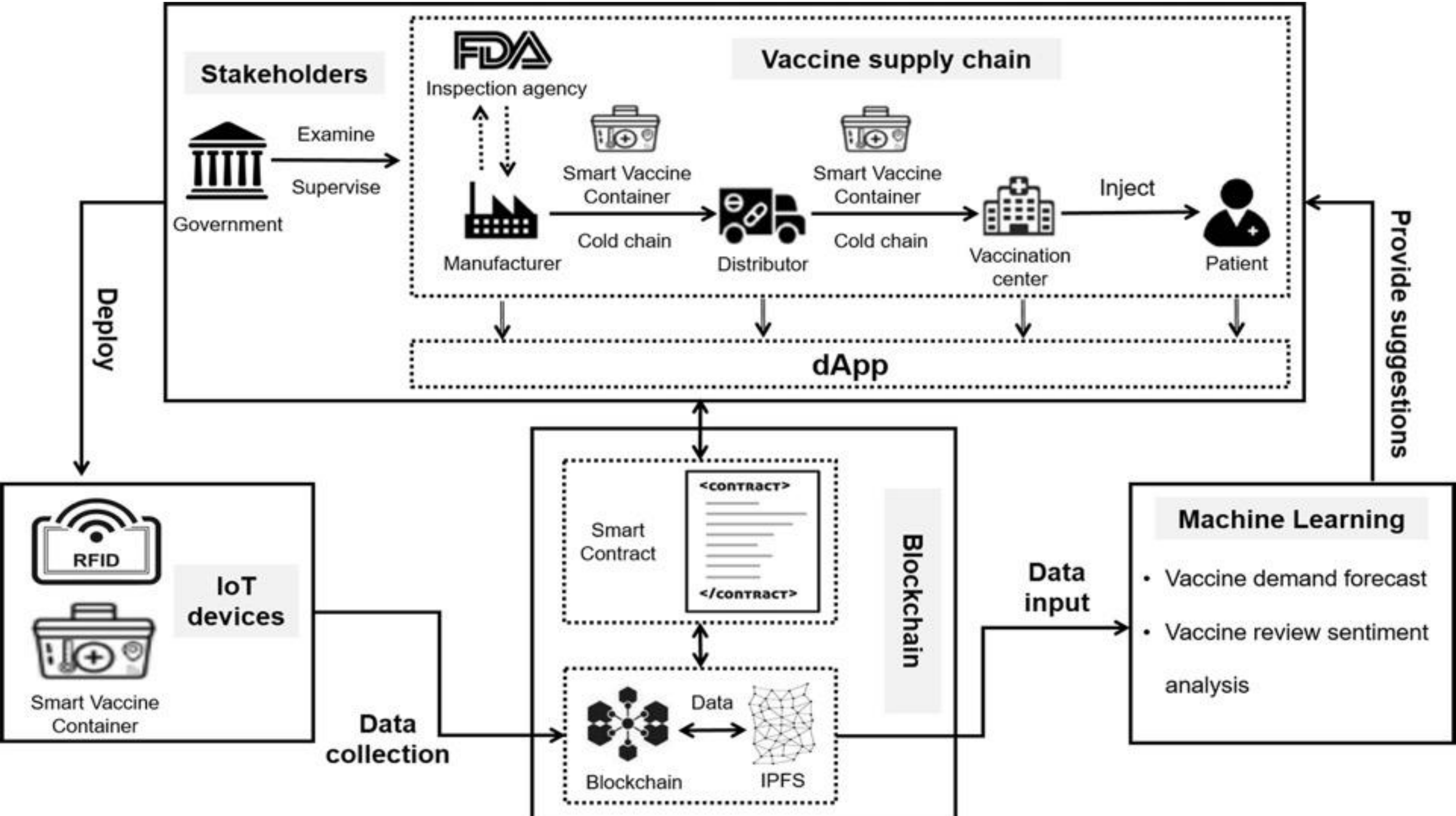
Tedarik Zinciri Ve Dağıtımda Yapay Zeka

- **"Blockchain"** merkezi olmayan, değiştirilemez ve şeffaf yapı tedarik zincirinde güven ve izlenebilirliği arttırır.

- **Nesnelerin interneti (IoT)** sensörler gibi cihazlarla ürünlerin konum, sıcaklık ve durumunu gerçek zamanlı izler.

- **Makine öğrenmesi,** belirsizlik koşullarında talep tahmini, üretim, dağıtım optimizasyonu ve risk yönetiminde kararlar sunar.

Hu et al. 2023. "Vaccine Supply Chain Management: An Intelligent System Utilizing Blockchain, IoT and Machine Learning." *Journal of Business Research* 156 (February): 113480.


Stakeholders
Vaccine supply chain
FDA
Inspection agency
Government
Examine
Supervise
Smart Vaccine Container
Cold chain
Manufacturer
Smart Vaccine Container
Cold chain
Distributor
Inject
Vaccination center
Patient
dApp
Deploy
Provide suggestions
RFID
IoT devices
Smart Vaccine Container
Data collection
Smart Contract
<CONTRACT>
</CONTRACT>
Blockchain
Data
Blockchain
IPFS
Data input
Machine Learning
• Vaccine demand forecast
• Vaccine review sentiment analysis

İnfoepidemiyoloji
Sohbet botları ve Yapayzeka

vaccines

MDPI

Article

A Theory and Evidence-Based Artificial Intelligence-Driven Motivational Digital Assistant to Decrease Vaccine Hesitancy: Intervention Development and Validation

Yan Li [1], Kit-Ching Lee [1], Daniel Bressington [2], Qiuyan Liao [3], Mengting He [1], Ka-Kit Law [1], Angela Y. M. Leung [1,4], Alex Molassiotis [5] and Mengqi Li [1,*]

İnfoepidemiyoloji
Sohbet botları ve Yapayzeka

vaccines

MDPI

Article

Artificial Intelligence and Public Health: Evaluating ChatGPT Responses to Vaccination Myths and Misconceptions

Giovanna Deiana [1,2], Marco Dettori [2,3,4,*], Antonella Arghittu [3], Antonio Azara [2,3], Giovanni Gabutti [5] and Paolo Castiglia [2,3,5]

İnfoepidemiyoloji
Sohbet botları ve Yapayzeka

- Sosyal medyadaki aşı karşıtı bilgileri tespit edip yayılımı azaltabilir
- Zaman içinde daha kişiselleştirilmiş bir etkileşim sağlar
- Destekleyen bir insan varmış hissi yaratıyor
- Yanlış yanıt verebilir ama aşı karşıtılığını azaltabilir

Yapay Zeka Kullanımının Zorlukları ve Etik Sorunlar

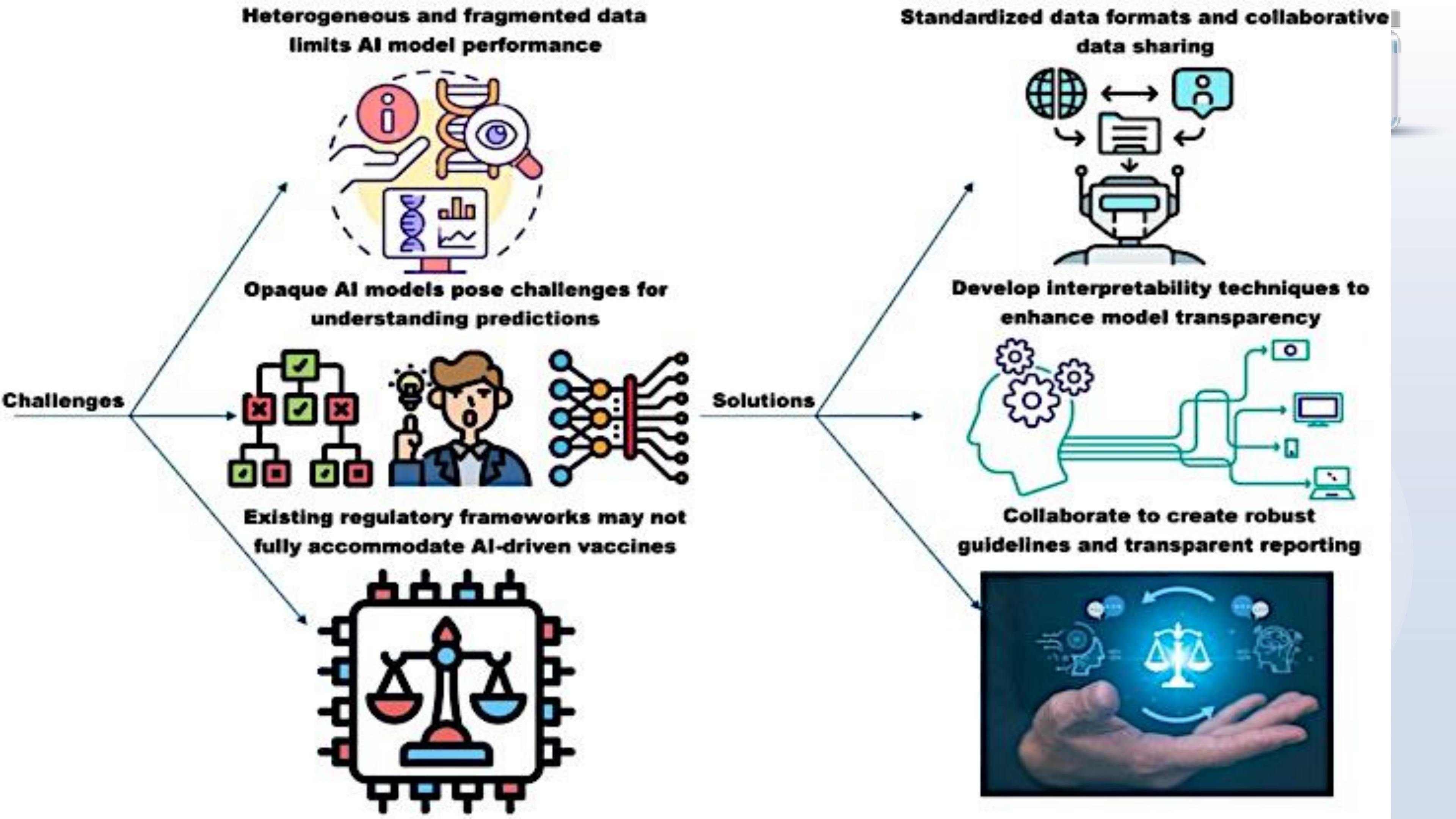
- Yapay zeka, genom dizileri, klinik denemeler, elektronik sağlık kayıtları, sosyal medya gibi platformlardan kişisel veri kullanır

- Dataların şifrelenmesi ve anonim olması gerekir

- Data eksik, dengesiz, taraflı olabilir, adil olmayan kararlar, hatalı tahminler üretebilir

- Algoritmalar karmaşık ve şeffaf değil

Olawade, et al. 2024. “Leveraging Artificial Intelligence in Vaccine Development: A Narrative Review.” *Journal of Microbiological Methods* 224 (September): 106998.


Heterogeneous and fragmented data limits AI model performance
Opaque AI models pose challenges for understanding predictions
Existing regulatory frameworks may not fully accommodate AI-driven vaccines
Challenges
Solutions
Standardized data formats and collaborative data sharing
Develop interpretability techniques to enhance model transparency
Collaborate to create robust guidelines and transparent reporting

SONUÇ

Yapay zeka

Denetimli kullanılmalı-data ne kullanıyor

Maliyet ve zamansal avantaj sağlayabilir

Thank You

Update: WHO EVM1 database, July 2021

EVM – *setting a standard for the vaccine supply chain*

World Health Organization

unicef