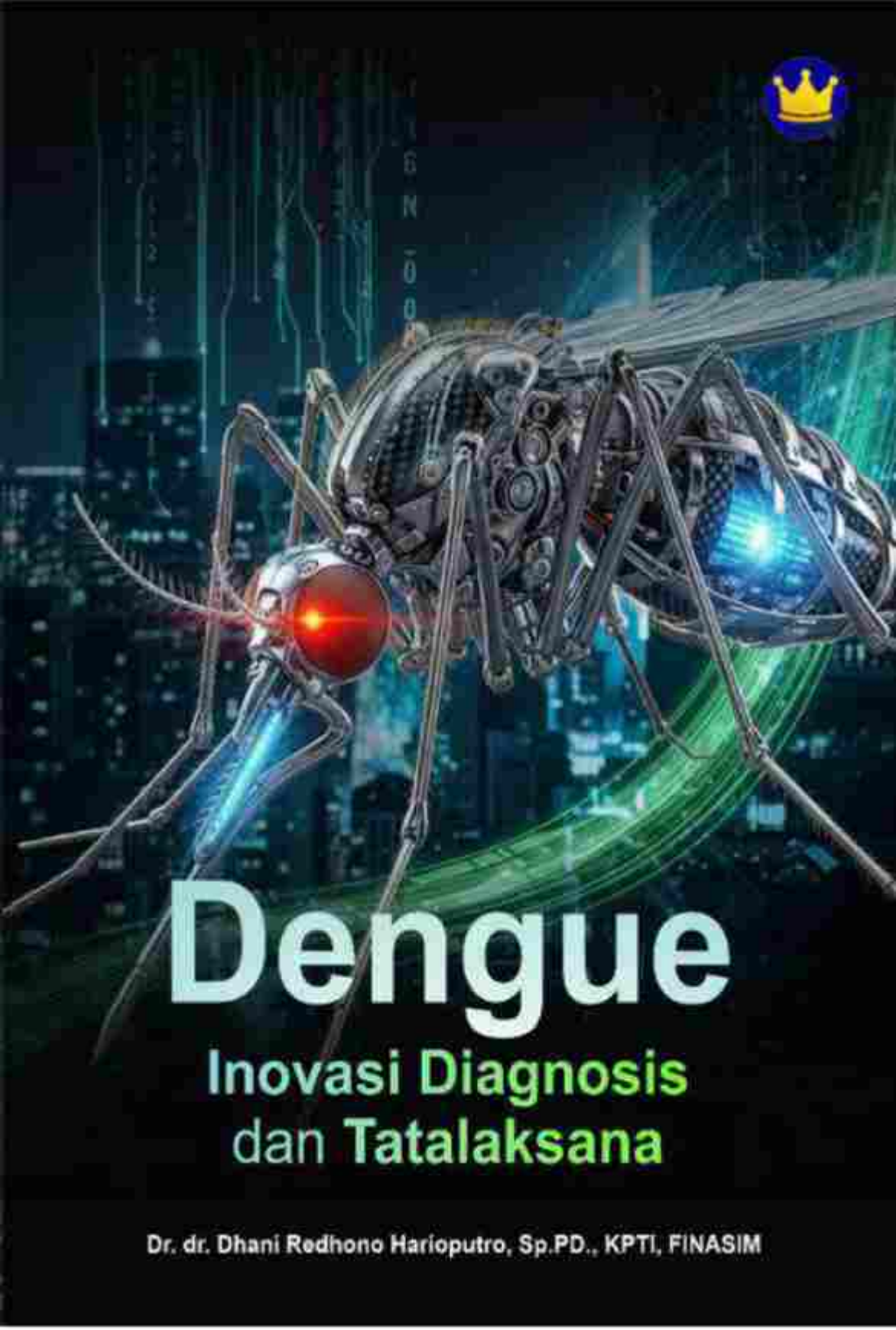




Dengue

Inovasi Diagnosis
dan Tatalaksana

Dr. dr. Dhani Redhono Harioputro, Sp.PD., KPTI, FINASIM

DENGUE : INOVASI DIAGNOSIS DAN TATALAKSANA

Dr. dr. Dhani Redhono Harioputro, Sp.PD., KPTI, FINASIM



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DENGUE : INOVASI DIAGNOSIS DAN TATALAKSANA

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KATA PENGANTAR

Puji syukur kami panjatkan ke hadirat Allah SWT, karena atas rahmat dan karunia-Nya, buku berjudul "Dengue : Inovasi Diagnosis dan Tatalaksana" ini akhirnya selesai. Infeksi dengue tetap menjadi salah satu tantangan kesehatan masyarakat paling krusial di dunia. Meskipun upaya pengendalian telah dilakukan selama puluhan tahun, angka morbiditas dan mortalitas masih tinggi.

Buku ini disusun untuk memberikan cakrawala baru dalam menghadapi tantangan tersebut. Penulis menyadari bahwa pendekatan konvensional saja tidak lagi cukup. Oleh karena itu, fokus utama karya ini adalah memaparkan berbagai inovasi mutakhir, mulai dari pemanfaatan *Artificial Intelligence* dalam prediksi wabah, pengembangan alat diagnostik berbasis mikrofluida yang cepat dan akurat, hingga strategi pencegahan inovatif melalui teknologi *Wolbachia* dan vaksinasi generasi terbaru.

Besar harapan kami, buku ini dapat menjadi referensi yang relevan bagi para klinisi, peneliti, mahasiswa kedokteran, serta pengambil kebijakan kesehatan dalam menyusun strategi pengendalian dengue yang lebih efektif, presisi, dan adaptif terhadap perkembangan zaman. Akhir kata, semoga buku ini memberikan manfaat luas dalam upaya kita bersama menurunkan beban penyakit dengue.

Penulis

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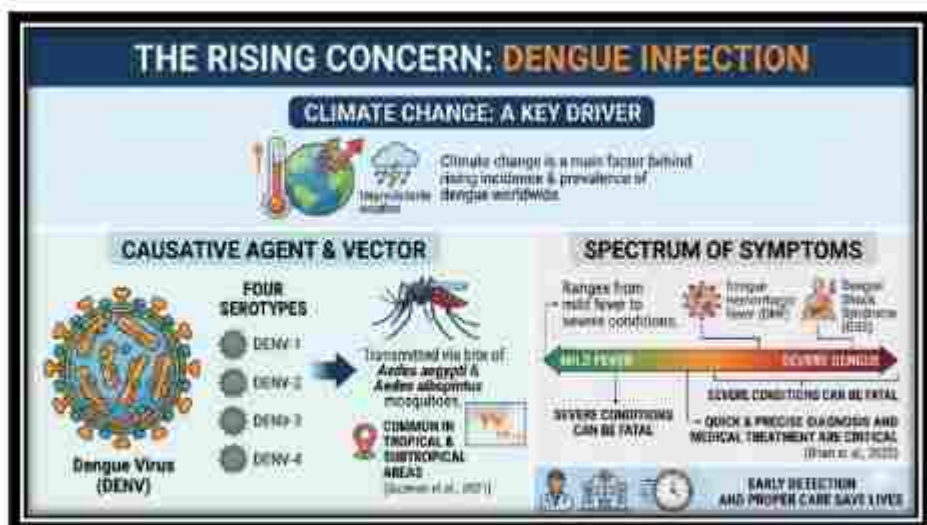
- ADE (*Antibody-Dependent Enhancement*)
AI (*Artificial Intelligence*)
ANN (*Artificial Neural Networks*)
ATBSB (*Attractive Toxic Blood Sugar Bait*)
DBD (*Demam Berdarah Dengue*)
DENV (*Dengue Virus*)
DL (*Deep Learning*)
DSS (*Dengue Shock Syndrome*)
EWARS (*Early Warning Alert and Response System*)
IFN (*Interferon*)
IgG (*Immunoglobulin G*)
IgM (*Immunoglobulin M*)
LAMP (*Loop-Mediated Isothermal Amplification*)
LFA (*Lateral Flow Assay*)
MHC (*Major Histocompatibility Complex*)
ML (*Machine Learning*)
NS1 (*Non-Structural Protein 1*)
PCA-SVM (*Principal Component Analysis - Support Vector Machine*)
PCR (*Polymerase Chain Reaction*)
POC (*Point-of-Care*)
PSN (*Pemberantasan Sarang Nyamuk*)
RDT (*Rapid Diagnostic Test*)
RT-LAMP (*Reverse Transcription Loop-Mediated Isothermal Amplification*)
RT-PCR (*Reverse Transcription Polymerase Chain Reaction*)
TNF- α (*Tumor Necrosis Factor-alpha*)
WHO (*World Health Organization*)

1

PENDAHULUAN



Infeksi dengue saat ini masih menjadi masalah kesehatan global yang semakin mengkhawatirkan. Perubahan iklim merupakan faktor utama di balik melonjaknya insidensi dan prevalensi infeksi dengue di seluruh dunia. Demam Dengue disebabkan oleh *Dengue Virus* (DENV), yang terbagi menjadi empat serotipe, yaitu : DENV-1, DENV-2, DENV-3, dan DENV-4, yang ditularkan melalui gigitan nyamuk *Aedes aegypti* dan *Aedes albopictus*, di daerah tropis dan subtropis.¹ Spektrum gejalanya dari demam ringan hingga kondisi yang parah, seperti Demam Berdarah Dengue (DBD) dan *Dengue Shock Syndrome* (DSS) (Gambar 1.1). Kondisi berat ini dapat berakibat fatal jika diagnosis dan penanganan medis tidak dilakukan dengan cepat dan tepat.²



Gambar 1.1. Virus Dengue dan Spektrum gejala.

A. EPIDEMIOLOGI TERBARU

Pada tahun 2025, penyakit dengue tercatat sebagai masalah kesehatan yang terjadi pada lebih dari 4 juta kasus yang tersebar di 100 negara, serta dilaporkan angka mortalitasnya 2.500 jiwa hingga pertengahan tahun.³ Di kawasan Amerika, hingga minggu ke-24, jumlah kasus yang dilaporkan mencapai 3.291.538, di mana 40% di antaranya terkonfirmasi secara laboratorium, dengan angka fatalitasnya sebesar 0,047%.⁴ Sementara itu di wilayah Pasifik dan Asia Tenggara, khususnya di Tiongkok, terjadi peningkatan kasus yang cukup tajam. Pada Juni 2025 tercatat 1.257 kasus, meningkat signifikan dibandingkan dengan 554 kasus pada periode yang sama tahun sebelumnya.³

Epidemiologi global memperkirakan ada 390 juta infeksi dengue setiap tahun, dengan sekitar 100 juta diantaranya terdiagnosis secara klinis.⁵ Wilayah dengan beban penyakit tertinggi meliputi Asia Tenggara, Amerika Latin, dan Afrika Sub-Sahara, di mana negara-negara seperti Indonesia, Brasil, dan Thailand menunjukkan

tren peningkatan kasus.⁶ Hal ini dikaitkan dengan faktor lingkungan dan sosial, seperti perubahan iklim, urbanisasi yang cepat, serta perilaku manusia yang mendukung perkembangbiakan nyamuk *Aedes* sp. sebagai vektor utama.⁷ Lebih dari 70% kasus dengue global dilaporkan berasal dari kawasan Asia-Pasifik, yang masih menghadapi tantangan signifikan dalam pengendalian vektor, termasuk meningkatnya resistensi nyamuk terhadap insektisida.⁸



Gambar 1.2. Jumlah Kasus DBD di Indonesia

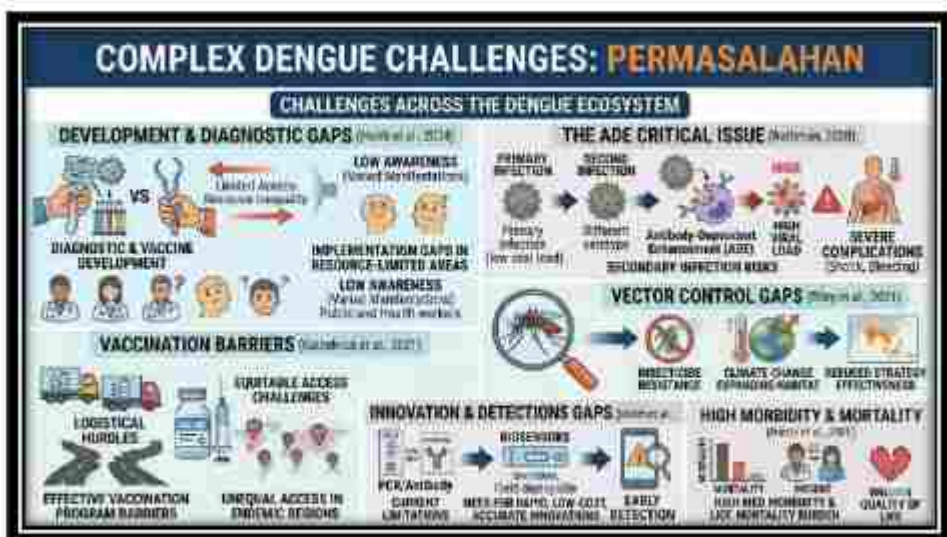
Data kasus DBD di Indonesia yang dibandingkan dari tahun 2023 hingga 2026 tampak adanya penurunan jumlah kasus. Pada tahun 2023, kasus tetap terkendali namun mulai menunjukkan tren kenaikan di akhir tahun akibat peralihan musim, sedangkan tahun 2024 terjadi lonjakan signifikan, dengan kenaikan kasus lebih dari 120% dibandingkan 2023. Hal ini disebabkan oleh fenomena El Nino yang membuat siklus hidup nyamuk lebih cepat dan jangkauan terbang lebih luas. Wilayah Tertinggi di Jawa Barat (Kota Bandung, Bekasi, Depok) dan Bali (Gianyar) (Gambar 1.2)

Pada tahun 2025, kasus menurun dibanding 2024, hal ini kemungkinan karena intervensi masif seperti program pelepasan nyamuk ber-Wolbachia dan vaksinasi. Angka kematian berhasil ditekan hingga 0,41%, dengan angka terendah dalam 3 tahun terakhir, yang menunjukkan perbaikan tata laksana DBD. Kabupaten Karawang merupakan daerah dengan kasus tertinggi nasional, yaitu 6.567 kasus. Pada tahun 2026, dari awal tahun hingga akhir Maret 2026, data menunjukkan situasi yang lebih stabil dibandingkan awal 2025.

B. PERMASALAHAN

Ketidakseimbangan dalam akses terhadap teknologi diagnostik modern dan terapi, disertai dengan rendahnya tingkat pemahaman masyarakat maupun tenaga kesehatan mengenai variasi manifestasi klinis merupakan salah satu masalah di Indonesia.⁹ Mekanisme *Antibody-Dependent Enhancement* yang terjadi pada infeksi DENV sekunder, berpotensi memperburuk kondisi klinis pasien melalui peningkatan *viral load*, yang pada akhirnya dapat memicu komplikasi berat.¹⁰ Saat ini pengembangan vaksin dengue terus berlangsung, penerapan vaksinasi di wilayah endemik masih menghadapi berbagai kendala, antara lain hambatan logistik serta tantangan dalam pemerataan akses imunisasi bagi populasi berisiko.^{11,12}

Upaya pengendalian vektor masih menjadi tantangan dalam mitigasi dengue. Munculnya resistensi pada populasi nyamuk vektor serta perubahan iklim yang memperluas habitat dan distribusi geografisnya telah memperburuk situasi.¹³ Oleh karena itu, perlunya penelitian inovatif untuk mengembangkan strategi pengendalian vektor yang lebih efektif serta teknologi diagnostik yang cepat, akurat, dan berbiaya rendah guna mendukung deteksi dini dan pengendalian dengue secara berkelanjutan (Gambar 1.3)



Gambar 1.3. Permasalahan pada Infeksi Dengue.

Efektivitas pengendalian vektor yang masih rendah, keterbatasan distribusi vaksin dengue, serta meningkatnya resistensi nyamuk terhadap insektisida menambah rumit dalam upaya pengendalian infeksi ini.^{14,15} Patogenesis dengue yang kompleks, hingga melibatkan banyak fenomena yang terjadi, antara lain fenomena ADE, trojan horse, trombositopenia, disfungsi endotel hingga kelainan pada fungsi liver.

Diagnosis dini masih tetap menjadi kendala, terutama dalam hal kecepatan dan ketepatan deteksinya. Oleh karena itu, inovasi dalam teknologi diagnostik seperti penggunaan biosensor yang lebih sensitif dan dapat dilakukan di lapangan menjadi sangat diperlukan untuk meningkatkan ketepatan diagnosis dini dan mempercepat intervensi medis pada kasus dengue.¹⁶

Penerapan strategi tatalaksana yang lebih terarah dan berbasis bukti ilmiah sangat diperlukan untuk meminimalkan risiko komplikasi berat dan meningkatkan keberhasilan terapi klinis.

2

INFEKSI DENGUE



Demam Berdarah Dengue merupakan salah satu penyakit infeksi zoonosis yang masih merupakan ancaman serius bagi kesehatan masyarakat secara global. Berdasarkan laporan dari *World Health Organization* (WHO) hingga bulan Agustus 2024, lebih dari 12,4 juta kasus DBD di dunia, terjadi kenaikan hampir dua kali lipat dari tahun sebelumnya yang mencapai 6,5 juta kasus. Penyakit ini terutama ditemukan di wilayah Amerika Latin, Asia Tenggara, dan Pasifik Barat, akibat perubahan iklim dan peningkatan kepadatan penduduk di suatu area.¹⁷ Kurang lebih 4 miliar penduduk dunia tinggal di daerah yang berisiko terhadap penularan virus *dengue* dan angka ini diperkirakan akan meningkat menjadi 5 miliar orang pada tahun 2050 nanti.¹⁷ Beberapa faktor yang berpengaruh terhadap hal tersebut adalah tingkat urbanisasi yang cepat, perubahan iklim yang tidak sesuai, serta kemampuan nyamuk *Aedes sp.* dan *Aedes*



PENUTUP

Buku ini ini menyajikan ulasan komprehensif mengenai patogenesis DBD, diikuti dengan pemaparan berbagai inovasi mutakhir dalam bidang diagnosis dan terapi. Inovasi tersebut meliputi pengembangan teknologi deteksi dini yang lebih sensitif hingga pendekatan terapi presisi yang secara khusus menargetkan mekanisme patogenetik tertentu. Secara keseluruhan, rangkaian inovasi ini menunjukkan potensi baru dalam mengurangi beban penyakit yang signifikan. Beberapa inovasi menunjukkan pergeseran paradigma dalam penatalaksanaan DBD menuju strategi yang lebih akurat, terarah, dan terpersonalisasi.

Inovasi diagnosis adalah menggunakan *Rapid Diagnostic Test* dan *Reverse Transcription Polymerase Chain Reaction* dan *Artificial Intelligence*, sedangkan Inovasi lebih terfokus untuk meningkatkan efektivitas terapi adalah dengan Target Molekuler dan Antibodi Monoklonal yang menggunakan antibodi buatan yang dirancang untuk menyerang virus secara langsung dan berpotensi dalam mengurangi keparahan penyakit dan mencegah dampak ADE.

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PROFIL PENULIS



Dr. dr. Dhani Redhono Harioputro, Sp.PD., KPTI, FINASIM, FISQua adalah seorang pakar dan konsultan di bidang Penyakit Tropik Infeksi. Beliau menyelesaikan pendidikan kedokteran (S1) serta spesialis Ilmu Penyakit Dalam (Sp-1) di Universitas Diponegoro (2005), menempuh jenjang Sub Spesialis

Penyakit Tropik Infeksi di Universitas Sebelas Maret (2016), dan meraih gelar Doktor Ilmu Kedokteran dari Universitas Sebelas Maret (2021). Saat ini, menjabat sebagai Kepala Divisi Tropik Infeksi RSUD Dr. Moewardi Surakarta sekaligus mendedikasikan ilmunya sebagai dosen senior di Fakultas Kedokteran Universitas Sebelas Maret.

Dalam dunia akademik, beliau merupakan pengampu utama materi Update Tatalaksana Infeksi Dengue. Sebagai peneliti aktif dengan profil yang terindeks di SINTA dan Scopus, beliau telah mempublikasikan berbagai karya ilmiah pada jurnal internasional bereputasi (Q1-Q4), di antaranya:

- Studi Inovatif Antraks (Scopus Q1/Q3): Penelitian mendalam mengenai efek Indonesian Propolis dalam menghambat sitokin proinflamasi dan stres oksidatif pada model hewan antraks (Saudi Journal of Biological Sciences & Indonesian Biomedical Journal).
- Dengue & COVID-19 (Scopus Q3/SINTA 2): Publikasi mengenai Neutrophil-Lymphocyte Ratio (NLR) sebagai prediktor kebocoran plasma pada infeksi Dengue, serta studi perbandingan manifestasi klinis antara Dengue dan COVID-19 (Acta Medica

Indonesiana & Indonesian Journal of Tropical and Infectious Disease),

Penulis telah diakui secara global melalui kontribusi aktif dalam berbagai forum ilmiah internasional bergengsi, di antaranya:

- European Academy of Dermatology and Venereology (EADV).
- European Congress on Tropical Medicine and International Health (ECTMIH).
- Turkish Society of Infectious Diseases and Clinical Microbiology Congress (EKMUD)
- Asia Pacific Society of Infection Control (APSIC).
- International Conference on Climate Change,

Sebagai peneliti, beberapa karya saat ini, antara lain studi inovatif mengenai penggunaan Indonesian Propolis untuk infeksi bakteri, hingga penelitian klinis mengenai Neutrophil-Lymphocyte Ratio (NLR) sebagai prediktor kebocoran plasma pada pasien Dengue. Melalui buku ini, dr. Dhani menyatukan wawasan dari forum global dengan pengalaman praktis di lapangan untuk memberikan panduan komprehensif penanganan Dengue di Indonesia.

Dengue : Inovasi Diagnosis dan Tatalaksana

Di tengah ancaman perubahan iklim global yang memicu lonjakan kasus dengue hingga dua kali lipat dalam satu tahun terakhir, dunia medis kini berpacu dengan waktu. Buku "Dengue : Inovasi Diagnosis dan Tatalaksana" hadir sebagai jawaban atas urgensi global terhadap infeksi ini.

Buku ini bukan sekadar literatur medis biasa, tetapi sebuah peta navigasi modern yang membedah kompleksitas virus dengue, mulai dari mekanisme Antibody-Dependent Enhancement (ADE) hingga cytokine storm.

Penulis berusaha menuntun pembaca melampaui metode konvensional, mengeksplorasi garis depan teknologi dengan mengupas peran algoritma deep learning dalam memprediksi wabah dengan akurasi tinggi dan menjelajahi masa depan pengobatan melalui personalized medicine, kandidat antivirus molekuler, hingga kisah sukses teknologi nyamuk Wolbachia yang berhasil menurunkan kasus di Indonesia.

Disusun secara sistematis dari sisi patogenesis hingga tantangan masa depan, buku ini menjadi referensi krusial bagi klinisi, peneliti, dan bagi siapa pun yang berkomitmen untuk mengubah statistik suram menjadi cerita kemenangan dalam pengendalian dengue secara berkelanjutan.



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