Zimam
Developing Careers in Digital Health

In collaboration with
eMed SUPPORT

White Paper 2025

DIGITAL TWINS, REAL-WORLD DATA, & AI:

The Triple Helix of Next-Gen Clinical Research

Dr. Osama El Hassan
Chair & Co-Founder
ZIMAM

Dr. Henrique Martins
Associate Professor
BRUDHI, ISCTE

Dr. Tiago Taveira - Gomes
Founder & CEO
SIGIL Scientific Enterprises

Dr. Denis Losik
MD, PhD, Cardiologist, CEO
eMed Support Systems

Dr. Koray Atalag
Honorary Academic, Auckland Bioengineering Institute and Founder & Senior Consultant
GALATA-Digital

Dr. Mohamed Khaldi
Assistant Professor of Public Health
Canadian University Dubai

Brought to you by:
mwan events

Key Terms & Abbreviations

ADHDS – Abu Dhabi Health Data Services

AI – Artificial Intelligence

CAD – Coronary Artery Disease

CDSS – Clinical Decision Support System

DHA – Dubai Health Authority

DT – Digital Twin

EHR – Electronic Health Record

EMR – Electronic Medical Record

HIE – Health Information Exchange

HTA – Health Technology Assessment

LLM – Large Language Model

MENA – Middle East & North Africa

NABIDH – Network & Analysis Backbone for Integrated Dubai Health

PPP – Public-Private Partnership

RWD – Real World Data

RWE – Real World Evidence

UAE – United Arab Emirates

Introduction: Gulf Region's Strategic Position for RWD Research

The GCC region combines several unique advantages to become a strategic testbed for next-generation, data-driven clinical research. There is a highly diverse population and genetic pool large enough to yield meaningful outcomes yet compact enough to enable rapid implementation and iterative learning; stable, vision-driven leadership that actively prioritises digital health; and a young, digitally literate population that is generally open to engaging with digital services and data-driven care.

Governments and regulators are investing in flexible, forward-looking frameworks, while health systems increasingly capture rich, longitudinal data not only from clinical encounters, but also from genomics initiatives, lifestyle and wellness ecosystems. At the same time, there is a critical gap between generating data and consistently converting it into robust real-world evidence, underlining the need for new analytical tools, digital infrastructures and even novel models of clinical research such as digital trial centres and population-based digital twins.

The United Arab Emirates specifically demonstrates a high level of digital maturity, leveraging clinical data for value-based initiatives and real-world evidence usability.

Across the Emirates, HIE platforms connect public and private providers, aggregate clinical data, and enable secure access to longitudinal electronic medical records at the point of care. Together, these platforms create near-national coverage of patient journeys and standardize data flows in a way that supports both continuity of care and the creation of large, diverse cohorts for research [1].

NABIDH*	Malaffi**
Dubai Health Authority	Department of Health Abu Dhabi and ADHDS
19.35M unified medical records#	**13M** unique patients
2,891 connected facilities	**3,100** connected facilities
(unavailable)	**3.5** Billion Clinical Records
Data on Nov, 2025	*Data on Sep, 2025*

*https://nabidh.dha.gov.ae/

**https://www.malaffi.ae/malaffi-progress-report/

#unified medical records represents the number of patients who have at least two linked records from different providers aggregated into a single record.

Real-world data and real-world evidence have become essential elements in pharmaceutical research and regulatory decisions, supplementing traditional randomized controlled trials [2,3]. RWE derived from HIE can offer patient registries and digital health platforms comprehensive insights into treatment effectiveness, safety profiles, and patient outcomes for value-based care [2]. Unlike conventional clinical trials with restrictive eligibility criteria, RWD captures the heterogeneity of actual clinical practice, including underrepresented patient populations and those with comorbidities typically excluded from controlled studies [3,4]. This broader representation enhances the generalizability and transportability of evidence across different healthcare settings and geographic regions [2].

Pharmaceutical companies are progressively utilising RWD to enhance regulatory submissions via external control arms, expedite drug development timelines, and facilitate post-marketing surveillance to promote value-based care approaches [2,4]. The integration of RWE with traditional clinical trial data enables more efficient identification of therapeutic targets, optimization of trial designs, and assessment of comparative effectiveness in routine practice [2].

However, the utility of RWD for generating robust RWE depends critically on data quality, standardization, and interoperability across healthcare systems [2]. Advanced analytical methodologies, including machine learning algorithms and artificial intelligence, are vital for deriving meaningful insights from large-scale, diverse datasets while tackling potential biases inherent in observational data [2,5].

Concept of Human Digital Twins in Healthcare

Digital twin technology represents a paradigm shift in personalised medicine by creating virtual replicas of patients that integrate systems and condition models with real-time clinical

data. Healthcare digital twins combine information across various biological scales ranging from cellular and tissue levels to organ systems and whole-body physiology, enabling predictive modelling of disease progression and therapeutic responses [6]. The RWD from Electronic Medical Records is a fundamental basis for the development, validation, and continual refinement of these digital twin models. Unlike traditional clinical research, which relies on controlled trial settings, digital twins utilise extensive RWD from electronic health records, medical imaging, laboratory results, and continuous monitoring devices to create dynamic, personalised patient models for value-based medicine [6].

We are also witnessing the convergence of mechanistic approaches, underpinned by multi-scale computational physiology models, and data-driven digital twin technologies by using AI and RWD. Building on decades of research to represent the structure and biophysical behaviour from molecules to cells to tissues to organs and ultimately to entire humans and even populations, a multitude of next generation of personalised and predictive diagnostic and therapeutic clinical applications have already been deployed [7]. By parameterising these mechanistic models with interoperable and multi-modal patient specific data, incredibly accurate biological insights can be gathered by simulations; to a degree that completely in-silico clinical trials can now be performed. A recent breakthrough, by using surrogate AI models, allowed running these simulations in almost real-time as opposed to many hours even with supercomputers before. This approach complements current RWD driven digital twins by providing large amounts of realistic synthetic data and also embedding real-world physical and anatomical constraints to provide biological guardrails for AI applications [8].

Case 1: AI-Powered Cardiovascular System Digital Twin

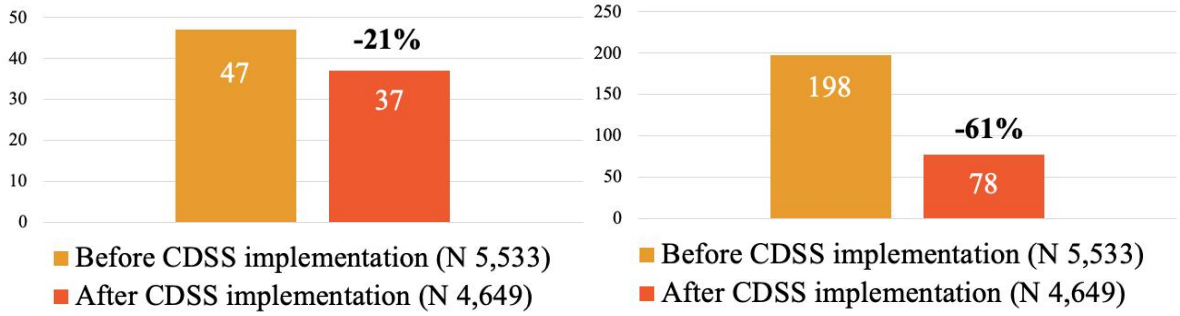
Cardiovascular disease is a leading driver of morbidity and value-based healthcare expenditure, and an ideal setting for AI-enabled digital twins due to the availability of continuous, multimodal physiological and laboratory data.

Despite effective lipid-lowering therapies, real-world practice often shows substantial gaps in guideline adherence, treatment optimization and post-discharge follow-up. The SuccESS study evaluated a Clinical Decision Support System that generated digital patient profiles and ensured guideline-based care across 49 medical centers in three regions of the Russian Federation. Real-world data from EMRs were analyzed, comparing outcomes one year before and after the implementation.

Following deployment, lipid monitoring increased by more than 50%, care gaps and follow-up delays decreased, and prescribing patterns shifted toward higher-intensity therapy. Most significantly, hospitalizations related to major adverse cardiovascular events declined across patient cohorts:

Number of patients with stable CAD or Dyslipidemia with primary hospitalizations decreased by 21%

Number of patients with secondary hospitalizations for cardiovascular events decreased by 61%



Supported by one of the major pharmaceutical companies, this study illustrates how public-private collaboration can facilitate the integration of digital technologies into clinical practice, and how RWD and AI-powered analytics can improve value-based care through enhanced guideline adherence, optimized therapies, and a substantial reduction in cardiovascular hospitalizations.

Self-supervised multivariate clinical models (SSMCM) leveraging RWD advance cardiovascular digital twin research by facilitating the generation of synthetic data for rare conditions such as hypertrophic cardiomyopathy. These models produce realistic clinical narratives and patient records that supplement incomplete datasets by imputing missing imaging reports or biomarker patterns derived from available data [14].

For treatment heterogeneity research, LLMs mine unstructured clinical notes to identify patient phenotypes with differential treatment responses, extracting nuanced symptom descriptions, functional limitations, and social factors beyond structured data to explain variable therapeutic benefits. Additionally, LLMs perform post-market surveillance through real-world evidence generation, detecting adverse event signals from clinical narratives by identifying temporal patterns and unusual symptom combinations not captured in traditional structured pharmacovigilance reports, thereby improving cardiovascular safety monitoring and therapeutic optimization [14].

Case 2: RWD-Enabled Assessment of Chronic Kidney Disease

Another Portuguese study emphasises the considerable importance of RWD for the assessment of chronic kidney disease (CKD) at the population level by analysing two decades of EHR data from an integrated healthcare system. The study encompassed 136,993 adults, accounting for approximately 90% of the adult population in the region, thus providing nearly comprehensive population coverage [15].

The RWD approach allowed for comprehensive CKD characterisation by combining data from primary, secondary, and tertiary care settings, including laboratory results, comorbidities, medications, and demographic information. Importantly, the method addressed previous study limitations by confirming disease chronicity through multiple measurements taken at least three months apart, in line with KDIGO guidelines.

The study identified an overall CKD prevalence of 9.8%, with 4.7% successfully stratified according to KDIGO staging criteria. This RWD approach overcame biases inherent in voluntary survey-based studies, which tend to oversample individuals with multiple comorbidities [15].

The findings demonstrate that leveraging existing EHR provides robust, representative population-level estimates of the burden of CKD. Such RWE can guide healthcare providers in formulating targeted proactive prevention strategies and policies aimed at enhancing cardiovascular and other health outcomes. This methodology offers a scalable framework for continuous CKD surveillance without necessitating resource-intensive prospective data collection [16].

Health Technology Assessment for HealthTech Startups in the UAE

Drawing from the experience of Western countries such as Canada and Switzerland, where Health Technology Assessment frameworks have been established for over two decades, these insights are valuable for health technology startups managing sensitive healthcare data. The system demonstrates mature institutional capacity with designated organizations conducting systematic evaluations of health technologies prior to market entry [15]. Nonetheless, challenges remain regarding HTA independence, methodological standardization, and the translation of evidence into policy decisions, often hindered by bureaucratic delays and shifting requirements and IT infrastructure. For startups handling sensitive healthcare data, it is essential to evaluate secure IT infrastructure, economic benefits, adoption strategies, and ethical considerations before engaging in HTA. Emerging technologies typically necessitate GPU virtual machines and hosting on-premise or in secure cloud environments. Budget impact analysis should be included as a model to project future economic benefits and return on investment (ROI). Usually, ROI in healthcare is realized over the long term and should not be expected in proof-of-concept (PoC) stages. These requirements must be clearly documented and comply with applicable data laws. The subsequent step involves assessing clinical benefits. To demonstrate potential clinical advantages, an independent clinical team should thoroughly evaluate the study design or PoC, often operating within academic centres of excellence. Healthcare solutions with clinical teams should be prevalent during the assessment process. Technical evaluation can be performed by the IT team managing the infrastructure where the health technology solution is hosted, such as AWS, Microsoft, or Oracle. Key regulatory milestones include: (1) early engagement with HTA agencies during product development; (2) demonstration of clinical utility beyond existing solutions; (3) cost-effectiveness analysis aligned with local healthcare priorities; and (4) implementation of robust data protection frameworks compliant with privacy regulations. Successful health technology implementation requires systematic evidence generation, stakeholder engagement across policy, managerial, and technical domains, and transparent governance structures. These lessons are especially pertinent for emerging HTA systems in middle-income countries such as the UAE, where balancing innovation with patient safety and data security remains crucial.

Regional Roadmap and Strategic Recommendations

A regional roadmap for next-generation, data-driven clinical research will depend less on creating entirely new structures from scratch and more on connecting existing assets into coherent, repeatable pathways. Collaboration models that make it easier for different stakeholders to work together around specific use cases, especially in high-burden therapeutic areas, are central to this transition. One practical configuration is PPP: a tripartite public-private-innovation relationship in which a pharmaceutical company supports the piloting and implementation of a startup technology for RWD analytics within a public or large provider organisation. In such a setting, the provider gains tools to address a clearly defined clinical

gap, the sponsor benefits from disease- and product-relevant evidence generation, and the innovator obtains a structured route to test and refine its solution in real-world practice. For this to work systematically rather than as isolated one-offs, transparency, documented expectations and shared understanding of value for each party are essential, along with general awareness in the ecosystem that such models exist and can be legitimately pursued.

To avoid fragmentation and duplication of efforts, it is useful to have a steering group where stakeholders from academia, startups, digital health innovators, healthcare providers, HTA experts and industry can regularly exchange on RWD, digital twins and health technology assessment. Rather than a formal regulatory body, this type of steering group functions as a coordination and learning mechanism: a place where new project ideas can be stress-tested, synergies across initiatives identified, and emerging programmes made visible to a broader community. Over time, regular dialogue of this kind can help align around priority therapeutic areas, common outcome measures and evaluation approaches that are realistic for local data and resource constraints, while still meeting international expectations for evidence quality.

Recently launched Dubai Health Data Sandbox illustrates a potential pathway to test this kind of collaboration in practice. A single, well-scoped use case can be taken deliberately through an end-to-end journey: initial exploration on de-identified data, co-design of evaluation metrics with clinicians and HTA experts, a limited pilot in a clinical setting and subsequent integration into routine workflows if results are favourable. Documenting this experience in detail, including obstacles and workarounds, provides not only value for the specific project but also a reference pattern for future innovators, sponsors and provider organisations looking to navigate similar paths from concept to implementation.

Technology alone, however, will not ensure adoption. Identifying and supporting clinical champions within participating institutions is critical for making digital twin and RWD initiatives part of everyday clinical practice rather than parallel projects. These are clinicians who understand local workflows, care deeply about improving outcomes and are willing to take ownership of change. When they are involved early as co-designers rather than brought in late as end-users, they help frame realistic use cases, bridge communication between technical teams and clinical staff and build trust among colleagues. Recognising their contribution, whether through academic credit, visibility in publications or protected time for project work, is an important element of a sustainable roadmap.

Skills and capabilities are another foundational pillar. Real-world evidence, digital twins and HTA require a blend of competencies that rarely exist in a single profile: clinical insight, data literacy, understanding of regulatory and HTA requirements and familiarity with AI and analytics. Over time, nurturing such a talent pool creates not only the capacity to run individual pilots but also the foundation for a self-sustaining learning system in which new tools and methods can be evaluated, improved and scaled.

Taken together, these elements suggest a roadmap that is less about imposing a single top-down blueprint and more about enabling a portfolio of well-governed experiments, supported by shared infrastructure, trusted collaboration models, clinical leadership and growing expertise in RWD and HTA. Pursued consistently, this combination can help move from isolated success stories to a mature, integrated ecosystem where digital twins, real-world data

and AI form a practical backbone of clinical research and evidence-informed decision-making.

Acknowledgments

This white paper is based on insights shared during the round table "Digital Twins, Real-World Data & AI: The Triple Helix of Next-Gen Clinical Research" held on 4 November 2025 in Dubai, United Arab Emirates in terms of 8th ZIMAM Digital Health Forum. The authors would like to thank all participants for their time, openness and thoughtful contributions to the discussions.

We would like to express our special appreciation to ZIMAM, whose work in strengthening the digital health workforce and fostering knowledge exchange on digital health and real-world data across the GCC provided the impetus for this round table and informed the preparation of this white paper.

We are also grateful to the representatives of health authorities, academic and research institutions, digital health innovators and pharmaceutical companies who shared their perspectives on real-world data, digital twins and artificial intelligence in the Gulf region. Their practical experience and critical reflections shaped the priorities, examples and recommendations presented in this paper.

The authors further acknowledge the efforts of teams working on health information exchange platforms across the UAE, whose publicly available documentation and ecosystem developments informed the overview of national RWD infrastructure.

Any errors or omissions remain the responsibility of the authors, and the views expressed in this white paper do not necessarily reflect the official positions of the participating institutions.

References

1. Ahmed Deeb, Bisera Lakinska, Rahul Goyal, Atif Al Braiki, Hamed Al Hashemi, Chapter 32 - Bringing health information exchange to the Middle East and North Africa: the case of Malaffi in Abu Dhabi, Health Information Exchange (Second Edition), Academic Press, 2023, Pages 665-680, ISBN 9780323908023, https://doi.org/10.1016/B978-0-323-90802-3.00020-4.

2. Subbiah, V. The next generation of evidence-based medicine. Nat. Med. 2023, 29, 49–58. https://doi.org/10.1038/s41591-022-02160-z

3. Concato, J.; Corrigan-Curay, J. Real-world evidence—where are we now? N. Engl. J. Med. 2022, 386, 1680–1682.DOI: 10.1056/NEJMp2200089

4. Degtiar, I.; Rose, S. A review of generalizability and transportability. Annu. Rev. Stat. Appl. 2023, 10, 501–524.DOI: 10.1146/annurev-statistics-042522-103837

5. Rajpurkar, P.; Chen, E.; Banerjee, O.; Topol, E.J. AI in health and medicine. Nat. Med. 2022, 28, 31–38.

6. Sel, K.; et al. Digital Twins for Personalized Cardiology. Journal of the American Heart Association 2024.

7. Loewe A, Hunter PJ, Kohl P. Computational modelling of biological systems now and then: revisiting tools and visions from the beginning of the century. Philos Trans A Math Phys Eng Sci. 2025 May 8;383(2296):20230384.

8. Viceconti M, De Vos M, Mellone S, Geris L. Position Paper From the Digital Twins in Healthcare to the Virtual Human Twin: A Moon-Shot Project for Digital Health Research. IEEE J Biomed Health Inform. 2024 Jan;28(1):491–501.

9. American Heart Association. 2017. Cardiovascular Disease: A Costly Burden for America - Projections Through 2035.

10. Itani, H. et al. (2024). Digital twins for cardiovascular medicine: promise, challenges, and roadmap for clinical translation. The Lancet Digital Health, 6(8), e547–e556. https://doi.org/10.1016/S2589-7500(24)00193-6

11. Marat Ezhov[1],Igor Sergienko[1],Leonid Esev[2], Vera Petrakovskaia[2], Kseniya Astrakova[3], Alexei Uranov[3], Igor Mikheenko[3]. The impact of clinical decision support systems on the quality and organization of medical care in patients at risk of cardiovascular events (SuccESS). This study was sponsored by Novartis Pharma LLC, Russia. ID:11398064/INC/ppt/04.25/0

12. Benimetskaya KS, Provatorov SI, Ezhov MV, Krivosheev YS, Gavrilko AD, Uranov AE, Mikheenko IL, Kovalev EA, Ponomarenko AV, Shangina AM, Efremova YE, Kolmakova TE, Matveeva MA, Dolgusheva YA, Alekseeva IA, Osokina AK, Nozadze DN, Atyunina IV, Paleev FN, Meshkova MA, Sharapova YA, Losik DV. Retrospective Analysis of Lipid-Lowering and Antiplatelet Therapy Regimen by Clinical Decision Support Service Based on Real-World Data from Electronic Medical Records "Intellect 3 Study". Kardiologiia. 2023 Dec 5;63(11):46-56. Russian, English. doi: 10.18087/cardio.2023.11.n2555. PMID: 38088112.

13. Astrakova (Benimetskaya) K.S., Mikheenko I.L., Uranov A.E., Gartung A.A., Kovalev E.A., Spiridonov A.A., Shestova I.I., Strokolskaya I.L., Meshkova M.A., Esev L.I., Reznik A.V., Petrakovskaia V.A., Shangina A.M., Efremova Yu.E., Sergienko I.V., Ezhov M.V., Barbarash O.L., Paleev P.N. The impact of clinical decision support systems on adherence to clinical guidelines and achieving target levels of low-density lipoprotein cholesterol in patients at risk of developing cardiovascular events (SuccESS). Rational Pharmacotherapy in Cardiology. 2024;20(6):625-636. (In Russ.) https://doi.org/10.20996/1819-6446-2024-3138.

14. Phyllis M Thangaraj, Sean H Benson, Evangelos K Oikonomou, Folkert W Asselbergs, Rohan Khera, Cardiovascular care with digital twin technology in the era of generative artificial intelligence, *European Heart Journal*, Volume 45, Issue 45, 1 December 2024, Pages 4808–482, https://doi.org/10.1093/eurheartj/ehae619

15. Carla Santos-Araújo, Luís Mendonça, Daniel Seabra Carvalho, Filipa Bernardo, Marisa Pardal, João Couceiro, Hugo Martinho, Cristina Gavina, Tiago Taveira-Gomes, Ricardo Jorge Dinis-Oliveira, Twenty years of real-world data to estimate chronic kidney disease

prevalence and staging in an unselected population, *Clinical Kidney Journal*, Volume 16, Issue 1, January 2023, Pages 111–124, https://doi.org/10.1093/ckj/sfac206

16. Magalhães, T.; Dinis-Oliveira, R.J.; Taveira-Gomes, T. Digital Health and Big Data Analytics: Implications of Real-World Evidence for Clinicians and Policymakers. Int. J. Environ. Res. Public Health 2022, 19, 8364. https://doi.org/10.3390/ijerph19148364

17. Mohammed Alkhaldi, Aisha Al Basuoni, Márcia Matos, Marcel Tanner & Sara Ahmed (2021) Health Technology Assessment in High, Middle, and Low-income Countries: New Systematic and Interdisciplinary Approach For Sound Informed-policy Making: Research Protocole, Risk Management and Healthcare Policy, 2757-2770, DOI: 10.2147/RMHP.S310215

18. Dubai Health Authority. NABIDH Health Information Exchange. Dubai, United Arab Emirates. Available online: https://www.nabidh.ae (accessed 2025).

19. Department of Health Abu Dhabi. Malaffi Health Information Exchange. Abu Dhabi, United Arab Emirates. Available online: https://www.malaffi.ae (accessed 2025).