N-of-1 Medicine

Dean Ho
Provost's Chair Professor
Director, The Institute for Digital Medicine (WisDM)
Director, The N.1 Institute for Health (N.1)
Head, Department of Biomedical Engineering
Department of Pharmacology
National University of Singapore

Validating and Implementing N-of-1 Medicine

Technology Alone Cannot Transform Healthcare

Getting Different Disciplines Together in a Room is Easy

Deep Collaboration is Hard

Keywords in Healthcare Innovation

Translational

Impact

How Do We Define Impact?
How Do We Define Translation?

T2

T0 = Cells, Tissues, Animals **T1** = Human **T2** = Patients/Large Trials **T3** = To Practice **T4** = To Communities

WisDM Clinical Programmes (All Interventional)

- **Validating Impact:** WisDM has pioneered over 14 first-in-kind human trials.
- **Impact At-Scale:** WisDM has successfully digitally decentralized multiple trials.
- **Outcomes:** Our trials have led to life-saving outcomes.

Clinicaltrials.gov Registration Number	Clinical Trial Description
NCT03527238	Liver Transplant Immunosuppression
NCT03832101	Digital Therapeutics for Cognitive Training
NCT02711956	Personalised Prostate Cancer Therapy
NCT03759093	Hematologic Cancer Personalised Therapy
NCT03248193	Chemo-Induced Neuropathy Tx
NCT04522284	PRECISE CURATE.AI: Solid Cancer Therapy
NCT02632474	HIV Combination Therapy
NCT04769141	Hypertension/Diabetes Personalised Therapy
NCT04848935	The Cor-Tx Digital Therapy Trial (Neuro-oncology)
NCT05532397	Neuro-Oncology Combination Therapy
NCT05381038	Hybrid Combo and Dose Optimisation (Gastric Cancer)
NCT05083676	Digital Mental Health Implementation Trial

How Did We Get There?

Leadership

Prof. Dean Ho
Director, WisDM
N-of-1 Medicine
CURATE.AI

A/P Ngiam Kee Yuan
Dy Director, WisDM
AI
Bioinformatics

Poonam Rai
Innovation and Administration
Partnerships
Programme Coordination

IDEATION

Tech in Medicine
AI/Machine Learning
Cognitive/Physical Performance

Prof. Hanry Yu
Biomaterials
Drug Screening

A/P Edward Chow
Research Director
Drug Dev

A/P Tan Tin Wee
Chief Executive
NSCC

Dr. Minh Le
Digital Nanomed
Oncology

A/P Mehul Motani
Incentive Design
Deep Learning

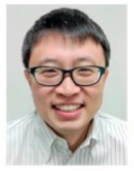
Dr. Alex Remus
Digital Medicine
Wearables

Dr. Agata Blasiak
Digital Therapeutics
Medtech

A/P Jason Lee
N-of-1 human
performance

A/P Chris Asplund
Psychology
N-of-1 Learning

Dr. Raghav Sundar
Oncology
Personalised Med



A/P Thomas Yeo
Machine Learning
Brain Mapping

. Bala Vellayappan
Rad-Oncology
Digital Tx

IMPLEMENTATION

Behavioural Sciences
Healthcare Economics
Design/User Engagement

Yoann Sapanel
Insurance
Medtech

Dr. V Vien Lee
Behavioural Science
Psychology

Dr. Smrithi Vijayakumar
Behavioural Science
Psychology

Dr. Renwen Zhang
Digital health
Mental health

Dr. Bina Rai
Serious Games
Mental health

Dr. Soo Jung Hong
Health Communicatior
Culture & Tech

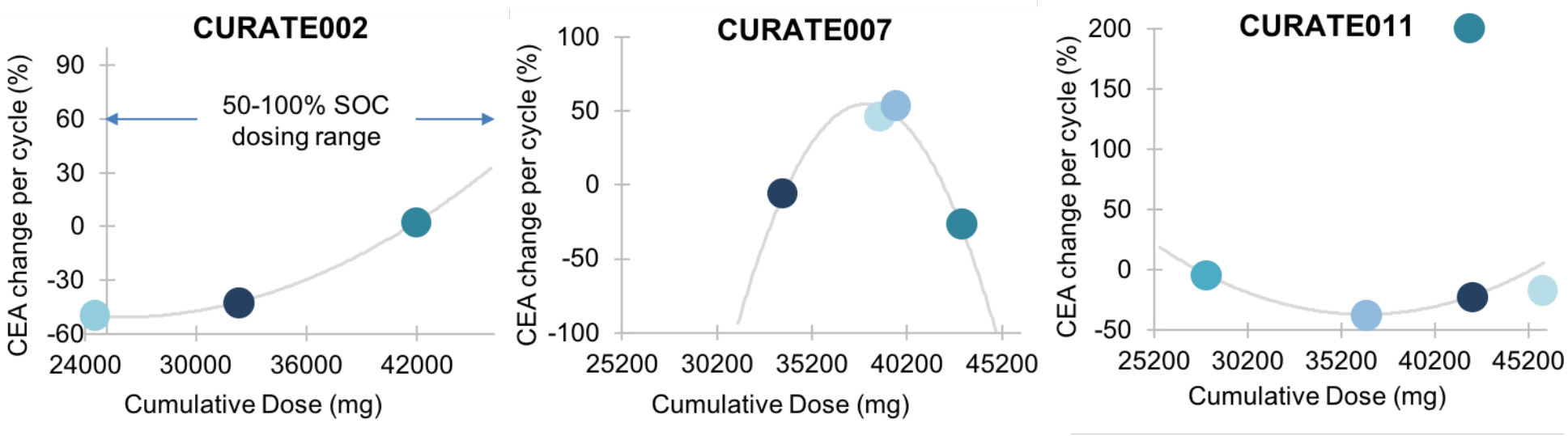
r. Geckhong Yeo
ehavioural Science
Mental Health

A/P Jussi Keppo
NUS Business
Healthcare Econ

Mathias Egermark
Clinical trials
Pharma industry

A/P Brian Stone
Interaction design
Healthtech

Patient Use Case : CURATE.AI for Advanced Colon Cancer



- Good drugs given at the wrong dose = misperception of no efficacy.
- Patients can switch from non-responders to responders to treatment.
- Can we pinpoint more responders to therapy?

Blasiak et al., 2022

2022 ASCO ANNUAL MEETING
ADVANCING EQUITABLE CANCER CARE THROUGH INNOVATION

IDentif.AI: Crowdsourced Combination Therapy

FULL PAPER

ADVANCED THERAPEUTICS
www.advtherap.com

Project IDentif.AI: Harnessing Artificial Intelligence to Rapidly Optimize Combination Therapy Development for Infectious Disease Intervention

Aynur Abdulla, Boqian Wang, Feng Qian, Theodore Kee, Agata Blasiak, Yoong Hun Ong, Lissa Hooi, Falgunee Parekh, Rafael Soriano, Gene G. Olinger, Jussi Keppo, Chris L. Hardesty, Edward K. Chow, Dean Ho, and Xianting Ding**

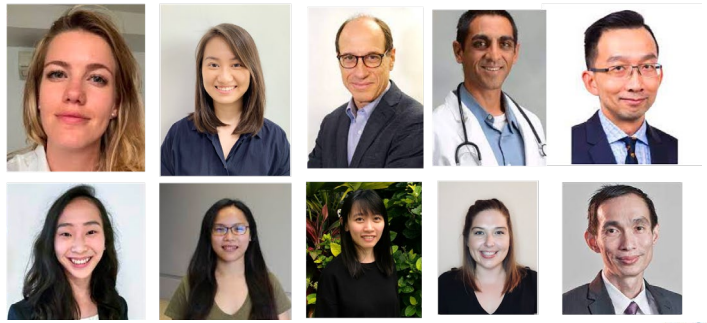
ESSAY

ADVANCED INTELLIGENT SYSTEMS
www.advintellsyst.com

Addressing COVID-19 Drug Development with Artificial Intelligence

Dean Ho

"The economic evaluation of interventions may become increasingly important as extraordinary circumstances strain healthcare system-wide operations as well as industry operations."

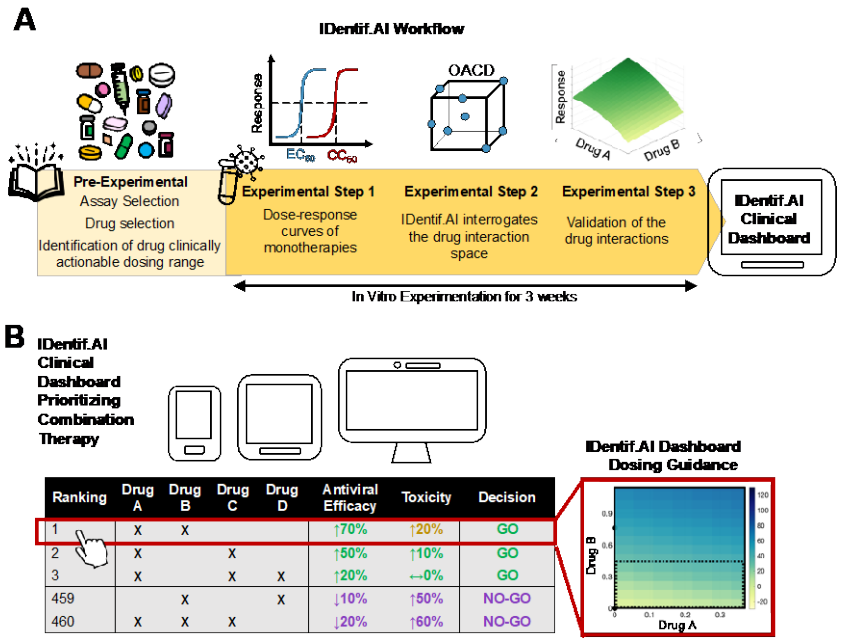


Advanced Therapeutics, 2020
Advanced Intelligent Systems, 2020

KPMG Singapore | NUS National University of Singapore | WisDM Yong Loo Lin School of Medicine INSTITUTE FOR DIGITAL MEDICINE | NUS National University of Singapore | N.1 INSTITUTE FOR HEALTH | NUS National University of Singapore | NUS BUSINESS SCHOOL | EpiPointe | MRIGlobal

IDentif.AI: Crowdsourced Combination Therapy

Rapidly-implemented workflow

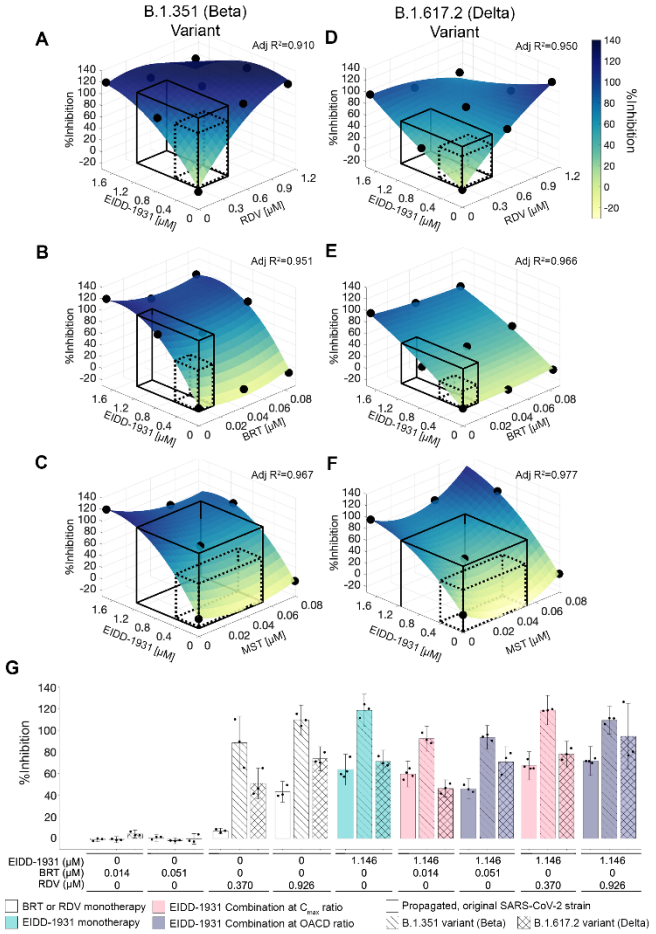


Ranking	Drug A	Drug B	Drug C	Drug D	Antiviral Efficacy	Toxicity	Decision
1	X	X			↑70%	↑20%	GO
2	X		X		↑50%	↑10%	GO
3	X		X	X	↑20%	↔0%	GO
459		X		X	↓10%	↑50%	NO-GO
460	X	X	X		↓20%	↑60%	NO-GO

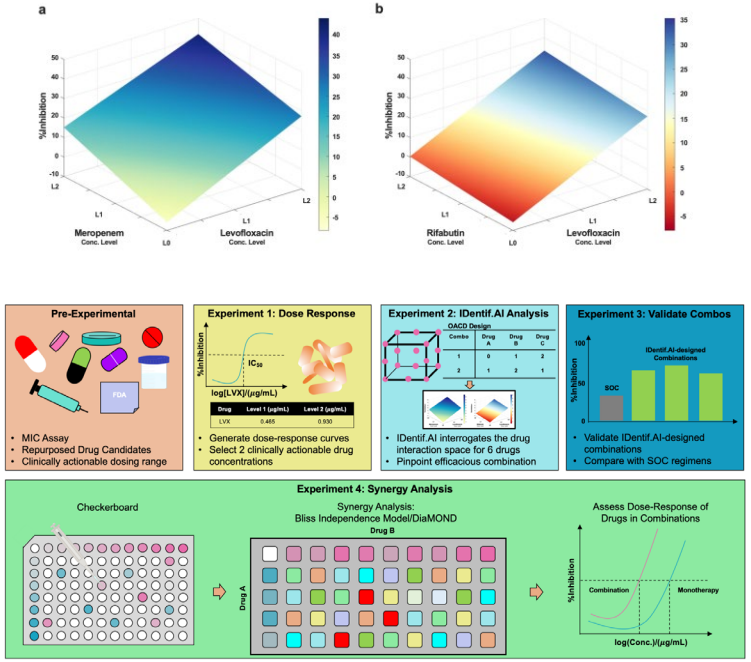
- Harnessing IDentif.AI to optimise regimens against Wildtype, Beta, and Delta Variants
- Novel workflow developed integrating clinician-technology-laboratory domains.

Blasiak et al., Bioengineering Translational Medicine, 2020.
Blasiak et al., MedRxiv, 2021.
Straits Times, 2021.
Lancet Digital Health, 2021.
WHO AI4H Working Group, 2021.

Validated in Beta and Delta Variants
Molnupiravir: Top candidate



Antimicrobial Resistance
Nontuberculous Mycrobacterium



- Rapid drug optimisation against AMR
- Can serve populations or N-of-1

What's Next?

CLINICAL TRIALS

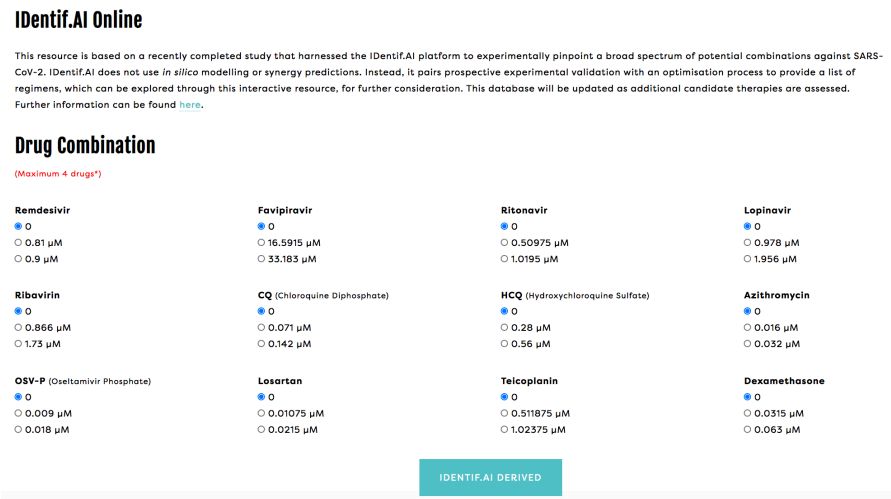
Leveraging the IDentif.AI Artificial Intelligence Platform to Find Optimal Drug Combination Regimens Against Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)

A Multi-center, Open-label, Randomized, 12-month , Multi-armed, Superiority Clinical Trial to Evaluate the Efficacy and Safety of Remdesivir and Lopinavir/Ritonavir Combination Selected by IDentif.AI, an AI-Augmented In Vitro Experimentation Platform, for the Treatment of Patients with Moderate COVID-19 (**REvoLutionAIRy**)

EDUCATION AND OUTREACH

https://n1labs.org/defeatvinnythevirus

Free Download



IDentif.AI Online

This resource is based on a recently completed study that harnessed the IDentif.AI platform to experimentally pinpoint a broad spectrum of potential combinations against SARS-CoV-2. IDentif.AI does not use *in silico* modelling or synergy predictions. Instead, it pairs prospective experimental validation with an optimisation process to provide a list of regimens, which can be explored through this interactive resource, for further consideration. This database will be updated as additional candidate therapies are assessed. Further information can be found here.

Drug Combination

(Maximum 4 drugs*)

Remdesivir	Favipiravir	Ritonavir	Lopinavir
0	0	0	0
0.81 µM	16.5915 µM	0.50975 µM	0.978 µM
0.9 µM	33.183 µM	1.0195 µM	1.956 µM
Ribavirin	**CQ** (Chloroquine Diphosphate)	**HCQ** (Hydroxychloroquine Sulfate)	**Azithromycin**
0	0	0	0
0.866 µM	0.071 µM	0.28 µM	0.016 µM
1.73 µM	0.142 µM	0.56 µM	0.032 µM
OSV-P (Oseltamivir Phosphate)	**Losartan**	**Teicoplanin**	**Dexamethasone**
0	0	0	0
0.009 µM	0.01075 µM	0.511875 µM	0.0315 µM
0.018 µM	0.0215 µM	1.02375 µM	0.063 µM

IDENTIF.AI DERIVED

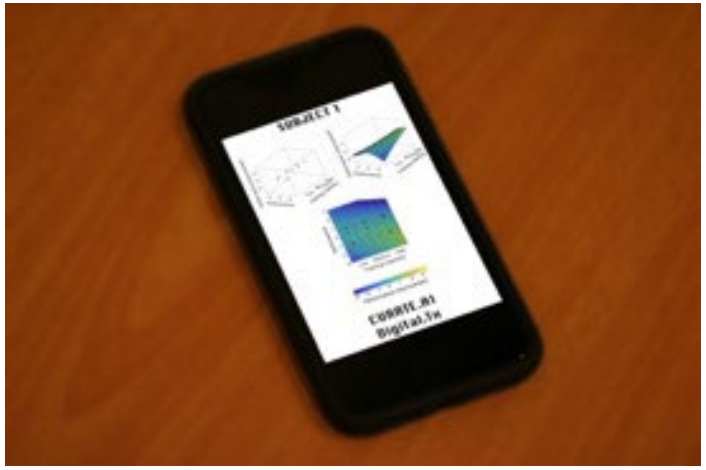
POLICY/SUPPORT/ WORKING GROUPS

World Health Organization

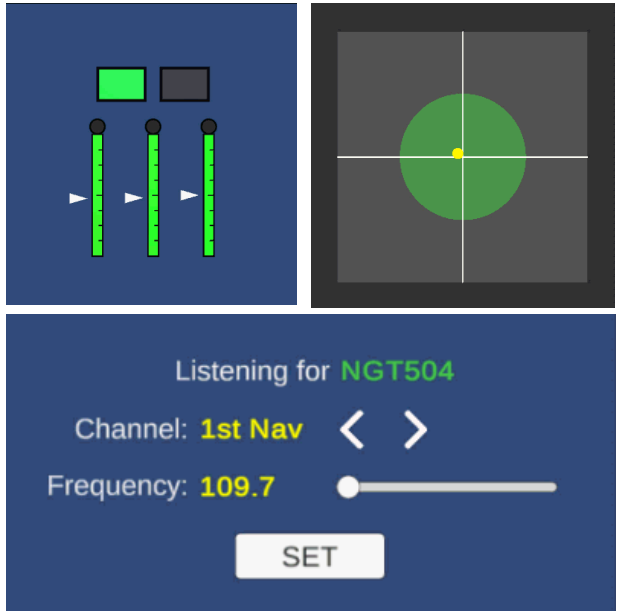
Foundation Micron

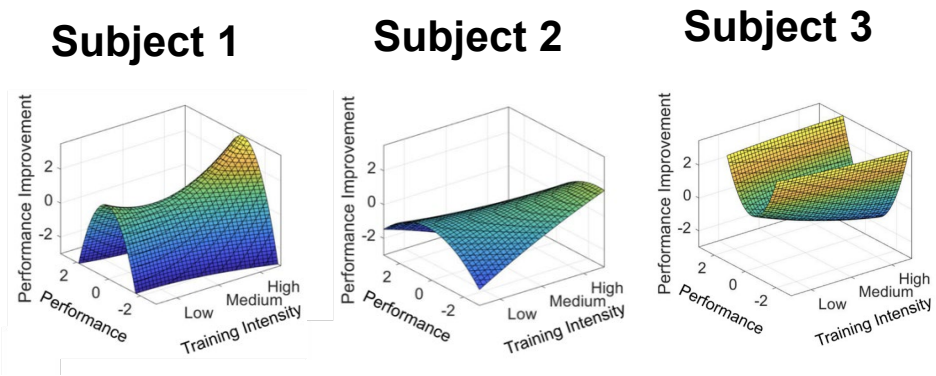
Sun Life

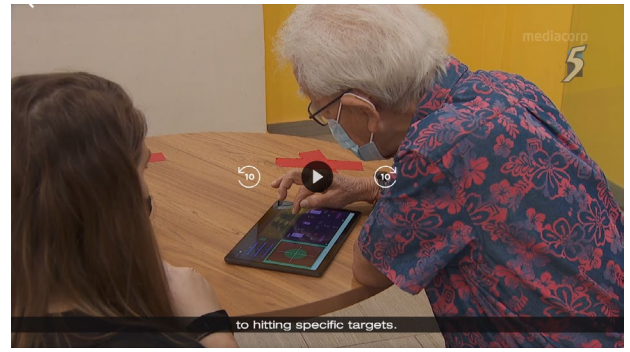
Digital Therapeutics (DTx)



w/ Dr. Bala Vellayappan, NCIS, N2CR
A/P. Chris Asplund, Yale-NUS







Medicine Without the Pill: Bringing Hospital to Home

J Labbe (Former Lucasfilm, Industrial Light and Magic), A Remus, MATB adaptation, 2020

How do we design and launch our trials?

IMPLEMENTATION

Behavioural Sciences
Healthcare Economics
Design/User Engagement

Aging is not a chore: A qualitative study to understand the motivators of digital health usage among the elderly in Singapore

InVitroVista | NUS | N.1 | WisDM

Qiao Ying Leong[1,2], V Vien Lee[1,2], Smrithi Vijayakumar[1,2], Ingela Mauritzon[4], Ni Yin Lau[1,2], Wei Ying Ng[1,2], Siong Peng Kwek[1,2], Agata Blasiak[1,2,3,5*], Dean Ho[1,2,3,5,6*]

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Therapy From Home? Exploring the general acceptability and user experience of a digital therapeutic for cognitive training in an elderly population in Singapore

NUS | N.1 | WisDM

Siong Peng Kwek[1,2], Smrithi Vijayakumar[1,2], V Vien Lee[1,2], Ni Yin Lau[1,2], Qiao Ying Leong[1,2], Wei Ying Ng[1,2], Bina Rai[1,3], Marlena Raczkowska[1,2], Alexandria Remus[1,2,3*], Dean Ho[1,2,3,4,5*]

1. The N.1 Institute for Health, National University of Singapore; 2. The Institute for Digital Medicine (WisDM), Yong Loo Lin School of Medicine, National University of Singapore; 3. Department of Biomedical Engineering, College of Design and Engineering, National University of Singapore,

Yoann Sapanel
Insurance
Medtech

Dr. V Vien Lee
Behavioural Science
Psychology

Dr. Smrithi Vijayakumar
Behavioural Science
Psychology

Dr. Renwen Zhang
Digital health
Mental health

Dr. Bina Rai
Serious Games
Mental health

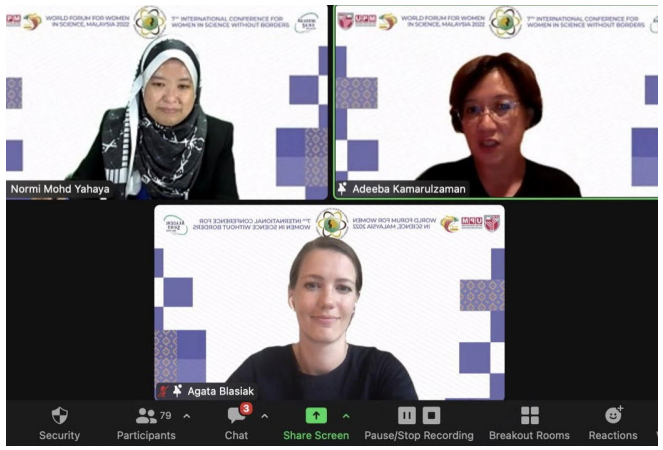
Dr. Soo Jung Hong
Health Communicatio
Culture & Tech

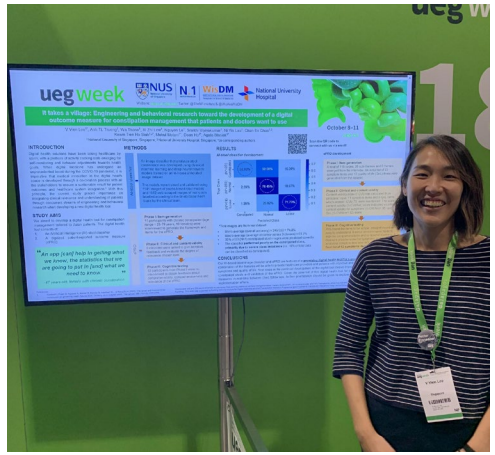
Dr. Geckhong Yeo
Behavioural Science
Mental Health

A/P Jussi Keppo
NUS Business
Healthcare Econ

Mathias Egermark
Clinical trials
Pharma industry

A/P Brian Stone
Interaction design
Healthtech





ACRLE
@ACRLE_NUS

Ending for Track 2 - hear from Ms Ng Wei Ying, @TheN1Institute as she gathers the voices of pre- to post-pregnant women on unwanted features in conception-based mobile apps, endeavoring a stepping stone into an eden for greater consumer-based personalization. #ACRLEx2022

ACRLE
@ACRLE_NUS

Do pregnant women have sufficient dietary literacy to offer what's best for her conception? What are the common barriers faced and how can harnessing digital health platforms help? Look no further and get your curiosity satisfied by Ms Lau Ni Yin,@TheN1Institute, NUS! #ACRLEx2022

NUS National University of Singapore | WisDM Yong Loo Lin School of Medicine INSTITUTE FOR DIGITAL MEDICINE

CORTx Feasibility Trial: Intervention Acceptability

Clinicaltrials.gov: NCT04848935

"It's **useful for cognitive function** post-radiotherapy. The game requires you to multitask and multitasking is what we do at work. If I can do this**, I could have a better chance on catching up at work** when I go back"

30-40yo, Nurse

"The game itself is very unique. This is the first time I'm seeing an indoor digital game [...]. I'm totally amazed at this"

"It was challenging me. It **kept me on my feet**"

40-50yo, Sales Representative

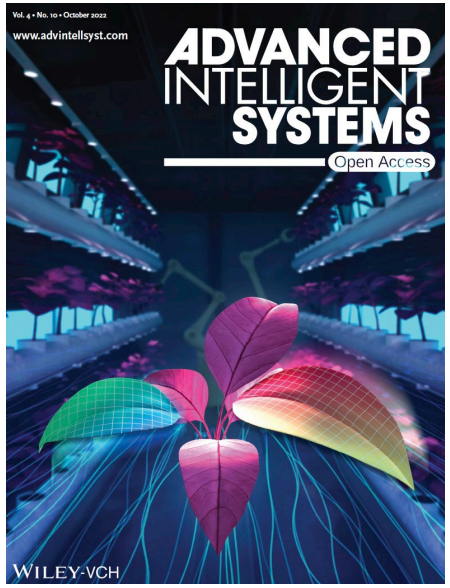
"If I can, I really want to help, so that you are able to treat future patients better and become more effective";
"I think the **the goal, the intent, all are good**"
"Out of the 3 *[tasks]*, 2 are relatively simple. It's the last one that is not user-friendly"

50-60yo, Director

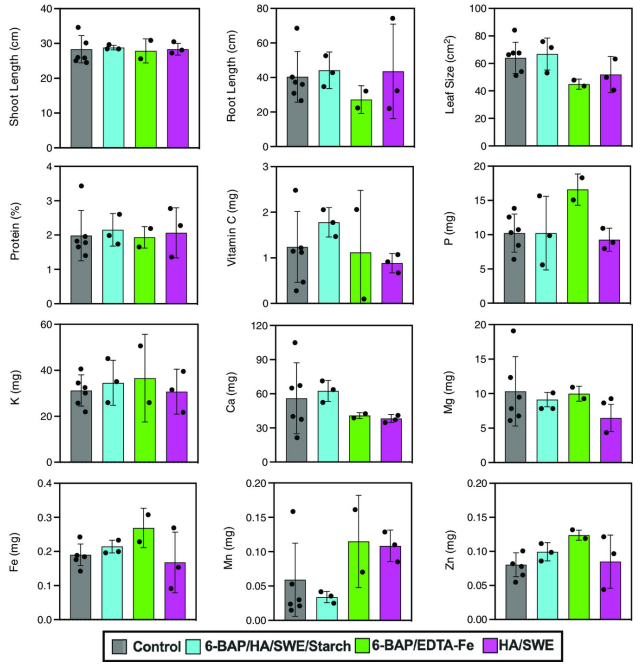
NUS National University of Singapore | WisDM Yong Loo Lin School of Medicine INSTITUTE FOR DIGITAL MEDICINE

Conclusions

- Personalised medicine must be defined.
- How much data versus how data is acquired.
- Personalised medicine may be dynamic.
- Multiple use cases validated. Larger trials en route.
- What's next???



Can We Learn From Healthcare to Rethink Planetary Health?



Less Ingredients → 30%+ Increase in Yield → No Reduction in Nutritional Content

Advanced Intelligent Systems, 2022

Re-imagining Innovation Dialogue Internationally

Co-Chairing SSF Global Meeting 2023

World Health Organization

2023 ASCO® ANNUAL MEETING

7th world one health CONGRESS

AI among strategies that could play crucial role against future pandemics

NUS' Department of Biomedical Engineering head Dean Ho and his team plan to continue using his interactive digital platform to experiment with drug regimens. PHOTO: SINGHEALTH DUKE-NUS GLOBAL HEALTH INSTITUTE

Agency signing

Newson Wallwork Media Limited

A literary agency specialising in professional and academic nonfiction

More Deal News
It was a real pleasure to work with Professor Dean Ho, Yoann Sapanel and Dr. Agata Blasiak, PhD on the groundbreaking Medicine Without the Meds: How Digital Therapeutics Will Reimagine Patient Care that Johns Hopkins University Press has recently signed

Medicine without Meds

Transforming Patient Care with Digital Therapies.

Book Release Q3 2023

Foreword: D.A. Wallach

D.A. is an acclaimed investor and recording artist named by Fast Company as one of the 100 Most Creative People in Business. He is a Co-Founder of Time Bioventures and former artist-in-residence at Spotify.

Closing Remarks: Dr. Eddie Martucci

Eddie is a co-founder and CEO of Akili Interactive (NASDAQ: AKLI). After earning his doctorate, he studied healthcare entrepreneurship as a Kauffman Fellow.

Coming soon...

Technology Alone Cannot Change Healthcare

Our Collaborators and Supporters

Thank You!

biedh@nus.edu.sg

@thedeanh