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RESEARCH ARTICLE

Efficient and Effective Diabetes Care in the Era of Digitalization and Hypercompetitive Research Culture: A Focused Review in the Western Pacific Region with Malaysia as a Case Study

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ABSTRACT

There are approximately 220 million (about 12% regional prevalence) adults living with diabetes mellitus (DM) with its related complications, and morbidity knowingly or unconsciously in the Western Pacific Region (WP). The estimated healthcare cost in the WP and Malaysia was 240 billion USD and 1.0 billion USD in 2021 and 2017, respectively, with unmeasurable suffering and loss of health quality and economic productivity. This urgently calls for nothing less than concerted and preventive efforts from all stakeholders to invest in transforming healthcare professionals and reforming the healthcare system that prioritizes primary medical care setting, empowering allied health professionals, improvising health organization for the healthcare providers, improving health facilities and non-medical support for the people with DM. This article alludes to challenges in optimal diabetes care and proposes evidence-based initiatives over a 5-year period in a detailed roadmap to bring about dynamic and efficient healthcare services that are effective in managing people with DM using Malaysia as a case study for reference of other countries with similar backgrounds and issues. This includes a scanning on the landscape of clinical research in DM, dimensions and spectrum of research misconducts, possible common biases along the whole research process, key preventive strategies, implementation and limitations toward high-quality research. Lastly, digital medicine and how artificial intelligence could contribute to diabetes care and open science practices in research are also discussed.

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Diabetes care; digital medicine; Meta-research; primary care; Roadmap

Introduction

Worldwide, except in a few developed countries, the incidence and prevalence of pre-diabetes and diabetes mellitus (DM) continue to rise without much improvement in the achievement of treatment targets.[1–5] It was estimated that 206 million adult (20–79 year-old) DM live in the Western Pacific Region (WP) in 2021.[2] This constitutes about 12% of the regional prevalence of adults living with DM knowingly or unknowingly. This is estimated to increase to 260 million by 2045. Furthermore, 300 million adults in WP have dysglycaemia, and this is projected to reach 335 million by 2030 and 350 million by 2045.[2] Approximately 110 million adults have undiagnosed DM in WP, and 1 in 7 live births were affected by hyperglycemia in pregnancy.[2]

In tandem with that is the increase in diabetes-related complications, morbidity, mortality, and healthcare cost.[6–8] In 2021, the estimated total deaths related to DM was

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This article has been corrected with minor changes. These changes do not impact the academic content of the article.

2.3 million deaths in WP and a total of about 240 billion USD was spent on healthcare for people with DM in this region.[2] The estimated total health-care cost for DM in Malaysia was .0 billion USD (45.4% of total costs) in 2017.[7] Therefore, more concerted and preventive efforts are needed to reduce this burden, and to provide more efficient and effective diabetes care in prioritized healthcare settings.[9] Sufficient and continuous investment in health-care systems delivery includes healthcare professionals who are directly involved in diabetes care to have the right knowledge and skills that should not be compromised.[10] Evidence has shown that healthcare professionals in primary care, by seeing people with DM at the earlier stages, with multimorbidity and have a lower risk profile,[9,11,12] are more likely to contribute to significant cost-effective and health-promoting effects such as achieving disease targets control, self-efficacy, self-care, emotional wellbeing and quality of life,[13–15] as compared to hospital-based specialty care.[16,17] This has also been associated with enhanced access to healthcare services, better health outcomes, and a decrease in hospitalization and use of emergency department visits, and a more equitable distribution of health in populations.[18,19] Therefore, primary medical care needs to be properly designed, supported, and invested in to bring about the greatest health outcomes in diabetes care for the country.[20,21]

The challenges of effective and efficient diabetes care have been likened to a "Double Valleys" of uphill tasks that require patients and physicians to perform, behave and be assisted to climb their respective slopes to reach the peak of good outcomes.[22] Patient's health behaviors need continuous support with accessibility to health services such as personal coaching, psycho-educational programmes and timely medical emergency care, affordable medical and surgical therapies, availability of all required screening facilities, availability of the necessary laboratory tests with optimal turnaround time, and continuous accessibility to all types of medications.[22] Many of these health behaviors likely to arise from aligned health beliefs, formed from good health knowledge (literacy) with that of their physicians, which in combination would affect the patient's motivation in effective self-care.[22,23] Most importantly, the attitude of trust in patients is affected by the attitudes of the treating physicians and delivery of the healthcare services.[22,24] Physicians require regular trainings and updates on diabetes care and prescribing habits.[25,26] They also require a conducive clinical environment for consultations with patients for an appropriate length of time, enabled by efficient appointment systems.[27,28] Physicians also require adequate remuneration, incentives, and attractive career development paths.[29] While robust primary health care support requires the presence of dedicated allied health team members in the management of both the medical and non-medical aspects of patient care.[30] This system also demands multiple risk factors management, supportive secondary care services, and a well administered registry that allows for periodic assessment of clinical performance.[22]

This article proposes initiatives a country can take to tackle suboptimal diabetes care and control of comorbidities,[31,32] and to institute dynamic and efficient healthcare services that are effective in managing people with DM. It is a multicomponent medical-health-social system with a multitiered societal and population-based prevention strategy, taking into account the effect of professional clinical care on society—population—community interacting with the environment—agent—host.[33] The plan envisions a five-year transformation and reformation initiatives at the primary care settings where certain parts can be adaptable to private clinic or hospital practice. It is also assumed that a better healthcare service (the supply side) would attract a positive change of health-seeking behaviors and health literacy in a population (the demand side). These proposed initiatives involve multiple stakeholders at administrative levels including non-medical institutions responsible for the social and welfare services.[33] The complexity of this initiative does not stop short of also requiring strong political will, public and health-related non-governmental organizations advocacy and/or counter-lobbyists to meet this health agenda. Until these transformation are executed and sustained,[34] efficient and effective diabetes care is expected to be sporadic at health clinics that adopt the suggested interventions and planned actions.[35] Notwithstanding, at any scale this plan is believed to return health benefits, a higher quality of life, greater economic productivity, reduced morbidity and mortality, and lower healthcare cost.[33]

Accordingly, the objectives of this article were to explore how the healthcare system could be reformed to provide optimal diabetes care, identify the main challenges and key strategies for ensuring high-quality clinical research in DM amidst digitalization and hyper-competitive research culture, and examine the potential contributions of digital medicine, artificial intelligence, and open science practices to diabetes care and research.

Materials and Methods

This focused review of literature attempts to update and delineate practical recommendations to achieve an efficient and effective diabetes care at primary care setting based on the latest guidelines from major societies, overviews and different types of syntheses articles. A narrative synthesis was completed to answer these review questions: 1) How can the healthcare system be

reformed to provide optimal diabetes care? 2) What are the main challenges in conducting and key strategies to ensure high-quality clinical research in DM in the era of digitalization and hypercompetitive research culture? 3) How might digital medicine and artificial intelligence contribute to diabetes care? 4) What role does open science practices play in the context of diabetes research? Results were contextualized to the Malaysian healthcare system with specific time-based suggestion of improvements, and potential approaches in digital medicine and open science for diabetes care were presented broadly. As many clinical practice guidelines and treatment algorithms currently exist in varying details between countries, the aim of this focused review is not to provide new guidelines but to give more of "How to do" advice than "What to do" discussion, to get more patients to the recommended treatment targets. It strives to offer immediate suggestions that are useful in making important decisions to improvise existing services, and to prepare for the future of digital medicine with mobile technology, electronic- and internet-assisted healthcare.[36] Discussions are also provided on initiatives to encourage higher quality research in diabetes care.

Results and Discussion

Healthcare System Reforms to Provide Optimal Diabetes Care

Principles of Effective Diabetes Care

Effective diabetes care refers to achieving the desired, personalized, and important treatment outcomes through appropriate treatment strategies and psychosocial approaches.[37,38] An efficient diabetes care will be the care process that is timely, safe and sustainable where evidence-based mechanisms overcome the contextual challenges leading to the best outcomes, and with an appropriately use of technology.[39] These features in diabetes care overlap to some extent as effective treatments would encourage efficient use of resources, and efficient delivery systems often enhance treatment effectiveness safe and cheap. It is a fact that on some occasions, in a selected group of patients fewer effective therapeutic interventions are all that is available and acceptable, or on other occasions, to limit damage and mitigate an extreme risk, a significantly less effective strategy must be employed.

Current Initiatives and Evaluations

There were many initiatives in the developed countries but few in the developing countries to improve primary diabetes care.[40,41] The Enhanced Primary Healthcare (EnPHC) in Malaysia was an integrated care model comprising multifaceted evidence-based interventions in 20 public primary healthcare clinics.[42] The project compared the enhanced services and improved efficient utilization of existing infrastructure and human resources to 20 control clinics in the management and prevention of DM.[43] It improved only process of care but not disease control (HbA1c, low-density lipoprotein and blood pressure).[43] The process evaluation disclosed issues of human resources such as having a care coordinator to lead the team, having doctors or better trained healthcare providers to conduct health education,[12] and conducive physical infrastructure during implementation.[44] At post-intervention, the healthcare providers especially the nurses in the intervention clinics reported higher level of stress, experiencing more dissatisfaction at work, and were less likely to perceive their profession as well-respected,[45] and questionable sustainability.[21] Beside EnPHC, there were smaller scale initiatives at the healthcare delivery system[20] and using psychological interventions,[46] which showed limited effects on the important clinical outcomes.

Strategic Interventions on Possible Causes

Tables 1,2 describe the possible causes, interventions, and a roadmap to improve diabetes care at primary care levels over a 5-year period. Table 1 offers a comprehensive framework for understanding the causes of suboptimal diabetes care and provides possible interventions to address these issues.[68] The suggested actions are elaborated in Table 2 underscoring the need for a multifaceted strategy that includes healthcare system improvements, ongoing healthcare professional training, and patient-centered interventions, all implemented over varying timeframes to enhance the quality of diabetes care.

Challenges to Ensure Quality Research and Strategies to Achieve Quality Research

Higher Quality Research in Diabetes Care

Optimal treatment of DM requires high-quality and translational research. These inevitably result from participation of people with DM in clinical research as the healthcare consumers in managing personal aspects of the disease. Healthcare consumers decide whether to adhere to prescribed medication and healthful lifestyles with more physical activity and cardio-metabolic friendly diets. Involving healthcare consumers in the self-management of diseases such as in monitoring their disease status and adjusting their medication dosage (e.g., insulin) can improve health outcomes.[22,69] Accordingly, an important function of research on

Table 1. The possible causes of suboptimal diabetes care, interventions and planned actions[22].

No.	Causes	Possible Interventions (Supported by literature)	Plan of Action (Refer to Table 2)
1	**Healthcare system** (including policymakers): costs of new medications, formulary limitations and health delivery or working system that does not facilitate and support proper use of screening services, and treatment/ medication.	Improve medications availability, accessibility, and affordability. Care management interventions which include virtual coaching of patients by healthcare professionals including use of mobile applications, telemonitoring, point-of-care testing, and use of alerts, shared-decision-making tools, or embedded practice advisories in the electronic health record or other practice quality improvement programmes. Also empowering diabetes educators, nurses, dietitians, nutritionists and pharmacists in lifestyle/dietary intake and medication review and modification within acceptable and evidence-based scopes. Due attention to the organisation culture and working system that encourage intrinsic ability of healthcare professionals and best clinical performance.	• Item 2, 3 and 5 in the short-term (within one year) • Item 7 to 9 in the medium-term (within three years) • Item 10 to 13 in the long-term (three to five years)
2	**Physician/Health professionals**: competing priorities and lack of time, overconfidence in the quality of care and adherence to guidelines, lack of awareness of clinical inertia, delay in adopting new guidelines, discomfort, or lack of familiarity with prescribing new medications, and perceptions that patients will not be amenable or adherent to medication changes and healthy living recommendations.	Programmes delivered to physicians and other healthcare professionals who are involved in diabetes care including diabetes educators, dietitians, nurses, or pharmacists that are designed to influence their behaviour such as educational programmes, feedback or reminders, medication knowledge and management, medical audit of health records to improve prescribing habits, and trainings on patient-centred communication skills. Nurses, diabetes educators, dietitians and pharmacists are regularly updated on medications, treatment guidelines and diabetes lifestyle recommendations to provide professional support to patients on medication use and lifestyle changes.	• Item 1 and 4 in the short-term (within one year) • Item 6 in the medium-term (within three years) • Item 11 and 12 in the long-term (three to five years)
3	**Patient-level factors**: misperceptions about medication use, fear of unwanted side effects, and the impact of social determinants of health. This medication (non-) adherence may compound therapeutic inertia where medications are less effective, affordable or available.	Patient education or structured patient education programmes, family or peer support programmes, psychoeducation, or psychological interventions to improve health literacy, self-efficacy and practical self-care activities (a diabetes lifestyle intervention). These require a holistic approach including use of digital health technologies, non-medical interventions on social determinants of health.	• Item 6 and 8 in the medium-term (within three years) • Item 11 in the long-term (three to five years)

A part of Table 1 is adapted from Table 1. Causes and Possible Interventions for Therapeutic Inertia in Chew BH, et al. Overcoming Therapeutic Inertia as the Achilles' Heel for Improving Suboptimal Diabetes Care: An Integrative Review. DOI: https://doi.org/10.3803/EnM.2022.1649.

diabetes care services is therefore to acquire the best approaches that encourage and support people with DM to self-manage successfully by adopting healthy behaviors. Similarly, the engagement of clinicians and health facility staff in research would also improve healthcare performance.[70] However, the amount of information, encouragement, and support that can be conveyed during consultations by the physicians or educational classes by healthcare professionals or peer-supports within the existing service infrastructures or through other traditional media (such as leaflets), is limited. Moreover, the availability of high-quality scientific evidence in diabetes research to guide clinical practise is insufficient in many countries including Malaysia.[71] Real-world observational studies should be used judiciously[72] and upgraded accordingly with enhancement from big data.[33]

There are some recent notable non-drug clinical trials in diabetes care in Malaysia but appeared to be incomplete in reporting or sufficiently thorough in the methods and analysis,[10,73–81] sample size issue, efficiency in the trial conduct,[82,83] reported inconclusive negative results,[46,84–86] and avoidable salami publication.[82,87,88] The integrity of scientific research can be compromised by misconducts and biases, which have the potential to undermine the reliability and objectivity of research outcomes, risking public trust in science and incurring high-cost in their handling.[89] Biased clinical and biomedical research in DM may range from non-intentional errors to intentional frauds (Figure 1).[90] This may occur at any stage during the proposal, design, performance, recording, supervision, or review of research, or in the report of research results. Biased research (Figure 2)[89,91–94] not only skews our understanding of diabetology but can also have profound consequences for decision-making, policy formulation, and the overall advancement in diabetes care. Table 3 enlists some of the common and serious biases in diabetes research and proposes preventive plans with discussion of potential implementation and limitations that researchers and institutional stakeholders can employ to avoid or minimize those

Table 2. A suggested roadmap to improving diabetes care at the primary care level.

(a) Short-term (within one year)

1. Train at least 1–2 doctors* in every health clinic to provide high-quality diabetes care, prevent/treat its comorbidities (hypertension and dyslipidaemia), and have the skills in managing obesity, metabolic syndrome and prediabetes from progressing to type 2 diabetes. All patients with sub-optimal control of diabetes (HbA1c > 8.5%) are to be seen at a shorter interval by these doctors [47–49] Patients within good control could be followed-up by other doctors but must be reviewed at least annually by these designated doctors. Patients who still do not meet the personalised disease targets after being under the care of these doctors for at most 6 months should be discussed with or referred to the FMSs† for further management. Initiate and incorporate the "Stand Against Prediabetes: Don't Sugarcoat It"‡ in routine diabetes care at the clinics. Allocate adequate budget for point-of-care testing in the clinic for testing of glucose, HbA1c, and urinalysis for initial screening.
2. Make available most anti-diabetic, anti-hypertensive, anti-lipid and anti-obesity agents currently in the formulary for the designated doctors and FMSs. These doctors and FMSs to receive training in using newer agents.[50]
3. Review and strengthen the existing Diabetes Medication Therapy Adherence Clinic (DMTAC).[51] Conduct a nationwide medical audit on the quality of DMTAC services, and act on the findings to improve or standardise the service. Re-audit after 1–2-year post-intervention.
4. Reactivate and improve or develop a diabetes registry that includes important and relevant risk factors for DM. This would be an effective and efficient way of auditing diabetes care in each clinic. To include some patient-reported outcomes such as diabetes-specific symptoms, self-care activities, participation in social roles and activities, emotional wellbeing, health status and quality of life in the routine clinical practice.
5. Make FMSs the responsible clinical specialist and the administrator of the clinics.[52] All allocated resources and activities at health clinics are governed by FMSs and team toward providing dynamic primary medical care and diabetes care.

(b) Medium-term (within three years)

6. Train at least 1–2 dedicated nurses in every health clinic to provide self-management support (clinical coaching) to patients with poor disease control.[49,51,53] At the same time to pay attention to the newly diagnosed patients making sure they achieve target control within 3–6 months. Also, these designated nurses are to support all follow-up patients in adhering to the treatment plan, ensure health screenings are up to date and conduct follow-up defaulter tracing.[54]
7. Allocate adequate budget for laboratory testing of lipids, glucose, HbA1c and microalbuminuria for monitoring purposes; make available the screening tools at the clinics e.g., monofilament, fundus camera, echocardiography, ankle-brachial doppler and central aortic pressure measurement, and psychosocial measures such as illness perception, diabetes-specific symptoms, cognitive functions, participation in social roles and activities, diabetes distress, anxiety, depression, sleep and sexual functions.[55] Begin benchmarking on quality of diabetes care by using the ABCW (A= HbA1c, B= blood pressure, C= low-density lipoprotein cholesterol, and W= weight) as four major modifiable cardiovascular risk factors as critical quality indicators.[56]
8. Apply a continuous needs-driven approach and assessment in diabetes care service planning.[57] This is to ensure evidence-based health workforce model is used to maintain the healthcare team (number of manpower and competencies) required to support best-practices in diabetes care at the clinic level. Create a diabetes health coaching team comprising a FMS, 1–2 doctors*, diabetes educators/dietitians or nutritionists/nurses/medical assistants, and have an organisational culture that makes this team thrive.[58] Include trained physiotherapists and/or psychologists as a resident or visiting member to a clinic. Create, adopt and apply appropriate digital health technologies such as telemonitoring (mHealth and telephone communication) intermittently scanned glucose monitoring, continuous glucose monitoring, newer drug therapies (such as ultra-fast insulins, SGLT2 inhibitors, GLP-1 receptor agonists and GIP) to also reducing postprandial hyperglycaemia, glycaemic variability, and to extend as much as possible the time in range in near-normoglycaemia.[59,60] The same goes for other medications required to treat related comorbidity of DM.
9. Begin to feedback to the healthcare team, before the end of year-two, on the clinical performance on the process measures, the prevalence of ABCW targets achieved and treatment profiles. This is best done through a registry. Review and improve on a structured training for the members of the diabetes health coaching team. This is to be done on a regular basis such as every 2–3 years.

(c) Long-term (three to five years)

10. Make available more drugs for the designated doctors and FMSs. Strengthen the educational classes with the inclusion of psychosocial/emotional support programmes,[61,62] peer-to-peer group support, realises important contribution from industry, academia and public health communities towards better patient empowerment and self-care.[9,63–65]
11. Provide regular training courses for the designated doctors and nurses, or train new doctors and nurses to ensure non-disruption of these 'diabetes' doctors and nurses, and dietitians or nutritionists/nurses/medical assistant/physiotherapist/psychologist. Consider advanced or specialised courses in developing psychosocial competency as well as quality medical and non-medical management in diabetes care to enhance quality consultation and professional relationships with patients that facilitate the meeting and maintain clinical targets.[57,66] Consider recognising these courses as credentialing courses, from which the doctors and nurses will be awarded certificate and incentive in remuneration.
12. Create permanent posts in chronic diseases for the nurses who are credentialed and elevate them to nurse practitioners or clinical nurse specialists. Create the posts of the sister or matron levels in parallel with the challenges of the service needs in managing chronic diseases at the primary care level. The diabetes coaching team is led by an experienced nurse, avoiding loss of trained nurses due to career advancement.[58]
13. Consolidate all the above at each health clinic. Consider diabetes nurse prescribing protocols. Encourage innovation and adoption of more ehealth and digital medicine (wearables, mHealth or eHealth) approaches in diabetes care.[67]

ABC= A for HbA1c, B for blood pressure, C for LDL-cholesterol; FMSs= family medicine specialists; GIP= glucose-dependent insulinotropic polypeptide agonist; GLP-1= Glucagon-like peptide-1 receptor agonists; SGLT-2= Sodium-glucose cotransporter-2 inhibitors.

*qualified doctors with an undergraduate medical degree but not post-graduate training

† family physicians with post-graduate training in family medicine or general practice‡ This programme conducted by a coalition of professional bodies led by the Malaysian Endocrine and Metabolic Society (MEMS) to promote prediabetes screening, diagnosis and management involving both lifestyle and pharmacological interventions by the inclusion and standardization of prediabetes diagnostic values in laboratory test reports nationally, equipping healthcare professionals with the skills and knowledge to address prediabetes effectively and raising awareness among the public on prediabetes.

biases.[91,95] The biases are further classified into either Extrinsic or Intrinsic biases with the former are those external to the researchers while the latter are internal.[96,97]

Strategies to Achieve Quality Research—Collective Actions

The first step in a collaborative effort toward improving diabetes care services and research would be creating

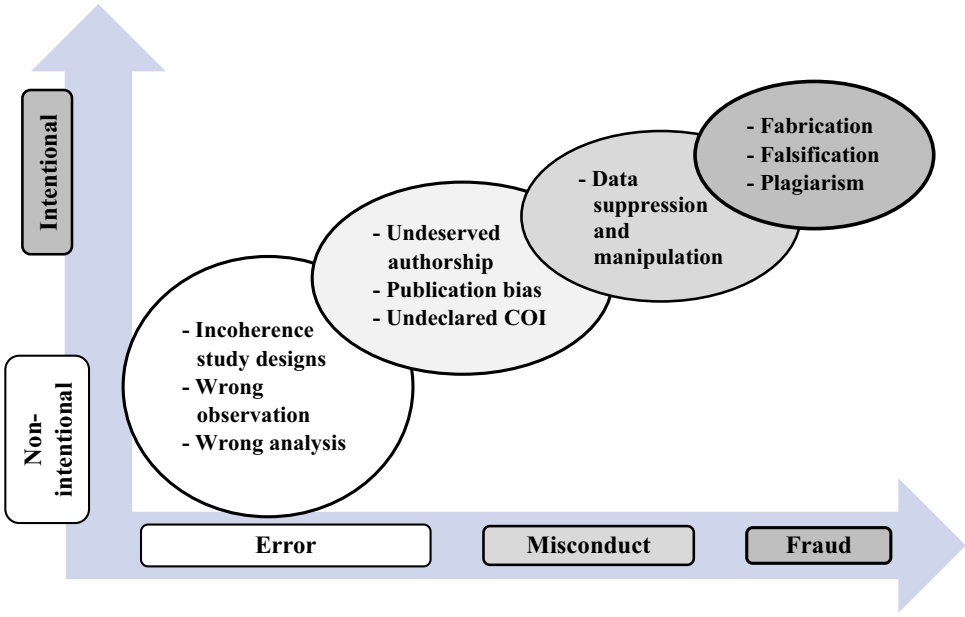


Figure 1. The dimensions and spectrum of misconducts. Modified from the figure in Nylenna M, et al. Scientific misconduct: a new approach to prevention. Lancet. 2006;367(9526):1882-4. Doi: http://10.1016/S0140-6736(06)68821-1. COI = conflict of interest.

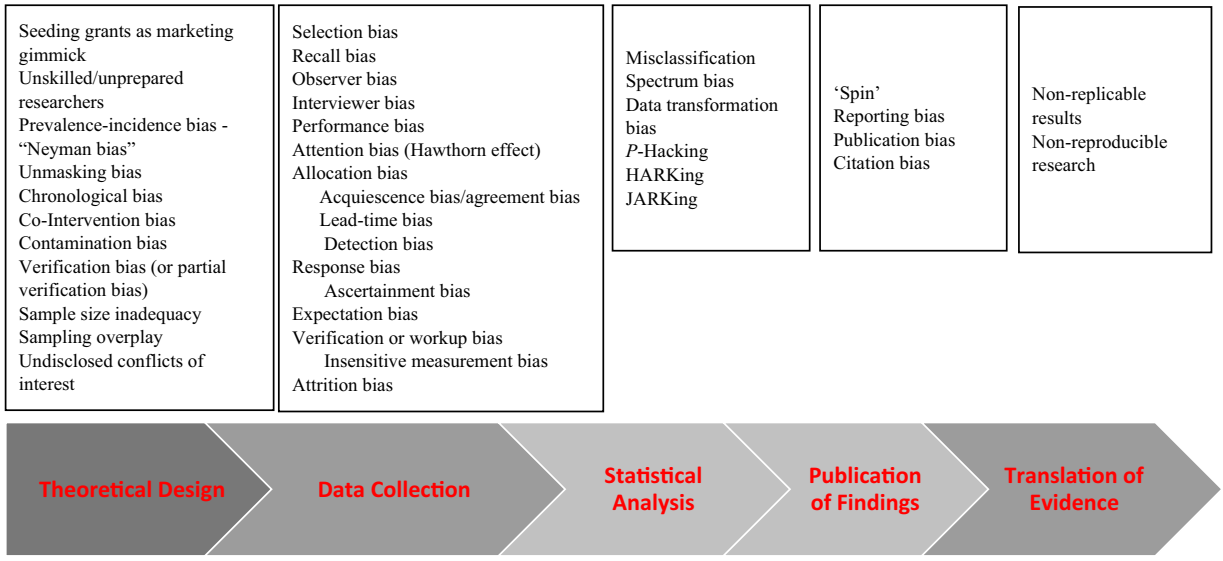


Figure 2. Possible biases along the whole research process. *P*-hacking= generating statistically significant results through repeated analyses. HARKing= **H**ypothesising **A**fter the **R**esult is **K**nown, a significant *p* value is retrospectively generated to match a hypothesis. JARKing= **J**ustifying **A**fter **R**esults are **K**nown "Spin"= presenting results of study as more striking, "positive" or newsworthy than warranted Misclassification and spectrum biases in the statistical analysis may occur in the earlier stages. For other biases that are labeled differently, please see Bias in medical research by Justin Morgenstern in Evidence Based Medicine Front Page. Published July 2, 2018-Updated June 8, 2021.https://first10em.com/bias/.

a group of diabetes scientists, researchers and clinicians who are trained in clinical epidemiology and research misconducts and biases as described above. Compilation and synthetization of local evidence to establish the best latest available evidence on effective diabetes care would be a good starting point. They would function as a consultation group to facilitate, coordinate and encourage higher quality clinical research and trials in diabetes care. The group could also assist in translating best evidence in practice in the shortest time possible by reviewing local and

Table 3. Common biases, key preventive strategies, implementation and limitations.

No.	Biases	Prevention/Detection	Implementation and limitations
Extrinsic			
1	Sponsorship bias[98]	(i) Sequestering investigators from private companies.	(i) Whenever possible. Otherwise, be utmost careful and sceptical with every step of the whole research process.
		(ii) Avoid engaging with industry-sponsored clinical research[99] and seeding trials[100] without rules and principles of integrity.	(ii) Require awareness, experience and guts on the researchers to say 'No" to the 'easy' grants and to stand up to the pressure of obtaining research grant in research institutions for career advancement.
		(iii) *Disclosure of all relationships.*	(iii) *Limited by timing and disclosures by (un) involved people in a research project.*
2	Flawed incentive structures and researcher performance metrics that preferentially value 'aesthetics' over authenticity[101]	(i) To prize authentic and robust research and their outputs whether their findings are positive or negative.	(i) A challenging transformation given the extent to which both the investigators and research institutions flourished under the current rewards structures.
		(ii) To encourage or educate both investigators and research institutions to recognise the extent to which they are entangled in the major conflict of commitment and interest between conducting authentic science and being successful and enjoying the individual and institutional rewards of success in 'aesthetic' science.	(ii) Researcher's personal behaviours are often determined by the institution's policy that would risk career advancement if not complied. While the institution's policy is often determined by the high-level stakeholder or policymakers fixed and outdated concepts of research excellence.
		(iii) To show proof of inclusion or exclusion of research papers produced by the researchers or the research institutions from high-quality systematic reviews in the related topics, if available. Otherwise, may consider conduct or simulate one that apply risk of bias assessment and grading of the certainty of the evidence.	(iii) Limited by the availability of related systematic reviews. The alternative approaches are limited by competent and availability of reviewers. If this were achieved, the findings could result in insightful and decisive prevention plan.
		(iv) Institutional leaders will need to take responsibility for eliminating the conflicts of interest that promote bias in research by having institutional metrics of professional success that align with good science ,[102–104]	(iv) To convince the leaders that good science will lead to the desired outputs and research excellence,[105] more satisfied and motivated researchers and vibrant research culture.[97] Can draw on existing resources such as the published five Hong Kong Principles for assessing researchers: 1) responsible research practices; 2) transparent reporting; 3) open science (open research); 4) valuing a diversity of types of research; and 5) recognizing all contributions to research and scholarly activity.[106]
		(v) Institution or a professional society to host a competition to develop the best prevention plan for respective department or discipline, respectively.	(v) This requires sizeable interest, having critical mass of champions and participation from the institutional leaders.
		(vi) Research institutions to sponsor audits of the work or outputs of their research teams	(vi) Systematic reviews that are available would be used to inform the audits. The audits could be conducted at random or only on teams that volunteer. The launch of the audits would need to be preceded by a communication effort that outlined the aim and value of the audits in order that they are not perceived or experienced as punitive.

(*Continued*)

Table 3. (Continued).

No.	Biases	Prevention/Detection	Implementation and limitations
3	Biased research practices have caused much scientific misconduct and diffused through the scientific community as an unhealthy condition to be handled *en masse*.[90] To impose a heavier responsibility than currently applied on all institutions and their leaders for ensuring ethical and sound research environments and avoiding minor breaches of good scientific practice.	(i) Acknowledge and address scientific misconduct	(i) Scientific misconduct should not be downplayed, and its occurrence must be openly acknowledged. Regular seminars and discussions on the causes, outcomes, and consequences of scientific misconduct should be held by research institutions.
		(ii) Broad definition of biased research practices	(ii) While a strict definition is suitable for legal action, a wider definition that includes all breaches of accepted scientific practice should be used for preventive measures.
		(iii) Simplify guidelines and improve training	(iii) Current guidelines and regulations should be simplified and readily accessible to researchers. Ethical and legal issues should be included in research training. Supervision of young researchers should be enhanced, with senior researchers serving as models for ethical behavior. Issues such as conflict of interest and guidelines for authorship should be addressed.
		(iv) Establish independent investigation mechanisms	(iv) National-level mechanisms for investigating suspected incidents of serious scientific misconduct should be established. Clear methods to manage whistleblowers should be in place, with designated individuals to receive complaints.
		(v) Reform academic system of reward and merit	(v) A thorough discussion is needed on the academic system of reward and merit. Emphasis on productivity and publication numbers should be reduced, while fostering a culture of transparency and ethics within academia. A wealth of resources is available on DORA (San Francisco Declaration on Research Assessment, https://sfdora.org/resource-library/)
Intrinsic			
4	Biased design, conduct and reporting of preclinical studies	(i) Peer reviewing the research proposal before study initiation (such as at the ethic committee or funding level), and manuscript for publication	(i) Limited by availability of competent and fair reviewers.
		(ii) Reporting guidelines such as the ARRIVE (Animal Research: Reporting of In Vivo Experiments) guidelines.[107] Many similar reporting guidelines and checklists are available on EQUATOR (**E**nhancing the **QUA**lity and **T**ransparency **O**f health **R**esearch) network for different study designs https://www.equator-network.org/..	(ii) Ensuring transparency of critical methodological aspects of animal studies.
5	Biased study designs due to incoherency in the whole research process	(i) To provide field-specific courses focused on the fundamentals of research methodologies, techniques or tools such as experimental design and statistics, reproducibility, and other practical skills related to the robustness of different types of research.[108,109]	(i) To convince researchers and institutional leaders that research knowledge and skills can be learned. Participation in courses and workshops may be a challenge to busy clinicians.
		(ii) Having an introductory course on research integrity in a safe and non-punitive environment.[109]	(ii) Having competent trainers, dedicated and regular slots that are supported by all stakeholders may be a challenge if this topic is not valued more than the 'aesthetic' outputs.[101]
		(iii) Principal Investigators (PIs) could also lead an annual informal research integrity discussion with their team, demonstrating their commitment to instilling a culture of integrity in their group.	(iii) A system change is likely to be needed to require and to record this practice. However, effectiveness of this within every team would depend on the passion and genuine interest and input of the PIs.
		(iv) Involvement of PIs and senior researchers as role models (iv).	(iv) This can be done quite easily with appropriate recognition to the role models.

(*Continued*)

Table 3. (Continued).

No.	Biases	Prevention/Detection	Implementation and limitations
6	Cognitive biases[95]: (i) Hypothesis myopia (ii) *p*-hacking (repeated tinkering with data and retesting) and HARKing (**h**ypothesizing **a**fter **r**esults are **k**nown) (iii) Asymmetric attention (iv) Just-so storytelling/ JARKing (**j**ustifying **a**fter **r**esults are **k**nown)	(i) Use the strong inference approach to explicitly considering competing hypotheses, and if possible, working to develop experiments that can distinguish between them. (ii) Transparency in registering research protocols, or publishing research proposal on repository or journals to subject the research to public/open scrutiny. This is to reduce the unconscious temptation to warp the data analysis. Another approach is blind data analysis where important variables are hidden, or dataset is added with removable noises. (iii) Use team of rivals (an adversarial collaboration) to quickly spot flaws such as hypothesis myopia, asymmetric attention or just-so storytelling. (iv) To explicitly list alternative explanations for all observations to reduce tendency to tell just-so stories.	(i) Researchers are to be always on the guard and prepared to be impartial when facing with the data and results. (ii) Belief in pre-print and publishing research protocols before the initiation of the study require motivation and support. This could come from journals that accept publication of research protocol without or with minimal cost and practice open access. (iii) This may be easier said than done. Such a practice demands big and open heart among the academic rivals and strive to support good science as the ultimate end. (iv) Same to item (i).

Content of this table was adapted from an article by the author shared in RECRUS Research Newsletter on July 2023, Vol. 3 Issues 23, page 641. (https://hsaas.upm.edu.my/upload/dokumen/20230801091907Biased_Research_Prevention_Plan.pdf).

international evidence at a regular basis and producing updates annually. All research in diabetes care must adhere to epidemiologic principles of efficiency, validity, and precision in the whole research process, particularly in the measurement aspects of quantitative clinical research.[110] Qualitative research on the right topics should also be encouraged. To improve the relevance and potency of clinical research, public and patient inclusion would be encouraged. These three attributes require proper use of study designs, participant, and control selection, along with the appropriate statistical strategies. Any diabetes research that is conducted without due diligence to the quality principles mentioned above, defeats the ultimate purpose of the research itself. Worse, the research contributes to research waste, results in missed opportunity and biased pooled estimates.

In addition, studies should be extended to assess any disparity between the effect size observed in clinical trials versus those observed in real-world settings. This bridges the gap between research and practice, enhancing the capacity to explain and promote the application, translation and implementation of research findings. In another perspective, meta-research initiatives or research on research should be given greater consideration, patients' participation and funding approaches in diabetes care research to be regarded with increased attention to safeguard high quality and public trust. This should include more capacity building and research into digital medicine in diabetes care. Broken systems in research training, guidance, funding, publication metrics and career promotion of researchers should be mended and supported. If the research was not conducted with credibility and without conflicts of interest, the clinical evidence would not be regarded as credible.

Digital Medicine, Artificial Intelligence, and Open Science Practices to Diabetes Care and Research

Digital Medicine in Diabetes Care and Research

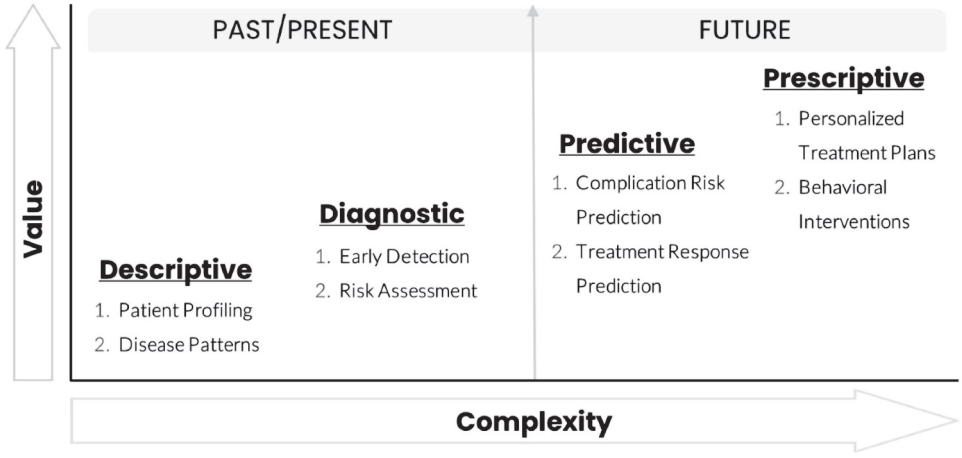
Technological advancement, the internet of things, machine learning and artificial intelligence (AI) will transform every aspect of human life including diabetes care.[111,112] The use or intrusion of digital technology in medicine and diabetes care is already significant and expanding fast, but is not without its limitations and ethical issues.[111,113–116] As human data are accumulating, big data analysis in diabetes care and for health behaviors may be the game-changer and ushering in the next paradigm shift in diabetes care delivery. Digital health interventions encompassing the e-health initiatives, telehealth programs, telemedicine and mobile health (mHealth) apps could contribute in the effort to address challenges that impede the attainment of health system goals. According to the Tanahashi framework published by WHO, these include: 1) accountability in coverage of the target population, 2) accessibility and availability of health facilities, and availability of human resources, 3) contact and continuous coverage of the target population for treatment, 4) effective coverage with quality medical and clinical care, and 5) affordability of app-based digital interventions.[117]

Recent mHealth interventions targeting type 1 and type 2 diabetes are diverse in their goals and components, which include insulin management applications, wearable blood glucose meters, automated text messages, health diaries and virtual health coaching for diabetes education, self-management and prevention.[118] Effective apps would have a structured interface which contains a module on diabetes-related complications and prevention,[119] while the clinical decision-making function needs further improvement and evaluation. Desirable apps are user friendly, encourage healthy eating, provide actionable reminders, consolidate data across peripheral health devices, provide news updates on developments in the field of diabetes, educational topics on problem solving, insulin pump therapy, signs of diabetes complication and transition from pediatric into adult care.[120] In low- and middle-income countries, there is a distinct lack of mHealth applications, a scarcity of formal outcome evaluations, and a relative lack of scalable services.[121] The most documented use of mHealth was 1-way text-message reminders to encourage follow-up appointments, healthy behaviors, and data gathering.[121]

However, digital health utilizing the various channels of mHealth and eHealth should be viewed at best as channels or containers. These devices and their apps will require good content and easy interfaces to meet active, engaged or smart users for it to be effective.[122,123] Therefore, for digital health interventions to be effective they first must be well created, tested, and maintained by the providers. This will then address the requirement of empowered patients who are supported by competent healthcare providers.[122,124] The content development, validation and deployment are to be sound for all kind of clinical interventions even more so for digital interventions infused with mathematical algorithms of AI.

AI is the cognitive capacity of machines made possible by mathematically designed neural networks.[125] The electronic neural networks are built to mimic human neuronal plexus and programmed to manage a myriad of data according to their categories and to assign different weights to different factors. The weights are determined based on provided data on specified outcomes, and this process is continuously enhanced with the registration of new data. The learning computer models are the machine learning (ML) version of the AI, whereas the deep learning (DL) version has multiple layers of neural networks.[126] Transformers exists when these deep learning models differentially weight the significance of each part of the input data and enable natural-language processing (for example, the ChatGPT stands for Chat Generative Pretrained Transformer).

When a vast quantity of data becomes interconnected, it generates new discoveries and opportunities at an individual level and in almost every aspect of diabetes care and research.[112] Augmented intelligence (AugI) is the application of artificial intelligence that complements and enhances human capabilities rather than substituting them. There are many FDA-approved software, applications, programmes and devices that use AI to interpret a broad range of imaging modalities, diagnostic and prognostic assistance, and helps outline possible treatments for clinicians.[127] The appropriate use of AI technology in healthcare is on the rise[128] and has the potential to be cost-effective, improved quality by reducing



AI= artificial intelligence; ML= machine learning

Figure 3. Potential aspects in diabetes care that artificial intelligence/machine learning could make a difference.

variation, safe and fast[129,130] if potential biases and discriminatory data are minimized or eliminated, during the development or deployment to the intended users. Figure 3 illustrates some of the potential aspects in diabetes care that AugI could make a difference.

A Full Development Process of Artificial Intelligence/ Machine Learning Tools

The following is a typical progression for the development and deployment of a new AI tool that could be applied in diabetes care and research.[129,131,132] It is consistent with other frameworks and could be expanded to incorporate health economic assessment.[133] Healthcare professionals and clinicians with an understanding of the development process of AI tools would help improving the therapeutic potential of the tools,[134] and facilitate clinical adoption and monitoring of these tools in healthcare settings.[135] A fuller elaboration on these nine stages will be disseminated elsewhere.

Clinical Problem Identification

These are challenges that are rooted in facts, mechanical, repetitive and complex in nature due to the need to process multiple aspects of diabetes care services or individuals with DM in the health system. AL/AugI/ML is of no assistance in dealing with personal values, health beliefs and emotions. Decision must be made on the level of the problem for the AI technology to solve, either descriptive, diagnostic, predictive or prescriptive (Figure 3). These pertain to the estimation of a condition's prevalence, diagnostic probability, prediction of certain outcomes, and recommendation of the most likely effective treatment. The order denotes an incremental level of value and complexity to be anticipated during the tool's development.

Form Project Team or Collaborate with Experts

The team must consist of the qualified people with the required skillsets. This includes data scientists to conduct data validation/transformation/curation and data visualization for AI/ML models; data engineers to implement data workflows (such as storage); data architects to design system architecture for data repository; and a chief data officer to design the data governance structure and policies if one is not already available. Clinicians, healthcare administrators and related stakeholders including patient and public groups of individuals are indispensable for the proper project planning, development, deployment, adoption and maintenance of the AI/ML tool. Health informatics, business or industry partners should be considered if available.

Data availability, organization and curation

Relevant real-world sources of data must be explored, annotated and pre-processed. Different types of data will have to be processed through distinctive stages before it is useful for the AI algorithms. These are standardization (coding of structured and unstructured data) for interoperability, cataloging, de-identification (pseudo- or anonymization), cleaning/transformation (validation) and linking and combining multiple sources into single dataset. Significant quantities of high-quality data, shared within credible data governance structures, present real challenges to achieve this objective.[136]

Infrastructure and Architecture for Data Repository and AI Technology

It is necessary to have adequate computer and server capacity, as well as the appropriate hardware, to process massive amounts of data with optimal speed. The operation of this data server includes robust cybersecurity, data privacy, controlled access and up-to-date regulatory policy on the proper use of the data, as well as supervised incremental learning of the AI/ML tools. In addition to security and proper governance, ease and speed of access to different users are of utmost importance. The infrastructure and architecture must be scalable to accommodate the growing needs and requirements of the tools.

AI Neural Networks on Open Access Platforms

Many AI algorithms are readily available on open access platforms. Applying the appropriate AL/ML models and methods to the required tasks to resolve the identified clinical problems. The creation of new AI neural networks is a time-consuming process that requires data scientists with advanced skillsets. The convolution neural network is ideal for images, while the recurrent neural network is best suited for text and numerical data.

AI/ML Models Validation

Mandatory non-clinical and clinical validation of the tools is required to determine their performance, integration into the routine clinical workflow, usability to those involved, and effects on clinical outcomes. This encompasses exploring and addressing the potential ethical and legal implications of having these tools in the healthcare services. Properly designed clinical research including a clinical trial on the tools is necessary to estimate its clinical effect in the real-world setting. The final step is to publish the report for broad dissemination and evaluation of the final product.

Registration

Register tools with relevant authority such as the medical device authority.

Clinical Deployment

Instructing clinicians and team members in the healthcare facilities where the tools will be utilized or integrated into the electronic medical record system. Be prepared to explain the decision process of the AI/ML tools and be present to support its use. Continue to measure the tool's effect on diabetes care and supervise the incremental learning of the tool. Also, continue to monitor for any unwanted effect arising from its use, including performance degradation, algorithm drift and pipeline decay owing to data integrity, cybersecurity, impact mitigation in case of breach and function recovery.[137] Be vigilance and prepared to re-train the AI/ML algorithm if the performance is below expectation.

AI Ecosystem Improvement

Engage stakeholders and public actively regarding the tool, and to progress the AI ecosystem in the institution and country.[130] This aims to promote a broader and better perception of AI/ML technologies, increasing interest and training, and establishing central governance, trusted custodian, ethical value and adequate confidence to permit innovation and the implementation of more AI/ML tools.

Ethical considerations of data privacy and patient safety are well-known challenges lying ahead.[111,138] Similarly, the traditional principles of medicine are here to stay because they uphold the dignity of patients, and mutual trusts between the doctor, the patient, and the society. A win-win partnership between technology companies as the technological know-how and healthcare facilities as the data sources and expert input to the algorithms would be the greatest challenge ahead. This is to be regulatory compliant and economically beneficial to the two key stakeholders.[139]

Open Science Practice for Diabetes Research

All stakeholders, including scientists, clinical and biomedical researchers, must have a better appreciation and adoption of Open Science (OS) in diabetes research.[140] OS encourages the practice of diabetes research that is "opened" from the beginning to the end throughout the whole research process. This includes sharing research protocols (in the safe preprint servers or by stages), making public research tools, involving public and patient in the research planning, transparent in the research undertakings, collaborative with experts and conduct high-quality research with integrity. It advocates sharing and use of openly available, accessible and reusable research products for everyone, to facilitate scientific collaborations and sharing of information for the benefits of science and society, and to expand access to the processes of scientific knowledge creation, evaluation and communication beyond the traditional scientific community.[141] It comprises all scientific disciplines and aspects of scholarly practices, including basic and applied sciences, natural and social sciences, and the humanities.[141]

OS system practice is compatible with intellectual property rights[142]and not free of cost.[143] OS is to be as open as possible so that all stakeholders can appreciate its full meaning and benefit from science via the FAIR (findable, accessible, interoperable and reusable) principles,[144] but at the same time be as close as possible to the local problems, values, cultures and legal requirements via the CARE (collective benefit, authority to control, responsibility and ethics) principles.[145] OS does not mean indiscriminate openness, and consent of or license to use any open sources of a research product, as permission should be first obtained from the intellectual property rightsholder. Similarly, potential rightsholders are urged to advocate for the use of copyright and licenses to compel the openness of a free research/scientific products. OS does not mean free of cost. The initial transition to OS may necessitate investments in the infrastructures and capacity building, as well as ongoing maintenance costs. Nevertheless, with the OS practise, science will generate multiple returns on investment through accelerated high-quality research, innovation, and commercialization.

Diabetes researchers may practice OS on the Open Science Framework (https://help.osf.io/article/576-tips-and-tricks.) to improve sharing of research project's information (metadata) for discoverability, collaboration, and reuse of materials or products of the research project (tools, data management plans, software codes, datasets and publications) for self and by others.

Strengths and Limitations

This review offers several notable strengths that contribute to its value in the field of diabetes care and research. Firstly, the focus on Malaysia as a case study provides a detailed and in-depth analysis of the challenges and opportunities within a specific context. This specificity allows for a thorough examination of the issues and the development of targeted strategies that can be adapted by other countries facing similar challenges. While this approach provides detailed insights and concrete examples, it may limit the applicability of the findings and

recommendations to other countries in the WP. Each country within the region has distinct healthcare systems, economic conditions, and cultural contexts, which might affect the relevance and implementation of Malaysia-specific solutions elsewhere. To enhance the relevance and applicability of the review's findings for other countries in the WP, it is crucial to tailor strategies to fit specific needs and contexts including case studies from diverse countries and conducting comparative analyses can highlight common challenges and successful strategies for regional adaptation. Engaging stakeholders from various countries provides valuable insights and facilitates the adaptation of solutions, while promoting regional knowledge sharing and collaboration help disseminating best practices. Pilot programs could be conducted in diverse settings to test and refine interventions before broader implementation. Additionally, developing flexible frameworks that accommodate unique challenges and opportunities, ensures that proposed interventions are scalable and adaptable across different healthcare systems and resource settings.

The review emphasizes the importance of a comprehensive and multi-faceted approach to diabetes care, highlighting the necessity of concerted and preventive efforts from all stakeholders. It advocates for the transformation of healthcare professionals and the reform of healthcare systems with a holistic perspective, instituting effective interventions that encompass primary care, allied health professionals, health organization improvements, and support systems for people with diabetes. However, implementing the proposed transformation of healthcare professionals and the reform of healthcare systems requires significant resources, necessitate extensive training and education, which may not be available in all healthcare settings, particularly in low- and middle-income countries. Resistance to change among established professionals may also pose a barrier.

Additionally, the review's discussion on important roles of high-quality research for diabetes care, as well as the open science practices in research that adds value by promoting transparency, collaboration, and the sharing of knowledge. Conducting high-quality research involves significant investment in terms of time, funding, and expertise. Similarly, ensuring consistent application of open science practices can be challenging, especially in under-resourced settings. These are crucial factors for efficient and effective diabetes care and research that should be improvised within the country and promoted in collaboration externally with other countries in the WP or internationally.

Another strength of the review is its forward-looking approach, proposing a detailed roadmap for the next five years, and inclusion of digital medicine and AI as potential contributors to diabetes care. Educated clinicians are pillars of healthcare transformation.[146] They could ensure digital solutions meet their unique needs and preferences, emphasizing patient safety and quality of care. Their involvement facilitates seamless integration into the clinical workflows,[147] supports adoption, drives innovation, and optimizes clinical outcomes.[148,149] The availability, readiness and needs for these are again to be assessed at different levels in different countries.

Conclusions

For patients, physicians, healthcare systems, and their stakeholders in many nations, including those in the WP and Malaysia, diabetes care is often defined with descriptions such as difficult, complex, costly, and perplexing. The ultimate goal of diabetes care is to achieve patient-perceived outcomes as they progress through life's stages. The best investment for quality and cost-effective diabetes care will be at the primary medical care level. This could be achieved in three stages: Short-term (within one year), medium-term (within three years) and long-term (three to five years). This requires concerted efforts of multiple parties in the government agencies and non-government organizations to facilitate the transformation and sustain it. Until then, only health clinics adopting the suggested interventions and planned actions would provide the optimal diabetes care. For optimal healthcare performance, the transformation initiative calls for high-quality diabetes care research and clinical evidence.[150] Therefore, a working group is required to compile and synthesize local evidence to provide information on the best and most recent available evidence regarding effective diabetes care. In the absence of best evidence, the group will facilitate, coordinate, and encourage high-quality clinical research and trials in diabetes care that adhere to the epidemiologic principles of efficiency, validity, and precision, the appropriate use of digital technology, and the practise of open science throughout the research process.

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BHC wrote the paper, all authors provided critical inputs with PL, AG, MYBN and TSC provided focused input on allied health professionals, nutritional, dietetics and laboratory perspectives, respectively. WPF and CLC provided input on the Enhanced Primary Care initiative in Malaysia. SD and BNI commented on the overall draft from the aspects of technical and grammatical quality. NHZ, WPF and CLC also provided general overviews.

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References

1. Tobias M. Global control of diabetes: information for action. The Lancet [Internet]. 2011 [cited 2024 May 23]. 378(9785):3–4. https://linkinghub.elsevier.com/retrieve/pii/S0140673611606041.
2. Magliano D, Boyko EJ. IDF diabetes atlas. 10th ed. Brussels: International Diabetes Federation; 2021.
3. World Health Organization. Global report on diabetes [internet]. Geneva: World Health Organization; 2016 [cited 2024 May 23]. https://iris.who.int/handle/10665/204871.
4. Amarra MS, Chong M-F, Titapant V, Somprasit C, Rogacion J, Irwinda R, Huynh TNK, Nalliah S. ILSI southeast asia symposium: prevalence, risk factors, and actions to address gestational diabetes in selected southeast Asian countries. Eur J Clin Nutr [Internet]. 2021 [cited 2024 May 23]. 75(9):1303–08. https://www.nature.com/articles/s41430-020-00838-6.
5. Wan KS, Mustapha F, Chandran A, Ganapathy SS, Zakariah N, Ramasamy S, Subbarao GR, Mohd Yusoff MF. Baseline treatments and metabolic control of 288,913 type 2 diabetes patients in a 10-year retrospective cohort in Malaysia. Sci Rep [Internet]. 2023 [cited 2024 May 23]. 13(1):17338. https://www.nature.com/articles/s41598-023-44564-y .
6. Lim LL, Abdul Aziz A, Dakin H, Buckell J, Woon Y-L, Roope L, Chandran A, Mustapha FI, Gregg EW, Clarke PM, et al. Trends in all-cause mortality among adults with diagnosed type 2 diabetes in West Malaysia: 2010 – 2019. Diabetes Res And Clin Pract [Internet]. 2023 [cited 2024 May 23]. 205:110944. https://linkinghub.elsevier.com/retrieve/pii/S0168822723007076
7. Ministry of Health Malaysia. Direct health-care cost of noncommunicable diseases in Malaysia [internet]. Putrajaya, Malaysia: Ministry of Health Malaysia; 2022. https://www.moh.gov.my/moh/resources/Penerbitan/Rujukan/NCD/NCD_Laporan/HEALTH-COST_of_NCDs-7a-WEB.pdf.
8. Zhang P, Zhang X, Brown J, Vistisen D, Sicree R, Shaw J, Nichols G. Global healthcare expenditure on diabetes for 2010 and 2030. Diabetes Res And Clin Pract [Internet] 2010 [cited 2024 May 23]. 87(3):293–301. https://linkinghub.elsevier.com/retrieve/pii/S0168822710000495.
9. Mohan S, Khunti K, Prabhakaran D. Principles for the prevention and control of non-communicable disease. Nat Med [Internet]. 2023 [cited 2024 May 23]. 29(7):1598–600. https://www.nature.com/articles/s41591-023-02368-7.
10. Lim SC, Mustapha FI, Aagaard-Hansen J, Calopietro M, Aris T, Bjerre-Christensen U. Impact of continuing medical education for primary healthcare providers in Malaysia on diabetes knowledge, attitudes, skills and clinical practices. Med Educ Online [Internet]. 2020 [cited 2024 May 23]. 25(1):1710330. 10.1080/10872981.2019.1710330.
11. Chew BH, Mastura I, Bujang MA. Comparing the disease profiles of adult patients with type 2 diabetes mellitus attending four public health care facilities in Malaysia. Malays Fam Physician. 2013;8:11–18.
12. Jaafar N, Perialathan K, Zulkepli MZ, Mohd Zin Z, Jonoi PE, Johari MZ. Patients' perception towards health education services received at the enhanced primary healthcare facilities: a qualitative exploration. J Prim Care Community Health [Internet]. 2020 [cited 2024 May 23]. 11:215013272098062. 10.1177/2150132720980629.
13. Johari MZ, Abdullah Z, Mohd Hanafiah AN, Mohammed Nadzri NI, Razli SA, Kong YL. Can patients make heads or tails of enhanced primary health care (EnPHC)? Experience through their own journey. BMC Fam Pract [Internet]. 2020 [cited 2024 May 23]. 21(1):182. 10.1186/s12875-020-01254-2.
14. Goh LH, Siah CJR, Tam WWS, Tai ES, Young DYL. Effectiveness of the chronic care model for adults with type 2 diabetes in primary care: a systematic review and meta-analysis. Syst Rev [Internet]. 2022 [cited 2024 May 23]. 11(1):273. https://systematicreviewsjournal.biomedcentral.com/articles/10.1186/s13643-022-02117-w.
15. Hodgson S, Morgan-Harrisskitt J, Hounkpatin H, Stuart B, Dambha-Miller H. Primary care service utilisation and outcomes in type 2 diabetes: a longitudinal cohort analysis. BMJ Open [Internet]. 2022 [cited 2024 May 23]. 12(1):e054654. 10.1136/bmjopen-2021-054654.

16. Weeks G, George J, Maclure K, Stewart D. Non-medical prescribing versus medical prescribing for acute and chronic disease management in primary and secondary care. Cochrane Database Of Systematic Rev [Internet]. 2016 [cited 2024 May 23]. 2017(10). doi.10.1002/14651858.CD011227.pub2.
17. Anderson ZL, Scopelliti EM, Trompeter JM, Havrda DE. Management of prediabetes: a comparison of the treatment approaches utilized by a family practice clinic and an internal Medicine/Endocrinology practice. J Pharm Pract [Internet]. 2015 [cited 2024 May 23]. 28(1):86–92. 10.1177/0897190013514089.
18. Starfield B, Shi L, Macinko J. Contribution of primary care to health systems and health. Milbank Q [Internet]. 2005 [cited 2024 May 23]. 83(3):457–502. https://onlinelibrary.wiley.com/doi/10.1111/j.1468-0009.2005.00409.x.
19. Shi L. The impact of primary care: a focused review. Scientifica [Internet]. 2012 [cited 2024 May 23]. 2012:1–22. http://www.hindawi.com/journals/scientifica/2012/432892/.
20. For the EMPOWER-PAR Investigators, Ramli AS, Selvarajah S, Daud MH, Haniff J, Abdul-Razak S, Tg-Abu-Bakar-Sidik TM, Bujang MA, Chew BH, Rahman T, Tong SF, et al. Effectiveness of the EMPOWER-PAR intervention in improving clinical outcomes of type 2 diabetes mellitus in primary care: a pragmatic cluster randomised controlled trial. BMC Fam Pract [Internet]. 2016 [cited 2024 May 23]. 17(1):157. http://bmcfampract.biomedcentral.com/articles/10.1186/s12875-016-0557-1.
21. Perialathan K, Johari MZ, Jaafar N, Yuke Lin K, Lee Lan L, Sodri NA, Mohd Yunus SN, et al. Enhanced primary health care intervention: perceived sustainability and challenges among implementers. J Prim Care Community Health [Internet]. 2021 [cited 2024 May 23]. 12:215013272110140. http://journals.sagepub.com/doi/10.1177/21501327211014096.
22. Chew BH, Mohd-Yusof B-N, Lai PSM, Khunti K. Overcoming therapeutic inertia as the achilles' heel for improving suboptimal diabetes care: an integrative review. Endocrinol Metab [Internet]. 2023 [cited 2024 May 23]. 38(1):34–42. 10.3803/EnM.2022.1649.
23. Street RL, Haidet P. How well do doctors know their patients? Factors affecting Physician understanding of patients' health beliefs. J GEN Intern MED [Internet]. 2011 [cited 2024 Aug 6]. 26(1):21–27. 10.1007/s11606-010-1453-3.
24. Chikodiri Nwosu L, Iruoghene Edo G, Alpha Jalloh A. Mediating role of patient trust in the impact of perceived physician communication on treatment adherence and its implication in healthcare industry. SEHS [Internet]. 2023 [cited 2024 Aug 6]. 23050026. 23050026. doi:10.69598/sehs.17.23050026. https://li01.tci-thaijo.org/index.php/sehs/article/view/258977
25. Lucero KS, Larkin A, Zakharkin S, Wysham C, Anderson J. The impact of web-based continuing medical education using patient simulation on real-world treatment selection in type 2 diabetes: retrospective case-control analysis. JMIR Med Educ [Internet]. 2023 [cited 2024 Aug 6]. 9:e48586. 10.2196/48586.
26. Okemah J, Neunie S, Noble A, Wysham C. Impact on knowledge, competence, and performance of a faculty-led web-based educational activity for type 2 diabetes and obesity: questionnaire study among health care professionals and analysis of anonymized patient records. JMIR Form Res [Internet]. 2023 [cited 2024 Aug 6]. 7:e49115. 10.2196/49115.
27. Hariharan J, Fischer G, Simak D. "Comprehensive Care Model" for Diabetes within a Primary Care Clinic: Pre-Visit Planning, at-Visit efficiency, and inter-visit care. BMJ Qual Saf [Internet]. 2015 [cited 2024 Aug 6]. 24(11):729–30. 10.1136/bmjqs-2015-IHIabstracts.15.
28. Van Zyl DG, Rheeder P. Physician education programme improves quality of diabetes care. J Endocrinol, Metab And Diabetes Of South Africa [Internet]. 2005 [cited 2024 Aug 6]. 10(3):86–90. 10.1080/22201009.2005.10872126.
29. El Koussa M, Atun R, Bowser D, Kruk ME. Factors influencing physicians' choice of workplace: systematic review of drivers of attrition and policy interventions to address them. J Global Health [Internet]. 2016 [cited 2024 Aug 6]. 6(2):020403. http://www.jogh.org/documents/issue201602/jogh-06-020403.pdf.
30. Rees S, Williams A. Promoting and supporting self-management for adults living in the community with physical chronic illness: a systematic review of the effectiveness and meaningfulness of the patient-practitioner encounter. JBI Database Of Systematic Rev And Implementation Rep [Internet]. 2009 [cited 2024 Aug 6]. 7(13):492–582. http://journals.lww.com/01938924-200907130-00001.
31. Chew BH, Lee P-Y, Cheong A-T, Ismail M, Shariff-Ghazali S, Goh P-P. Messages from the Malaysian diabetes registries on diabetes Care in Malaysian public healthcare facilities. Primary Care Diabetes [Internet]. 2016 [cited 2024 May 23]. 10(5):383–86. https://linkinghub.elsevier.com/retrieve/pii/S1751991816300559.
32. Chandran A, Zakariah N. National diabetes registry report 2020. Putrajaya, Malaysia: Ministry of Health Malaysia; 2021.
33. Chan JCN, Lim L-L, Wareham NJ, Shaw JE, Orchard TJ, Zhang P, Lau ESH, Eliasson B, Kong APS, Ezzati M, et al. The lancet commission on diabetes: using data to transform diabetes care and patient lives. The Lancet [Internet]. 2020 [cited 2024 May 23]. 396(10267):2019–82. 10.1016/S0140-6736(20)32374-6. https://linkinghub.elsevier.com/retrieve/pii/S0140673620323746
34. Shanmuganathan S, Mustapha FI, Wilson A. Evaluating the sustainability of non-communicable diseases programs in Malaysia. BMC Public Health [Internet]. 2022 [cited 2024 May 23]. 22(1):1463. 10.1186/s12889-022-13891-6.
35. Mustapha FI, Aagaard-Hansen J, Lim SC, Nasir NH, Aris T, Bjerre-Christensen U. Variations in the delivery of primary diabetes care in Malaysia: lessons to Be learnt and potential for improvement. Health Serv Res And Managerial Epidemiol [Internet]. 2020 [cited 2024 May 23]. 7:233339282091874. 10.1177/2333392820918744.
36. Demiris G. Consumer health informatics: past, present, and future of a rapidly evolving Domain. Yearb Med Inf

[Internet]. 2016 [cited 2024 May 23]. 25(S 01):S42–7. 10.15265/IYS-2016-s005.
37. Del Prato S, Felton A-M, Munro N, Nesto R, Zimmet P, Zinman B. Improving glucose management: Ten steps to get more patients with type 2 diabetes to glycaemic goal: recommendations from the global partnership for effective diabetes management. Int J Clin Pract [Internet]. 2005 [cited 2024 May 23]. 59(11):1345–55. https://onlinelibrary.wiley.com/doi/10.1111/j.1742-1241.2005.00674.x.
38. Powell PW, Corathers SD, Raymond J, Streisand R. New approaches to providing individualized diabetes care in the 21st century. Curr Diabetes Rev. 2015;11 (4):222–30. doi:10.2174/1573399811666150421110316.
39. Busetto L, Luijkx KG, Elissen AMJ, Vrijhoef HJM. Context, mechanisms and outcomes of integrated care for diabetes mellitus type 2: a systematic review. BMC Health Serv Res [Internet]. 2015 [cited 2024 May 23]. 16(1):18. 10.1186/s12913-015-1231-3.
40. Konnyu KJ, Yogasingam S, Lépine J, Sullivan K, Alabousi M, Edwards A, Hillmer M, Karunananthan S, Lavis JN, Linklater S, et al. Quality improvement strategies for diabetes care: effects on outcomes for adults living with diabetes. Cochrane Database Of Systematic Rev [Internet]. 2023 [cited 2024 May 23]. 2023(6). http://doi.org/10.1002/14651858.CD014513.
41. Flood D, Hane J, Dunn M, Brown SJ, Wagenaar BH, Rogers EA, Heisler M, Rohloff P, Chopra V. Health system interventions for adults with type 2 diabetes in low- and middle-income countries: a systematic review and meta-analysis. PLoS Med [Internet]. 2020 [cited 2024 May 23]. 17(11):e1003434. https://doi.org/10.1371/journal.pmed.1003434.
42. Sivasampu S, Teh XR, Lim YMF, Ong SM, Ang SH, Husin M, Khamis N, Jaafar FSA, Wong WJ, Shanmugam S, et al. Study protocol on enhanced primary healthcare (EnPHC) interventions: a quasi-experimental controlled study on diabetes and hypertension management in primary healthcare clinics. Prim Health Care Res Dev [Internet]. 2020 [cited 2024 May 23]. 21:e27. 10.1017/S1463423620000250. https://www.cambridge.org/core/product/identifier/S1463423620000250/type/journal_article
43. Husin M, Teh XR, Ong SM, Lim YMF, Ang SH, Chan CL, Lim MT, Shanmugam S, Khamis N, Jaafar FSA, et al. The effectiveness of enhanced primary healthcare (EnPHC) interventions on type 2 diabetes management in Malaysia: difference-in-differences (DID) analysis. Primary Care Diabetes [Internet]. 2023 [cited 2024 May 23]. 17(3):260–66. 10.1016/j.pcd.2023.03.003. https://linkinghub.elsevier.com/retrieve/pii/S1751991823000645
44. Low LL, Rahim AB, Fi HN, Ismail MS. Process evaluation of enhancing primary health care for non-communicable disease management in Malaysia: uncovering the fidelity & feasibility elements. PLoS One [Internet]. 2021 [cited 2024 May 23]. 16(1):e0245125. https://doi.org/10.1371/journal.pone.0245125.
45. Wong WJ, Mohd Norzi A, Ang SH, Chan CL, Jaafar FSA, Sivasampu S. The effects of enhanced primary healthcare interventions on primary care providers' job satisfaction. BMC Health Serv Res [Internet]. 2020 [cited 2024 May 23]. 20(1):311. 10.1186/s12913-020-05183-9.
46. Chew BH, Vos RC, Fernandez A, Shariff Ghazali S, Shamsuddin NH, Ismail M, Rutten GEHM. The effectiveness of an emotion-focused educational programme in reducing diabetes distress in adults with type 2 diabetes mellitus at 12-month follow-up: a cluster randomized controlled trial. Ther Adv Endocrinol [Internet]. 2019 [cited 2024 May 23]. 10:204201881985376. http://journals.sagepub.com/doi/10.1177/2042018819853761.
47. Fitzpatrick C, Gillies C, Seidu S, Kar D, Ioannidou E, Davies MJ, Patel P, Gupta P, Khunti K. Effect of pragmatic versus explanatory interventions on medication adherence in people with cardiometabolic conditions: a systematic review and meta-analysis. BMJ Open [Internet]. 2020 [cited 2024 May 23]. 10(7):e036575. https://bmjopen.bmj.com/lookup/doi/10.1136/bmjopen-2019-036575.
48. Nieuwlaat R, Wilczynski N, Navarro T, Hobson N, Jeffery R, Keepanasseril A, Agoritsas T, Mistry N, Iorio A, Jack S, et al. Interventions for enhancing medication adherence. Cochrane Database Of Systematic Rev [Internet]. 2014 [cited 2024 May 23]. 2014(11). http://doi.org/10.1002/14651858.CD000011.pub4.
49. Slingerland AS, Herman WH, Redekop WK, Dijkstra RF, Jukema JW, Niessen LW. Stratified patient-centered care in type 2 diabetes. Diabetes Care [Internet]. 2013 [cited 2024 May 23]. 36(10):3054–61. https://diabetesjournals.org/care/article/36/10/3054/30516/Stratified-Patient-Centered-Care-in-Type-2.
50. Ortegon M, Lim S, Chisholm D, Mendis S. Cost effectiveness of strategies to combat cardiovascular disease, diabetes, and tobacco use in sub-saharan Africa and South East Asia: mathematical modelling study. BMJ [Internet] 2012 [cited 2024 May 23]. 344(mar02 1): e607–607. 10.1136/bmj.e607.
51. Powell RE, Zaccardi F, Beebe C, Chen XM, Crawford A, Cuddeback J, Gabbay RA, Kissela L, Litchman ML, Mehta R, et al. Strategies for overcoming therapeutic inertia in type 2 diabetes: a systematic review and meta-analysis. Diabetes Obes Metab [Internet]. 2021 [cited 2024 May 23]. 23(9):2137–54. https://dom-pubs.pericles-prod.literatumonline.com/doi/10.1111/dom.14455.
52. Bohmer RMJ. Leading clinicians and clinicians leading. N Engl J Med [Internet]. 2013 [cited 2024 May 23]. 368 (16):1468–70. 10.1056/NEJMp1301814.
53. Tan MY, Magarey J. Self-care practices of Malaysian adults with diabetes and sub-optimal glycaemic control. Patient Educ And Couns [Internet]. 2008 [cited 2024 May 23]. 72(2):252–67. https://linkinghub.elsevier.com/retrieve/pii/S0738399108001808.
54. Vaccaro O, Franzini L, Miccoli R, Cavalot F, Ardigò D, Boemi M, De Feo P, Reboldi G, Rivellese AA, Trovati M, et al. Feasibility and effectiveness in clinical practice of a multifactorial intervention for the reduction of cardiovascular risk in patients with type 2 diabetes. Diabetes Care [Internet]. 2013 [cited 2024 May 23]. 36(9):2566–72. 10.2337/dc12-1781. https://diabetesjournals.org/care/article/36/9/2566/37825/Feasibility-and-Effectiveness-in-Clinical-Practice
55. Terwee CB, Elders PJM, Blom MT, Beulens JW, Rolandsson O, Rogge AA, Rose M, Harman N,

Williamson PR, Pouwer F, et al. Patient-reported outcomes for people with diabetes: what and how to measure? A narrative review. Diabetologia [Internet]. 2023 [cited 2024 May 23]. 66(8):1357–77. https://doi.org/10.1007/s00125-023-05926-3.
56. Hermans MP, Elisaf M, Michel G, Muls E, Nobels F, Vandenberghe H, Brotons C. Benchmarking is associated with improved quality of care in type 2 diabetes. Diabetes Care [Internet]. 2013 [cited 2024 May 23]. 36(11):3388–95. https://diabetesjournals.org/care/article/36/11/3388/38003/Benchmarking-Is-Associated-With-Improved-Quality.
57. Segal L, Leach MJ, May E, Turnbull C. Regional primary care team to deliver best-practice diabetes care. Diabetes Care [Internet]. 2013 [cited 2024 May 23]. 36(7):1898–907. https://diabetesjournals.org/care/article/36/7/1898/33149/Regional-Primary-Care-Team-to-Deliver-Best.
58. Peers RL. Professionalism, and improvement — reframing the quality question. N Engl J Med [Internet]. 2022 [cited 2024 May 23]. 386(19):1850–54. http://www.nejm.org/doi/10.1056/NEJMms2200978.
59. Robson N, Hosseinzadeh H. Impact of telehealth care among adults living with type 2 diabetes in primary care: a systematic review and Meta-analysis of Randomised controlled trials. IJERPH [Internet] 2021 [cited 2024 May 23]. 18(22):12171. 10.3390/ijerph182212171.
60. Ceriello A, Prattichizzo F, Phillip M, Hirsch IB, Mathieu C, Battelino T. Glycaemic management in diabetes: old and new approaches. The Lancet Diabetes & Endocrinol [Internet]. 2022 [cited 2024 May 23]. 10(1):75–84. https://linkinghub.elsevier.com/retrieve/pii/S221385872100245X.
61. Chew BH, Fernandez A, Sazlina S-G. Psychological interventions for behavioral adjustments in diabetes care – a value-based approach to disease control. PRBM [Internet]. 2018 [cited 2024 May 23];Volume 11):145–55. https://www.dovepress.com/psychological-interventions-for-behavioral-adjustments-in-diabetes-car-peer-reviewed-article-PRBM.
62. Chew BH. Psychological aspects of diabetes care: effecting behavioral change in patients. WJD [Internet] 2014 [cited 2024 May 23]. 5(6):796. http://www.wjgnet.com/1948-9358/full/v5/i6/796.htm .
63. Khunti K, Gray LJ, Skinner T, Carey ME, Realf K, Dallosso H, Fisher H, Campbell M, Heller S, Davies MJ, et al. Effectiveness of a diabetes education and self management programme (DESMOND) for people with newly diagnosed type 2 diabetes mellitus: three year follow-up of a cluster randomised controlled trial in primary care. BMJ [Internet]. 2012 [cited 2024 May 23]. 344(apr26 2):e2333–2333. https://www.bmj.com/lookup/doi/10.1136/bmj.e2333.
64. Chew BH, Vos RC, Metzendorf M-I, Scholten RJ, Rutten GE. Psychological interventions for diabetes-related distress in adults with type 2 diabetes mellitus. Cochrane Database Of Systematic Rev [Internet]. 2017 [cited 2024 May 23]. 2017(10). doi.10.1002/14651858.CD011469.pub2.
65. Hu FB. Obesity in the USA: diet and lifestyle key to prevention. The Lancet Diabetes & Endocrinol [Internet]. 2023 [cited 2024 May 23]. 11(9):642–43. https://linkinghub.elsevier.com/retrieve/pii/S2213858723001948.
66. Egede LE, Walker RJ, Linde S, Campbell JA, Dawson AZ, Williams JS, Ozieh MN. Nonmedical interventions for type 2 diabetes: evidence, actionable strategies, and policy opportunities: review article examines type 2 diabetes nonmedical interventions. Health Aff [Internet]. 2022 [cited 2024 May 23]. 41(7):963–70. http://www.healthaffairs.org/doi/10.1377/hlthaff.2022.00236.
67. Gill JM, Chico TJ, Doherty A, Dunn J, Ekelund U, Katzmarzyk PT, Milton K, Murphy MH, Stamatakis E. Potential impact of wearables on physical activity guidelines and interventions: opportunities and challenges. Br J Sports Med [Internet]. 2023 [cited 2024 May 23]. 57(19):1223–25. https://bjsm.bmj.com/lookup/doi/10.1136/bjsports-2023-106822.
68. Wang W, Zhang J, Loban K, Wei X. High performing primary health care organizations from patient perspective: a qualitative study in China. Glob Health Res Policy [Internet]. 2023 [cited 2024 May 23]. 8(1):31. 10.1186/s41256-023-00315-0.
69. Rothman RL, Malone R, Bryant B, Shintani AK, Crigler B, Dewalt DA, Dittus RS, Weinberger M, Pignone MP. A randomized trial of a primary care-based disease management program to improve cardiovascular risk factors and glycated hemoglobin levels in patients with diabetes. The Am J Med [Internet]. 2005 [cited 2024 May 23]. 118(3):276–84. https://linkinghub.elsevier.com/retrieve/pii/S000293430400717X.
70. Boaz A, Hanney S, Jones T, Soper B. Does the engagement of clinicians and organisations in research improve healthcare performance: a three-stage review. BMJ Open [Internet]. 2015 [cited 2024 May 23]. 5(12):e009415. 10.1136/bmjopen-2015-009415.
71. Ganasegeran K, Hor CP, Jamil MFA, Suppiah PD, Noor JM, Hamid NA, Chuan DR, Manaf MRA, Ch'ng ASH, Looi I, et al. Mapping the scientific landscape of diabetes research in Malaysia (2000–2018): a systematic scientometrics study. IJERPH [Internet]. 2021 [cited 2024 May 23]. 18(1):318. https://www.mdpi.com/1660-4601/18/1/318.
72. Khunti K, Almalki M, Chan JCN, Amod A. The role of real-world evidence in treatment decision-making, regulatory assessment, and understanding the perspectives of people with type 2 diabetes: examples with Gliclazide MR. Diabetes Ther [Internet]. 2023 [cited 2024 May 23]. 14(10):1609–25. 10.1007/s13300-023-01458-6.
73. Tan MY, Magarey JM, Chee SS, Lee LF, Tan MH. A brief structured education programme enhances self-care practices and improves glycaemic control in malaysians with poorly controlled diabetes. Health Educ Res [Internet]. 2011 [cited 2024 May 23]. 26(5):896–907. 10.1093/her/cyr047.
74. Wasif Gillani S. Determining effective diabetic Care; a multicentre - longitudinal interventional study. CPD [Internet] 2017 [cited 2024 May 23]. 22(42):6469–76. 10.2174/1381612822666160813235704.

75. Ahmad Sharoni SK, Abdul Rahman H, Minhat HS, Shariff-Ghazali S, Azman Ong MH. The effects of self-efficacy enhancing program on foot self-care behaviour of older adults with diabetes: a randomised controlled trial in elderly care facility, Peninsular Malaysia. PLoS One [Internet] 2018 [cited 2024 May 23]. 13(3): e0192417. https://doi.org/10.1371/journal.pone.0192417.
76. Ayadurai S, Sunderland VB, Tee LBG, Md Said SN, Hattingh HL. Structured tool to improve clinical outcomes of type 2 diabetes mellitus patients: a randomized controlled trial: 改善2型糖尿病患者临床结果的结构化工具: 一项随机对照试? J Diabetes [Internet] 2018 [cited 2024 May 23]. 10(12):965–76. 10.1111/1753-0407.12799.
77. Alison C, Anselm S. The effectiveness of diabetes medication therapy adherence clinic to improve glycaemic control among patients with type 2 diabetes mellitus: a randomised controlled trial. Med J Malaysia. 2020;75:246–53.
78. Hashim SA, Mohd Yusof B-N, Abu Saad H, Ismail S, Hamdy O, Mansour AA. Effectiveness of simplified diabetes nutrition education on glycemic control and other diabetes-related outcomes in patients with type 2 diabetes mellitus. Clin nutr ESPEN [Internet]. 2021 [cited 2024 May 23]. 45:141–49. https://linkinghub.elsevier.com/retrieve/pii/S2405457721002795.
79. Ting CY, Ahmad Zaidi Adruce S, Lim CJ, Abd Jabar AHA, Ting RSK, Ting H, Osman NA, Ngau E, Talin BA, Muhammad M, et al. Effectiveness of a pharmacist-led structured group-based intervention in improving medication adherence and glycaemic control among type 2 diabetes mellitus patients: a randomized controlled trial. Res In Soc And Administrative Pharm [Internet]. 2021 [cited 2024 May 23]. 17(2):344–55. 10.1016/j.sapharm.2020.03.026. https://linkinghub.elsevier.com/retrieve/pii/S1551741119310265
80. Lee KW, Tan SF, Omar A, Nasir NH, Ching SM, Mohd Noor MK, Masdor NA, Lee YS, Noordin S, Mohamed H, et al. Effectiveness of system-based intervention in reducing incidence of type 2 diabetes and to improve the postnatal metabolic profiles in women with gestational diabetes mellitus: a randomized controlled study. Gynecological Endocrinol [Internet]. 2022 [cited 2024 May 23]. 38(1):55–62. https://www.tandfonline.com/doi/full/10.1080/09513590.2021.1988561 .
81. Gilcharan Singh HK, Chee WSS, Hamdy O, Mechanick JI, Lee VK, Barua A, Mohd Ali SZ, Hussein Z. Eating self-efficacy changes in individuals with type 2 diabetes following a structured lifestyle intervention based on the transcultural diabetes nutrition algorithm (tDNA): a secondary analysis of a randomized controlled trial. PLoS One [Internet]. 2020 [cited 2024 May 23]. 15(11): e0242487. https://doi.org/10.1371/journal.pone.0242487.
82. Hidrus A, Kueh YC, Norsa'adah B, Chang Y-K, Kuan G. Effects of technology-supported brain breaks videos on exercise self-efficacy among type 2 diabetes mellitus malaysians. Sci Rep [Internet]. 2022 [cited 2024 May 23]. 12(1):11651. https://www.nature.com/articles/s41598-022-15142-5.
83. Shyam S, Arshad F, Abdul Ghani R, Wahab NA, Safii NS, Nisak MYB, Chinna K, Kamaruddin NA. Low glycaemic index diets improve glucose tolerance and body weight in women with previous history of gestational diabetes: a six months randomized trial. Nutr J [Internet]. 2013 [cited 2024 May 23]. 12(1):68. http://nutritionj.biomedcentral.com/articles/10.1186/1475-2891-12-68.
84. Lee JY, Chan CKY, Chua SS, Ng CJ, Paraidathathu T, Lee KKC, Lee SWH. Telemonitoring and team-based management of glycemic control on people with type 2 diabetes: a cluster-randomized controlled trial. J GEN Intern MED [Internet]. 2020 [cited 2024 May 23]. 35 (1):87–94. https://doi.org/10.1007/s11606-019-05316-9.
85. Hanafiah AN, Aagaard-Hansen J, Ch Cheah J, Norris SA, Karim ZB, Skau JK, Ali ZM, Biesma R, Matzen P, Sulaiman LH, et al. Effectiveness of a complex, pre-conception intervention to reduce the risk of diabetes by reducing adiposity in young adults in Malaysia: the jom mama project – a randomised controlled trial. J Glob Health [Internet]. 2022 [cited 2024 May 23]. 12:04053. https://jogh.org/2022/jogh-12-04053.
86. Munsour EE, Awaisu A, Hassali MAA, Abdoun E, Dabbous Z, Zahran N, Ali H. The effect of tailored consumer medicine information on patients with type 2 diabetes mellitus: a randomised controlled interventional study. Int J Clin Pract [Internet]. 2020 [cited 2024 May 23]. 74(8). https://onlinelibrary.wiley.com/doi/10.1111/ijcp.13527.
87. Hidrus A, Kueh YC, Norsa'adah B, Chang Y-K, Kuan G. Effects of brain breaks video intervention of decisional balance among malaysians with type 2 diabetes mellitus: a randomised controlled trial. IJERPH [Internet] 2021 [cited 2024 May 23]. 18(17):8972. 10.3390/ijerph18178972.
88. Hidrus A, Kueh YC, Norsaádah B, Chang Y-K, Hung T-M, Naing NN, Kuan G. Effects of brain breaks videos on the motives for the physical activity of malaysians with type-2 diabetes mellitus. IJERPH [Internet]. 2020 [cited 2024 May 23]. 17(7):2507.https://www.mdpi.com/1660-4601/17/7/2507.
89. Edwards MA, Roy S. Academic research in the 21st Century: maintaining scientific integrity in a climate of perverse incentives and hypercompetition. Environ Eng Sci [Internet] 2017 [cited 2024 May 23]. 34 (1):51–61. 10.1089/ees.2016.0223.
90. Nylenna M, Simonsen S. Scientific misconduct: a new approach to prevention. The Lancet [Internet]. 2006 [cited 2024 May 23]. 367(9526):1882–84. https://linkinghub.elsevier.com/retrieve/pii/S0140673606688211.
91. Bradley SH, DeVito NJ, Lloyd KE, Richards GC, Rombey T, Wayant C, Gill PJ. Reducing bias and improving transparency in medical research: a critical overview of the problems, progress and suggested next steps. J R Soc Med [Internet]. 2020 [cited 2024 May 23]. 113(11):433–43. http://journals.sagepub.com/doi/10.1177/0141076820956799.
92. Phillips MR, Kaiser P, Thabane L, Bhandari M, Chaudhary V, Wykoff CC, Sivaprasad S, Sarraf D, Bakri SJ, Garg SJ, et al. Risk of bias: why measure it, and how? Eye [Internet]. 2022 [cited 2024 May 23]. 36

(2):346–48. 10.1038/s41433-021-01759-9. https://www.nature.com/articles/s41433-021-01759-9
93. Pannucci CJ, Wilkins EG. Identifying and avoiding bias in research: plastic and reconstructive surgery [Internet] Plast And Reconstructive Surg. 2010 [cited 2024 May 23]. 126(2):619–25. 10.1097/PRS.0b013e3181de24bc. http://journals.lww.com/00006534-201008000-00034
94. Lambert J. Statistics in brief: how to assess bias in clinical studies? Clin Orthop & Relat Res [Internet]. 2011 [cited 2024 May 23]. 469(6):1794–96. https://journals.lww.com/00003086-201106000-00039.
95. Nuzzo R. How scientists fool themselves – and how they can stop. Nat [Internet]. 2015 [cited 2024 May 23]. 526(7572):182–85. https://www.nature.com/articles/526182a.
96. Integrity in scientific research: creating an environment that promotes responsible conduct [internet]. Washington, D.C: National Academies Press; 2002 [cited 2024 May 23]. http://www.nap.edu/catalog/10430 .
97. Antes AL, Kuykendall A, DuBois JM. Leading for research excellence and integrity: a qualitative investigation of the relationship-building practices of exemplary principal investigators. Account In Res [Internet]. 2019 [cited 2024 May 23]. 26(3):198–226. 10.1080/08989621.2019.1611429.
98. Yarborough M. Moving towards less biased research. BMJ Open Sci [Internet]. 2021 [cited 2024 May 23]. 5 (1). http://access.portico.org/stable?au=phzkbvjfsmw.
99. Siena LM, Papamanolis L, Siebert MJ, Bellomo RK, Ioannidis JPA. Industry involvement and transparency in the most cited clinical trials, 2019-2022. JAMA Netw Open [Internet]. 2023 [cited 2024 May 23]. 6(11): e2343425. https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2811814 .
100. Sox HC, Rennie D. Seeding trials: just say "no". Ann Intern Med [Internet]. 2008 [cited 2024 May 23]. 149 (4):279. http://annals.org/article.aspx?doi=10.7326/0003-4819-149-4-200808190-00012.
101. Hardwicke TE, Ioannidis JPA. Mapping the universe of registered reports. Nat Hum Behav [Internet] 2018 [cited 2024 May 23]. 2(11):793–96. https://www.nature.com/articles/s41562-018-0444-y.
102. Benedictus R, Miedema F, Ferguson MWJ. Fewer numbers, better science. Nature [Internet] 2016 [cited 2024 May 23]. 538(7626):453–55. https://www.nature.com/articles/538453a.
103. Rice DB, Raffoul H, Ioannidis JPA, Moher D. Academic criteria for promotion and tenure in biomedical sciences faculties: cross sectional analysis of international sample of universities. BMJ [Internet]. 2020 [cited 2024 May 23]. m2081. https://www.bmj.com/lookup/doi/10.1136/bmj.m2081.
104. Sox HC, Schuster MA. Criteria for academic promotion in medicine. BMJ [Internet]. 2020 [cited 2024 May 23. m2253. https://www.bmj.com/lookup/doi/10.1136/bmj.m2253.
105. National Academies of Sciences, Engineering, and Medicine. Fostering integrity in research. Washington (DC): The National Academies Press; 2017. https://doi.org/10.17226/21896.
106. Moher D, Bouter L, Kleinert S, Glasziou P, Sham MH, Barbour V, Coriat A-M, Foeger N, Dirnagl U. The Hong Kong Principles for assessing researchers: fostering research integrity. PLoS Biol [Internet]. 2020 [cited 2024 May 23]. 18(7):e3000737. https://doi.org/10.1371/journal.pbio.3000737.
107. Kilkenny C, Browne WJ, Cuthill IC, Emerson M, Altman DG. Improving bioscience research reporting: the ARRIVE guidelines for reporting animal research. PLoS Biol [Internet]. 2010 [cited 2024 May 23]. 8(6): e1000412. 10.1371/journal.pbio.1000412.
108. Chew BH. Planning and conducting clinical research: the whole process. Cureus [Internet]. 2019 [cited 2024 May 3]. https://www.cureus.com/articles/17094-planning-and-conducting-clinical-research-the-whole-process.
109. Martinez-Campos M. Ten Tips for teaching research integrity to early career students: a perspective over 20 years. Front Res Metr Anal [Internet]. 2022 [cited 2024 May 23]. 7:989668. https://www.frontiersin.org/articles/10.3389/frma.2022.989668/full.
110. Grobbee DE, Hoes AW. Clinical epidemiology: principles, methods, and applications for clinical research. 2nd ed. USA: Jones & Bartlett Publishers; 2014.
111. Vayena E, Blasimme A, Cohen IG. Machine learning in medicine: addressing ethical challenges. PLoS Med [Internet] 2018 [cited 2024 May 23]. 15(11):e1002689. 10.1371/journal.pmed.1002689.
112. Haug CJ, Drazen JM, Drazen JM, Kohane IS, Leong T-Y. Artificial intelligence and machine learning in clinical medicine, 2023. N Engl J Med [Internet]. 2023 [cited 2024 May 23]. 388(13):1201–08. http://www.nejm.org/doi/10.1056/NEJMra2302038.
113. Thirunavukarasu AJ, Ting DSJ, Elangovan K, Gutierrez L, Tan TF, Ting DSW. Large language models in medicine. Nat Med [Internet]. 2023 [cited 2024 May 23]. 29(8):1930–40. https://www.nature.com/articles/s41591-023-02448-8.
114. He J, Baxter SL, Xu J, Xu J, Zhou X, Zhang K. The practical implementation of artificial intelligence technologies in medicine. Nat Med [Internet]. 2019 [cited 2024 May 23]. 25(1):30–36. https://www.nature.com/articles/s41591-018-0307-0.
115. Lancet Digital Health T, The Lancet Digital Health. Holding artificial intelligence to account. The Lancet Digit Health [Internet]. 2022 [cited 2024 May 23]. 4 (5):e290. 10.1016/S2589-7500(22)00068-1. https://linkinghub.elsevier.com/retrieve/pii/S2589750022000681
116. Lee P, Bubeck S, Benefits PJ. Limits, and risks of GPT-4 as an AI chatbot for medicine. N Engl J Med [Internet]. 2023 [cited 2024 May 23]. 388(13):1233–39. http://www.nejm.org/doi/10.1056/NEJMsr2214184.
117. World Health Organization. WHO guideline: recommendations on digital interventions for health system strengthening [internet]. Geneva: World Health Organization; 2019 [cited 2024 May 23]. https://iris.who.int/handle/10665/311941.
118. Shan R, Sarkar S, Martin SS. Digital health technology and mobile devices for the management of diabetes mellitus: state of the art. Diabetologia [Internet]. 2019

[cited 2024 May 23]. 62(6):877–87. 10.1007/s00125-019-4864-7.
119. Wu Y, Yao X, Vespasiani G, Nicolucci A, Dong Y, Kwong J, Li L, Sun X, Tian H, Li S, et al. Mobile app-based interventions to support diabetes self-management: a systematic review of randomized controlled trials to identify functions associated with glycemic efficacy. JMIR Mhealth Uhealth [Internet]. 2017 [cited 2024 May 23]. 5(3):e35. 10.2196/mhealth.6522.
120. Adu MD, Malabu UH, Malau-Aduli AEO, Malau-Aduli BS. Users' preferences and design recommendations to promote engagements with mobile apps for diabetes self-management: multi-national perspectives. PLoS One [Internet] 2018 [cited 2024 May 23]. 13(12): e0208942. https://doi.org/10.1371/journal.pone.0208942.
121. Källander K, Tibenderana JK, Akpogheneta OJ, Strachan DL, Hill Z, ten Asbroek AHA, Conteh L, Kirkwood BR, Meek SR. Mobile health (mHealth) approaches and lessons for increased performance and retention of community health workers in low- and middle-income countries: a review. J Med Internet Res [Internet]. 2013 [cited 2024 May 23]. 15(1):e17. http://www.jmir.org/2013/1/e17/.
122. Agarwal P, Mukerji G, Desveaux L, Ivers NM, Bhattacharyya O, Hensel JM, Shaw J, Bouck Z, Jamieson T, Onabajo N, et al. Mobile app for improved self-management of type 2 diabetes: multicenter pragmatic randomized controlled trial. JMIR Mhealth Uhealth [Internet]. 2019 [cited 2024 May 23]. 7(1): e10321. 10.2196/10321.
123. Brahmbhatt R, Niakan S, Saha N, Tewari A, Pirani A, Keshavjee N, Mugambi D, Alavi N, Keshavjee K. Diabetes mHealth apps: designing for greater uptake. Stud Health Technol Inf. 2017;234:49–53.
124. Bonoto BC, De Araújo VE, Godói IP, de Lemos LLP, Godman B, Bennie M, Diniz LM, Junior AAG. Efficacy of Mobile apps to support the care of patients with diabetes mellitus: a systematic review and Meta-analysis of randomized controlled trials. JMIR Mhealth Uhealth [Internet]. 2017 [cited 2024 May 23]. 5(3):e4. http://mhealth.jmir.org/2017/3/e4/ .
125. Beam AL, Drazen JM, Kohane IS, Leong T-Y, Manrai AK, Rubin EJ. Artificial intelligence in medicine. N Engl J Med [Internet]. 2023 [cited 2024 May 23]. 388(13):1220–21. 10.1056/NEJMe2206291.
126. Rajkomar A, Dean J, Kohane I. Machine learning in medicine. N Engl J Med [Internet]. 2019 [cited 2024 May 23]. 380(14):1347–58. 10.1056/NEJMra1814259.
127. U.S. Food and Drug Administration. Artificial intelligence and machine learning (ai/ml)-enabled medical devices [Internet]. 2024 [cited 2024 May 23]. https://www.fda.gov/medical-devices/software-medical-device-samd/artificial-intelligence-and-machine-learning-aiml-enabled-medical-devices .
128. Mehta N, Pandit A, Shukla S. Transforming healthcare with big data analytics and artificial intelligence: a systematic mapping study. J Biomed Inf [Internet]. 2019 [cited 2024 Mar 20]. 100:103311. https://linkinghub.elsevier.com/retrieve/pii/S1532046419302308 .
129. Ngiam KY, Khor IW. Big data and machine learning algorithms for health-care delivery. The Lancet Oncol [Internet]. 2019 [cited 2024 Mar 20]. 20(5):e262–73. https://linkinghub.elsevier.com/retrieve/pii/S1470204519301494.
130. Lysaght T, Lim HY, Xafis V, Ngiam KY. AI-Assisted decision-making in healthcare: the application of an ethics framework for big data in health and research. ABR [Internet]. 2019 [cited 2024 Mar 20]. 11 (3):299–314. 10.1007/s41649-019-00096-0.
131. Perlis RH, Fihn SD. Evaluating the application of large language models in clinical research contexts. JAMA Netw Open [Internet]. 2023 [cited 2024 May 23]. 6(10): e2335924. https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2809977.
132. Clark P, Kim J, Aphinyanaphongs Y. Marketing and US food and drug administration clearance of artificial intelligence and machine learning enabled software in and as medical devices: a systematic review. JAMA Netw Open [Internet]. 2023 [cited 2024 May 23]. 6(7): e2321792. https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2806839.
133. Bakker L, Aarts J, Uyl-de Groot C, Redekop K. How can we discover the most valuable types of big data and artificial intelligence-based solutions? A methodology for the efficient development of the underlying analytics that improve care. BMC Med Inf Decis Mak [Internet]. 2021 [cited 2024 Mar 20]. 21(1):336. 10.1186/s12911-021-01682-9.
134. Tan M, Lee H, Wang D, Subramonyam H. Is a seat at the table enough? Engaging teachers and students in dataset specification for ML in education. 2023 [cited 2024 Apr 3]. https://arxiv.org/abs/2311.05792.
135. Ng FYC, Thirunavukarasu AJ, Cheng H, Tan TF, Gutierrez L, Lan Y, Ong JCL, Chong YS, Ngiam KY, Ho D, et al. Artificial intelligence education: an evidence-based medicine approach for consumers, translators, and developers. Cell Rep Med [Internet]. 2023 [cited 2024 Mar 20]. 4(10):101230. 10.1016/j.xcrm.2023.101230. https://linkinghub.elsevier.com/retrieve/pii/S266637912300407X
136. Whicher D, Rapp T. The value of artificial intelligence for healthcare decision making—lessons learned. Value In Health [Internet]. 2022 [cited 2024 Mar 20]. 25 (3):328–30. https://linkinghub.elsevier.com/retrieve/pii/S1098301522000122.
137. Cohen IG, Evgeniou T, Gerke S, Minssen T. The European artificial intelligence strategy: implications and challenges for digital health. The Lancet Digit Health [Internet]. 2020 [cited 2024 Mar 20]. 2(7): e376–9. https://linkinghub.elsevier.com/retrieve/pii/S2589750020301126.
138. Klonoff DC. The current status of mHealth for diabetes: will it Be the next big thing? J Diabetes Sci Technol [Internet]. 2013 [cited 2024 May 23]. 7(3):749–58. 10.1177/193229681300700321.
139. Zeitoun J-D, Ravaud P. Artificial intelligence in health care: value for whom? The Lancet Digit Health [Internet]. 2020 [cited 2024 Mar 20]. 2(7):e338–9. https://linkinghub.elsevier.com/retrieve/pii/S2589750020301412.

140. Chew BH, Maxwell L, Anyiam FE, Menouni A, Kurniawan TA, Dimobe K, Sharma Tp P, Ali GAM, Tachamo Shah RD, et al. Statements on open science for sustainable development goals. CODATA [Internet]. 2024 [cited Aug 27]. 23:8. 10.5334/dsj-2024-049. https://datascience.codata.org/articles/10.5334/dsj-2024-049.
141. UNESCO, Canadian National Commission for UNESCO. An introduction to the UNESCO recommendation on open science [Internet]. UNESCO; 2022 [cited 2024 May 23]. https://unesdoc.unesco.org/ark:/48223/pf0000383771.
142. European Commission. Directorate general for research and innovation. Open science and intellectual property rights: how can they better interact?: state of the art and reflections: executive summary. [Internet]. LU: Publications Office; 2022 [cited 2024 May 23]. https://data.europa.eu/doi/10.2777/347305.
143. Chakravorty N, Sharma CS, Molla KA, Pattanaik JK. Open science: challenges, possible solutions and the way forward. ProcIndian Natl Sci Acad [Internet]. 2022 [cited 2024 May 23]. 88(3):456–71. https://doi.org/10.1007/s43538-022-00104-2.
144. Wilkinson MD, Dumontier M, IjJ A, Appleton G, Axton M, Baak A, Blomberg N, Boiten J-W, da Silva Santos LB, Bourne PE, et al. The FAIR guiding principles for scientific data management and stewardship. Sci Data [Internet]. 2016 [cited 2024 May 23]. 3(1):160018. https://www.nature.com/articles/sdata201618 .
145. Global Indigenous Data Alliance (GIDA). CARE Principles for Indigenous Data Governance. https://www.gida-global.org/care.
146. Sauerbrei A, Kerasidou A, Lucivero F, Hallowell N. The impact of artificial intelligence on the person-centred, doctor-patient relationship: some problems and solutions. BMC Med Inf Decis Mak [Internet]. 2023 [cited 2024 Mar 26]. 23(1):73. https://bmcmedinformdecismak.biomedcentral.com/articles/10.1186/s12911-023-02162-y.
147. Of California U, Francisco S, Adler-Milstein J, Aggarwal N, Evans BJ, Gonzalez AA, James CA, Lin S, Mandl KD, Matheny ME, et al. Meeting the moment: addressing barriers and facilitating clinical adoption of artificial intelligence in medical diagnosis. NAM Perspectives [Internet]. 2022 [cited 2024 Mar 21]. 22 (9). https://nam.edu/meeting-the-moment-addressing-barriers-and-facilitating-clinical-adoption-of-artificial-intelligence-in-medical-diagnosis.
148. Trinkley KE, An R, Maw AM, Glasgow RE, Brownson RC. Leveraging artificial intelligence to advance implementation science: potential opportunities and cautions. Implementation Sci [Internet]. 2024 [cited 2024 Apr 1]. 19(1):17. https://implementationscience.biomedcentral.com/articles/10.1186/s13012-024-01346-y.
149. UNESCO. Ethical impact assessment. A tool of the recommendation on the ethics of artificial intelligence [Internet]. UNESCO; 2023 [cited 2024 Apr 19]. https://unesdoc.unesco.org/ark:/48223/pf0000386276.
150. Djulbegovic B, Bennett CL, Guyatt G. Failure to place evidence at the centre of quality improvement remains a major barrier for advances in quality improvement. Evaluation Clin Pract [Internet]. 2019 [cited 2024 May 23]. 25(3):369–72. 10.1111/jep.13146.