

DIABETES TASKFORCE REPORT

Contents

AIM	1
BACKGROUND	1
CURRENT LANDSCAPE	2
<i>International Landscape</i>	2
<i>Industry Interest</i>	3
RESEARCH FOCUS AREAS	4
<i>Microvascular Complications of Diabetes</i>	4
<i>Primary Prevention of Diabetes</i>	5
ELABORATION OF THE PROPOSED THEMES FOR THE OPEN FUND – LARGE COLLABORATIVE GRANTS	5
<i>Microvascular Complications of Diabetes</i>	5
<i>Primary Prevention of Diabetes</i>	7
FIVE-YEAR ROAD MAP FOR DIABETES RESEARCH IN SINGAPORE	8
CONCLUSION	12
ANNEX	13

HBMS DIABETES TASKFORCE: FINAL REPORT

AIM

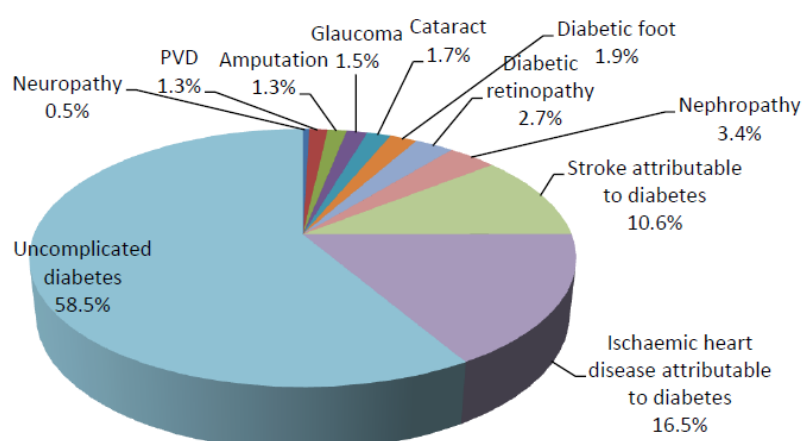
1. This report outlines the recommendations of the Diabetes Taskforce, which includes an overview of the diabetes research landscape, proposed focus areas and desired outcomes of diabetes research in Singapore.

BACKGROUND

2. Type 2 diabetes (T2D) is reaching epidemic proportions in Asia. In 2013, the number of people living with diabetes in Asia-Pacific was 210 million (M) and by 2035, the number is expected to grow to 325M. The percentage of undiagnosed cases in Southeast Asia (49%) is higher than the global average (46%).

3. In 2012, diabetes was the largest single cause of total burden of disease in our resident population, accounting for 10.4% of total DALYs¹. With the inclusion of the burden of cardiovascular diseases attributable to diabetes, the burden increased to approximately 14% of total DALYs. Diabetes burden (% share of DALYs) by specific cause can be found in the Figure 1 below.

Figure 1: Diabetes burden by specific cause



4. The National Steering Committee on Diabetes², formed in 2013, proposed three areas for research³:

- a. Health services delivery;
- b. Behavioural insights; and
- c. Medical treatment.

¹ Disability-adjusted life year (DALY) is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death.

² The National Steering Committee on Diabetes reviews and advises on strategies and initiatives for improving health outcomes for diabetic patients, and the reduction of the prevalence of diabetes in the Singapore population.

³ Presentation by Dr Jeannie Tey at the DTF workshop on 14 Nov 2015.

5. In October 2015, the Health and Biomedical Sciences (HBMS) Diabetes Taskforce (DTF) was formed to conduct a stocktake of the current state of diabetes research, and develop a health outcomes-driven five-year plan for diabetes research in Singapore. The composition of the DTF is in **Annex A**.

6. Subsequently, the DTF engaged investigators working on diabetes and its complications to develop a plan for the future direction of diabetes research in Singapore. The need to develop scalable, cost-effective means of delivering intensive multi-factorial risk factor controls to prevent the onset of diabetes and its progression with associated complications was highlighted. Two overarching themes of research focus were identified from the meeting: (1) Primary Prevention of Diabetes and (2) Complications of Diabetes.

CURRENT LANDSCAPE

7. Singapore has invested in metabolic diseases research in a sustained manner over the last 10 years. Singapore has a significant number of researchers working in the area of diabetes and its complications. In addition to research on disease aetiology and implementation sciences, there is also a strong base of supporting capabilities, such as in bioinformatics, material engineering and stem cell research. A number of research cohorts to support diabetes research have also been assembled over the years. Some cohorts may not have been specific to diabetes research, but provide useful longitudinal data relevant for various diabetes-related studies.

International Landscape

8. In Europe, the **Innovative Medicines Initiative (IMI)** is the world's largest private–public partnership (PPP) in the life sciences, and was co-funded by the Horizon 2020 initiative and the European Federation of Pharmaceutical Industries and Associations (EFPIA). Within the IMI, there is a Diabetes Platform comprising three projects which aims to investigate:

- a. Therapies to slow down progression of diabetes with a focus on pancreatic beta-cells;
- b. Patient stratification to determine best treatment options for each patient; and
- c. Therapy of late-stage micro- and macrovascular complications.

9. In the United States, the **National Institutes of Health (NIH) Accelerating Medicines Partnership (AMP)** was set up as a PPP between the NIH, FDA, several biopharmaceutical companies and multiple non-profit organisations to transform the current model for developing new diagnostics and treatments by jointly identifying and validating promising biological targets for therapeutics. The goal is to reduce the time and cost of developing these novel diagnostic and intervention methods. The programme was launched in 2014 with focus areas in Alzheimer's disease, T2D and systemic lupus erythematosus.

10. Also in the United States, the **National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK)** was established to support basic, clinical and translational research to combat diabetes and its associated complications through both intramural funding of its own researchers and extramural funding. Research

topics set up under the NIDDK included areas such as studying genetic and environmental factors that contribute to the development and progression of diabetes, newer and more convenient methods to prevent, diagnose, monitor and empower patients to self-manage diabetes.

11. The aforementioned programmes pay scant attention to how healthcare for patients with diabetes should be implemented in order to reduce healthcare expenditure and to address the impact of the aging population on the available workforce in Singapore. By having a strong focus on evaluating and developing models of care to optimise outcomes in our population, leveraging new technologies and improving patient engagement, Singapore could design a programme to specifically address this crisis in healthcare in a cost-effective manner. Our healthcare system also has some unique characteristics, which, along with the differences in culture and values between populations in Asia as compared to those in Europe or the United States, make for a need to adapt the systems to fit in Singapore.

12. In relation to complications in diabetes, Singapore is uniquely poised to compete effectively in this therapeutic area, by taking advantage of some of the highest complication rates in the world, and a population which represents (in some form or another), up to two thirds of the worlds' population.

Industry Interest

13. The global T2D market is projected to triple in value from US\$17.4B in 2013 to US\$45.3B in 2022, with a compound annual growth rate (CAGR) of 11.22%⁴. This is due to the increase in disease prevalence, as well as growth in the elderly and obese populations. However, given the availability of low-cost generic medications to reduce glucose levels, novel hypoglycaemic agents need to be differentiated from existing drugs by having additional benefits over and above glucose lowering. Medications which could improve rates of complications independent of their glucose-lowering effects are also of value.

14. In particular, the global Microvascular Complications of Diabetes (MCD) market is projected to double to US\$6.4B in 2022 at a CAGR of 5.8%. The market for diabetes-associated chronic kidney disease/end-stage renal disease (CKD/ESRD) is expected to grow rapidly, reaching US\$1.8B at a CAGR of 16%⁵. The main driver of the huge growth potential of the MCD market is the increase in prevalence of T2D and the very high cost of treating patients with CKD/ESRD. In addition, there have been no new therapies (since the advent of renin–angiotensin blockers) that retard diabetes associated CKD/ESRD for over 20 years, presenting a huge opportunity for investment by the pharmaceutical industry.

15. In the last two years, the Singapore diabetes community hosted multiple visits and received enquiries from pharmaceutical companies with a keen interest in T2D, particularly in MCD research. This represents industry's strategy of developing a better understanding of the disease aetiology as well as better clinical trial design in relation to MCD. Finally, a number of PPPs are in active development in the area of diabetes research, including an attempt to establish joint laboratories in Singapore.

⁴ DataMonitor Healthcare 2014.

⁵ Research and Markets 2013.

RESEARCH FOCUS AREAS

16. To maximise the use of research funds, there is a need to focus Singapore's research on areas that can have the greatest impact. The DTF recommends focusing on two areas of research for the Open Fund – Large Collaborative Grant (OF-LCG):

- a. Microvascular Complications of Diabetes; and
- b. Primary Prevention of Diabetes.

17. A large part of the investment in research related to diabetes and metabolic disease in Singapore has been focused on the very upstream portions of prevention (childhood and pre-gestational factors) and not on the prevention of diabetes in adults, in whom most cases of diabetes and its complications are going to develop over the next 1–2 decades. Lifestyle modification has been shown to reduce the incidence of diabetes by as much as 50% in these individuals. Similarly, multifactorial interventions targeting multiple risk factors for diabetes complications have been shown to reduce the incidence of all complications by up to 50%. Extending results from clinical trials to real-life interventions in the broader community requires effective methods to identify the at-risk group and maintain the fidelity of the intervention. To date, significant reduction in the effectiveness of interventions has been reported when programmes utilised in clinical trials are scaled up. It is also likely that local and cultural factors will modify the effectiveness of such interventions.

18. After considering factors such as disease burden and impact, concentration of local expertise, and potential for unique Singaporean research contributions (as described below), the DTF suggests that the complications theme be given highest priority.

Microvascular Complications of Diabetes

19. Forty-two percent of the burden of disease for diabetes is associated with complications. If we are to address the healthcare expenditure of diabetes in the short- to mid-term, we must improve the effectiveness of care to prevent the onset and progression of complications.

20. Although diabetes-associated CKD/ESRD accounts for only 3.4% of the burden of disease attributable to diabetes, it has a major impact on healthcare costs. Of all the diabetes related complications, kidney disease is the costliest. These patients also accounted for over one third of the total bed days used by diabetic patients with complications that year. The next one third was utilised by patients with cardiovascular disease and stroke. In this regard, the presence of diabetes associated CKD itself confers significant cardiovascular risk that is independent of conventional risk factors.

21. In addition to hospitalisation, the high cost of diabetes associated CKD/ESRD also relates to the need for dialysis. In 2013, 1,436 patients per million were receiving dialysis, up from 760 in 1999. This has doubled in only 15 years⁶. Each year, approximately 400 patients per million reach ESRD and 250 are initiated on dialysis.

⁶ Singapore Renal Registry Annual Registry Report 1999–2013; National Registry of Diseases Office, released 8 Oct 2014: <https://www.nrdo.gov.sg/docs/librariesprovider3/Publications---Kidney-Failure/singapore-renal-registry-annual-registry-report-1999-2013-preliminary.pdf?sfvrsn=0&AspxAutoDetectCookieSupport=1> accessed 9 Jan 2016.

The majority of these new cases are due to T2D. In fact, Singapore has the highest proportion of incident ESRD due to diabetes (>60%) of 42 countries for which data is available worldwide⁷. Given the extremely high cost associated with diabetes-associated CKD/ESRD, the likelihood of any therapy, even if it only retards the progression of ESRD by a few years, has a very good chance of being cost-effective or even cost-saving. As such, there is great interest from the pharmaceutical industry to develop novel therapies that have efficacy in the prevention and retardation of diabetes associated CKD/ESRD. This is one of several factors behind the DTF's recommendation to prioritise Microvascular Complications for the OF-LCG.

22. For specific research areas in microvascular complications, clinical discovery was thought to have the greatest potential. This should be followed closely by research on prevention and treatment of complications, along with application of novel digital monitoring technologies.

Primary Prevention of Diabetes

23. A large portion of the disease burden associated with diabetes in Singapore (58%) relates to just living with diabetes. Therefore, reducing the burden of disease related to diabetes must involve the prevention of diabetes.

24. In Singapore, nearly 40% of males born between 1981 and 1992 will become diabetic by age 65. Prevalence of T2D in Singapore adults aged 18–69 will double from 7.3% in 1990 to 15% in 2050. In fact, prevalence of diabetes among adults in Singapore was higher than the OECD average (9.8 vs. 6.9). Another pertinent issue with diabetes in Singapore is that an estimated 50% of diabetes in Singapore remains undiagnosed⁸.

25. Similar to complications associated with diabetes, the DTF has also completed a prioritisation of research areas for the primary prevention of diabetes. A detailed elaboration of the rationale and considerations would be addressed in the following sections.

ELABORATION OF THE PROPOSED THEMES FOR THE OPEN FUND – LARGE COLLABORATIVE GRANTS

Microvascular Complications of Diabetes

26. Complications due to diabetes are a major source of morbidity and mortality in patients with diabetes, and vascular complications are a particular problem resulting in many bed-years of hospitalisation and a large proportion of healthcare costs. Moreover, rates of diabetes complications are very high in Singapore compared with other developed countries. In this regard, a four-fold increase in the prevalence of complications due to diabetes, such as CKD/ESRD, stroke and cardiovascular disease, is projected in Singapore by 2050.

⁷ United States Renal Data System: International Comparison: http://www.usrds.org/2013/view/v2_12.aspx accessed on 9 Jan 2016.

⁸ National Health Survey 2010: https://www.moh.gov.sg/content/moh_web/home/Publications/Reports/2011/national_health_survey2010.html accessed on 9 Jan 2016.

27. The vascular complications of diabetes can be divided into small vessel (microvascular) and larger vessel (macrovascular) disease. The microvascular lesions constitute the underlying pathology in diabetes associated CKD/ESRD and retinopathy, and are pathognomonic for diabetes. Because of their intimate association with diabetes, their contribution to a spectrum of complications related to diabetes, and the existing research expertise and interest in microvascular complications within Singapore, the DTF is recommending a *primary* research focus of the OF-LCG on *Microvascular Complications of Diabetes*.

28. We believe there is a high likelihood for impact of this research in the projected timeline due to the large number of individuals at risk for development of complications in the next decade and the substantial unmet needs in this area. Examples of specific unmet needs include:

- a. Unknown precise pathogenesis of microvascular complications in diabetes;
- b. Poor uptake of established preventive strategies;
- c. Unexplained substantial associated cardiovascular risk;
- d. Poorly understood susceptibility factors, such as genetics; and
- e. The desperate need for new approaches to prevention and treatment of complications due to diabetes.

29. In line with recommendations by the National Steering Committee on Diabetes, one potential area of focus might be patient stratification and engagement, with the goals of improving effectiveness and reducing costs of healthcare delivery. Possible examples might include:

- a. Testing intervention programmes in patients at high risk for diabetes associated CKD/ESRD, including the development of novel tools for stratification;
- b. Using technology and incentives to promote adherence to lifestyle modification and medication;
- c. Rigorous evaluation of ongoing systems-level interventions including the Nephrology Evaluation Management and Optimisation (NEMO) Programme and the Singapore Integrated Diabetic Retinopathy Programme (SIDRP); and
- d. Development or scaling of new systems-level interventions and their evaluation.

30. In relation to para. 28(e), there is substantial pharmaceutical interest in development of new therapies for complications of diabetes, especially in CKD/ESRD. In addition, it should be noted that the skill sets involved in the activities stated below are similar to those proposed in the section on primary prevention of diabetes. Therefore, prioritisation of preventing the microvascular complications of diabetes will engage the larger diabetes community, including those involved in prevention of diabetes.

31. The theme related to the prevention of microvascular complications of diabetes might also include some issues of specific relevance to diabetes associated CKD/ESRD and eye disease. These could include:

- a. Developing new pharmacological approaches for slowing or reversing progression of diabetic nephropathy; and

- b. Identifying and testing new drug targets for the treatment of patients with microvascular complications.

Targets

- **Reduce blindness and ESRD due to diabetes by 30% within 10 years in the national population.**
- **Reduce diabetic microvascular complications by 30% within five years in study populations.**
- **Due to the overlapping risk factors and causes, it is expected that interventions reducing eye and ESRD will also have a significant effect in reducing other complications such as cardiovascular disease.**

Primary Prevention of Diabetes

32. The second thematic area recommended as a research priority by the DTF is the primary prevention and detection of diabetes. We suggest that this topic would be appropriate if there is a second OF-LCG call focused on diabetes. In addition, this could be an important focus to be supported by other funding mechanisms in RIE2020 directed towards the area of diabetes.

33. This research would directly address the rising incidence of diabetes and the relatively large number of Singaporeans who have diabetes but are not aware of it. Research to develop an effective diabetes prevention programme must address many questions, starting with what is the relative value of campaigns directed at populations versus individually targeted interventions.

34. There is currently much more evidence for the efficacy of targeted interventions. For targeted interventions, issues for researchers to consider would include:

- a. How to determine what is sufficient risk to warrant individual intervention?
- b. How to identify those above this risk threshold?
- c. What specific lifestyle interventions would be effective Singapore?
- d. How can effective interventions be scaled up to a population level?
- e. Who should deliver the intervention?
- f. What kind of training is required?
- g. How should a national programme be monitored?
- h. How will effectiveness be determined?
- i. How will the interventions be implemented in the real world?

35. Some specific sub-themes could include:

- a. Comparison between high-risk and population-based primary prevention programmes;
- b. Evaluation of current high-risk intervention programmes (e.g. pre-diabetics and family members of diabetics);
- c. Development of new interventions for high-risk groups (e.g. women with gestational diabetes);
- d. Evaluation of current systems-level interventions (e.g. Healthy Hawker Programme, Total Workplace Safety and Health, etc.);
- e. Development of new systems-level interventions;

- f. Development of programmes to reduce the number of undiagnosed diabetics;
- g. The use of technology and incentives to promote healthy living; and
- h. Development of nutritional strategies centred on Asian diets as interventions.

Targets

- **Reduce the incidence of diabetes by 20% by 2030.**
- **Reduce the proportion of undiagnosed diabetics to 30% (currently 50%) by 2025.**
- **Reduce the progression of gestational diabetes to T2D by 30% by 2025.**

FIVE-YEAR ROADMAP FOR DIABETES RESEARCH IN SINGAPORE

36. In this proposal, the DTF recommends two main areas of focus for diabetes R&D efforts in Singapore, namely: (1) microvascular complications associated with diabetes and (2) development of strategies for the prevention of diabetes.

37. Research in either area of focus can leverage efforts and outcomes arising from the other. For example, work done in relation to microvascular complications, which will generate new strategies, technologies and insights (e.g. e-health and patient engagement), can also be applicable for the primary prevention effort. We recommend that primary prevention be considered as a theme for a future OF-LCG call. In addition, there should be other opportunities to seek funding in this area (e.g. the use of mobile technologies through the Smart Nation Grant call).

38. We outline below our recommendations, over the next five years, to establish a broad portfolio of activities that will add value both to the healthcare system and the economy, while developing a talent pool to take Singapore's healthcare system forward into the next decade.

Recommendation 1: Developing evaluation framework(s) to review the effectiveness and cost-effectiveness of diabetes interventions. The framework(s) should (a) rigorously capture the impact on desired outcomes over time; (b) appropriately align stakeholder incentives with key objectives; and (c) be sufficiently flexible to allow for innovation and diversity.

39. The DTF recommends that the framework should explicitly link the evaluation findings to inform feedback and decision making processes at the facility and Ministry level to ensure optimal resource deployment.

Recommendation 2: Dedicating resources to support research themes related to the treatment and management of diabetes and its complications.

40. The DTF recommends the support of the development of infrastructure and capabilities that would allow us to deepen our understanding of biomarkers that could be used for risk stratification, therapeutic monitoring of diabetes and its complications and/or serve as therapeutic targets for new therapies. For example:

- a. Deep clinical phenotyping (e.g. ambulatory blood pressure, body composition analysis, CGMS⁹, vascular function like pulse-wave velocity, etc.) in both normal, pre-diabetic and diabetic patients;
- b. Prospective follow-ups (partly facilitated by electronic health records);
- c. Cryo-preservation of biological samples (e.g. blood and urine) of longitudinal diabetes cohorts;
- d. Understanding how biomarkers respond to changing glycaemic response to interventions e.g. diet, physical activities and medications; and
- e. Health systems research in particular the evaluation and implementation of multifaceted quality improvement strategies for the prevention and management of microvascular (retinopathy, neuropathy, coronary microvascular disease, and nephropathy) and macrovascular complications of diabetes.

41. The DTF recommends the development of a framework (in consultation with industry partners) for target identification, validation and selection for subsequent development. Resources required for target validation should be built up centrally to avoid duplication and maximise utilisation. Examples include large genomics databases of human genetics for target validation, access to databases for recruitment of patients for clinical trials/studies and specific phenotyping capacity for small and large animal work (metabolic flux imaging).

42. The DTF recommends the establishment of local biomarker reference ranges for the natural history of diabetes and its phenotypic subtypes in Singapore. This is to form a baseline for cohort studies in Singapore. This baseline would facilitate the understanding of disease progression and the (potential) protective mechanisms of novel therapeutics in the local context, which may differ from European populations.

Recommendation 3: Dedicating resources to support the research areas related to the prevention and management of diabetes through population-wide approaches in the Asian and Singapore context.

43. Similar to Recommendation 2, the DTF recommends the support of the development of infrastructure and capabilities that would allow us to deepen our understanding of the impact of nutrition and lifestyle modification to the Asian and Singapore specific context. This is in addition to developing and implementing a framework for digital health and digital education. These are elaborated in the paragraphs below.

44. The DTF recommends researchers to further study, develop and evaluate population-wide approaches and interventions. These studies/interventions go beyond the conventional health sector and require multi-sectoral engagement and co-operation, e.g. food labelling or hawker centres or school based interventions. The studies will integrate psycho-social profiling and biological risk stratification to enable targeted lifestyle and clinical interventions.

⁹ Continuous glucose monitoring system.

Nutrition and Lifestyle Modifications

45. Public education efforts are already underway as part of MOH's War on Diabetes. The DTF recommends further studies into the effectiveness of targeted strategies to engage and educate high-risk populations such as the obese, pre-diabetics, those with gestational diabetes and those with familial history of diabetes.

46. It is clear that the epidemiology, risk factors and pathophysiology of diabetes differ in Asians compared to those of European ancestry¹⁰. The DTF recommends further investigation into the understanding of current food and lifestyle choices across the life-course in the multi-ethnic Asian population in Singapore. This includes the development of evidence-based models of dietary patterns that combine culinary attractiveness, cultural identity and healthfulness (i.e. similar to Mediterranean patterns but localised in Singapore's context) for the public and food vendors, and developing technology for nutrition and diet monitoring that is quantifiable and contextualised.

47. The DTF recommends evaluating the effectiveness of nutritional awareness interventions, such as proper food labelling strategies and colour coding, which could modify food choices in pre-school children, mothers and food vendors/point of sales. In addition, investigations should be conducted on how societal (including legislations, e.g. soda tax¹¹ and fat tax) and environmental barriers can affect and facilitate healthier living. These studies should be framed in a multi-ethnic context, taking into consideration sub-groups of varying dietary habits.

48. Singapore has the opportunity and specialised resources to change the game where functional foods and eating patterns in Asia are concerned. The DTF recommends leveraging these capabilities to conduct research in the modification of local foods and dishes (structure/ingredients) in a culturally and sensorily acceptable way, and evaluating how these can improve the food environment (e.g. in hawker stalls).

49. Due to the high gestational diabetes mellitus (GDM) rates in Singapore and the rapid progression to T2D following GDM, the DTF recommends targeting women's metabolic health, not just in and after pregnancy but also during pre-conception. These include women-focused interventions (e.g. body-mass index management, postpartum glucose monitoring and follow-up) to reduce risk of GDM and progression to T2D.

Digital Health

50. The DTF recommends that a central coordinating body spearhead the development and implementation of a comprehensive framework to delineate the potential applications of digital health and digital education. This can improve processes, outcomes, and patients' and health professionals' experience and for integration of technologies and data generated into clinical workflows and pathways.

¹⁰ Chan JC, Malik V, Jia W, *et al.* Diabetes in Asia: Epidemiology, risk factors, and pathophysiology. *JAMA* 2009;301(20):2129–2140.

¹¹ Sánchez-Romero LM, Penko J, Coxson PG, *et al.* Projected impact of Mexico's sugar-sweetened beverage tax policy on diabetes and cardiovascular disease: A modeling study. In Blakely T, ed. *PLoS Medicine* 2016;13(11):e1002158.

51. The DTF recommends advancing the role of digital health for both disease prevention and management, through the following functions:

- a. *Communication* – between patients, peers and health professionals, including synchronous and asynchronous ICT (e.g. telephone, mobile, video communication, email, social media, peer-groups, SMS and other messaging) to improve access to healthcare and health information, triage, preventive healthcare, clinical management, follow up, feedback on services, etc.
- b. *Education* – ICT for information sharing and patient and population health education, and improving health literacy; including development of devices and apps that encourage positive behaviour change and compliance, e.g. through gamification.
- c. *Information acquisition* – ICT for all aspects of health-related data collection, including sensing and measurement in any form via any interface, platform or device (e.g. from data entry devices to apps, sensors in smartphones, -homes, -cars, -wearables); person-driven digital data collection (e.g. nutrition and diet monitoring to measurement and monitoring of blood sugar, blood pressure, symptoms and events); and personal health records (including privacy and security concerns of personal health data and the use of cloud architectures); and
- d. *Decision support* – ICT to support self-management, including prediction, personalisation, participation and data analytics of “small” and “big” data.

52. To facilitate deployment of new technologies at scale after successful pilots, the DTF recommends to consider the following:

- a. Evaluation of current regulatory and other frameworks for digital health adoption;
- b. Clear guidelines and access to capabilities to allow new technologies to integrate effectively with national platforms such as telehealth platforms, National Electronic Health Record (NEHR), Care and Case Management System (CCMS), EHRs and HealthHub;
- c. Integration of technologies into workflow designed to utilise data to improve health or develop new workflows/services to act on these data; and
- d. Models for assessing cost-effectiveness, which would have to be co-developed to ensure that it is acceptable to funders.

Recommendation 4: Building (i) the next generation of academic physicians with expertise in primary care reform and population health and (ii) a talent pool in health economics and data sciences.

53. The DTF recommends dedicated support for small proof-of-concept pilots for clinician-scientists working in T2D, while providing opportunities to develop the next generation of academic leaders in the field over the next five years.

54. The DTF also recommends the training of engineers and data scientists for the support of data analytics and health–tech integration, in view of Recommendations 2 and 3, that entail the detailed analysis of large volumes and types of data.

CONCLUSION

55. Diabetes and its complications are the largest disease burden in Singapore. Over the last 10 years, Singapore has built up its capabilities, platforms and manpower in the area of metabolic diseases. However, more can be done to reduce the disease burden in Singapore and to further engage industry. The DTF has reviewed the landscape and put forth the above recommendations to prioritise specific research areas and capability development. Research should also focus on strategies to prevent diabetes through diet modifications and the targeted management of high-risk groups. In order to efficiently translate research into practical solutions, there needs to be an increased coordination of efforts between public agencies and the research community.

56. The recommended diabetes research focus areas and the five-year roadmap stated above are submitted for consideration.

Prepared by: Diabetes Taskforce

With input from: MOH, HPB, MOHH/IHiS

Composition of the HBMS Diabetes Taskforce

S/N	Members	Designation
1	Prof Thomas Coffman (Co-Chair)*	Dean, Duke-NUS Medical School
2	Prof James Best (Co-Chair)*	Dean, Lee Kong Chian School of Medicine, NTU
3	A/Prof Chong Yap Seng*	Executive Director, Singapore Institute for Clinical Sciences (SICS), A*STAR
4	A/Prof Melvin Leow	Clinical PI, SICS, A*STAR
5	A/Prof Han Weiping*	Deputy Director, Singapore Bioimaging Consortium (SBIC), A*STAR
6	Prof Christiani Jeya Henry	Director, Clinical Nutrition Research Centre (CNRC), A*STAR
7	Dr Ralph Graichen	Director, Food, Nutrition and Consumer Care (FNCC) Cluster, Biomedical Research Council (BMRC), A*STAR
8	Prof Tan Sze Wee	Executive Director, Science and Engineering Research Council (SERC), A*STAR
9	A/Prof Tai E Shyong*	Head, Division of Endocrinology, NUHS
10	Prof Wong Tien Yin*	Medical Director, Singapore National Eye Centre (SNEC), SHS
11	A/Prof Carolyn Lam	Senior Consultant, National Heart Centre Singapore (NHCS), SHS
12	Prof Bernhard Boehm*	Scientific Director, Metabolic Disease Research Programme, Lee Kong Chian School of Medicine, NTU
13	Prof Karl Tryggvason*	Professor, Cardiovascular and Metabolic Diseases Programme, Duke-NUS Medical School
14	Dr Elaine Tan	Director, Primary and Community Care (PCC) Division, MOH
15	Dr Tan Ngiap Chuan	Director, Research, SingHealth Polyclinics (SHP), SHS
16	Prof Chia Kee Seng*	Dean, Saw Swee Hock School of Public Health (SSHSPH), NUS
17	Prof Tazeen Jafar	Professor, Programme in Health Services and Systems Research, Duke-NUS Medical School
18	Prof Ho Teck Hua	Senior Deputy President & Provost, NUS
19	A/Prof Josip Car	Chair, Health Services Outcomes Research Programme, Lee Kong Chian School of Medicine, NTU
20	Dr Chew Ling	Director, Research and Strategic Planning Division, HPB

*Diabetes Taskforce subgroup.