From Hong Kong Diabetes Register to JADE Program to RAMP-DM for Data-Driven Actions

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In 1995, the Hong Kong Diabetes Register (HKDR) was established by a doctor-nurse team at a university-affiliated, publicly funded, hospital-based diabetes center using a structured protocol for gathering data to stratify risk, triage care, empower patients, and individualize treatment. This research-driven quality improvement program has motivated the introduction of a territory-wide diabetes risk assessment and management program provided by 18 hospital-based diabetes centers since 2000. By linking the data-rich HKDR to the territory-wide electronic medical record, risk equations were developed and validated to predict clinical outcomes. In 2007, the HKDR protocol was digitalized to establish the web-based Joint Asia Diabetes Evaluation (JADE) Program complete with risk levels and algorithms for issuance of personalized reports to reduce clinical inertia and empower self-management. Through this technologically assisted, integrated diabetes care program, we have generated big data to track secular trends, identify unmet needs, and verify interventions in a naturalistic environment. In 2009, the JADE Program was adapted to form the Risk Assessment and Management Program for Diabetes Mellitus (RAMP-DM) in the publicly funded primary care clinics, which reduced all major events by 30–60% in patients without complications. Meanwhile, a JADE-assisted assessment and empowerment program provided by a university-affiliated, self-funded, nurse-coordinated diabetes center, aimed at complementing medical care in the community, also reduced all major events by 30–50% in patients with different risk levels. By combining universal health coverage, public-private partnerships, and data-driven integrated care, the Hong Kong experience provides a possible solution than can be adapted elsewhere to make quality diabetes care accessible, affordable, and sustainable.

THE SOCIETAL BURDEN OF DIABETES

In 2017, according to the Global Burden of Diseases, Injuries, and Risk Factors Study, noncommunicable diseases—mainly cardiovascular diseases (CVD), cancer, chronic respiratory diseases, and diabetes—accounted for three-quarters of global deaths, or 41 million (1). Because diabetes independently increases the risk of cardiovascular, renal, and cancer death by 1.3- to 3-fold, prevention and control of diabetes is a top priority in the prevention of noncommunicable diseases (2).

Between 1990 and 2010, U.S. surveillance data reported that in people with diabetes, the incidence of acute myocardial infarction (MI) had decreased by 68% to 45 per 10,000 person-years, stroke by 53% to 53 per 10,000 person-years, and

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end-stage renal disease (ESRD) by 28% to 20 per 10,000 person-years (3). During the same period in Australia, the death rates due to any cause, CVD, and type 2 diabetes (T2D) also decreased by an absolute rate of 1.8, 1.5, and 0.3 per 10,000 person-years, respectively (4). Worryingly, in these developed countries, the declining rate of MI, stroke, ESRD, and all-cause death has slowed down since 2010, in part because of the stagnant improvement in health care delivery and/or increased incidence of event rates among youth and young adults diagnosed with T2D before the age of 45 years (4).

In 2015, the projected cost of diabetes in people aged 20–79 years was US$1.3 trillion or 1.8% of the global gross domestic product (GDP), of which two-thirds consisted of direct medical costs including outpatient consultations, laboratory tests, emergency department visits, and hospitalizations, while one-third was indirect medical costs due to lost productivity (5). It has been estimated that if we fail to curb the diabetes epidemic, the global economic burden will double and reach US$2.5 trillion by 2030 (5).

TRANSLATING EVIDENCE TO PRACTICE

Diabetes is characterized by clustering of multiple cardiometabolic risk factors that interact with other host attributes (e.g., age, sex, education, family history, socioeconomic status, lifestyle factors) to give rise to an abnormal internal milieu. Depending on a person's age and the age of diagnosis, i.e., disease duration, these risk factors can cause widespread inflammation along with vascular and nerve damage. If not diagnosed, managed, and controlled, they can lead to multiple morbidities and hospitalizations with competing causes of premature death (Fig. 1). Numerous randomized controlled trials (RCTs) have confirmed the efficacy of controlling key cardiometabolic risk factors in preventing or delaying onset of cardiovascular-renal complications and related deaths (6–9). These improvements are made possible by ensuring access to continuing care, medications, and patient education/empowerment, accompanied by multifactorial management for optimizing the control of blood glucose, blood pressure (BP), and blood lipids, together with timely use of organ-protective medications (e.g., statins, renin-angiotensin

system inhibitors [RASi]), often within an RCT setting (10).

However, in real-world practice, there are major care gaps irrespective of health care settings, health workforce availability, and studied populations (Fig. 2). In a recent analysis of 6 million people with diabetes from 11 countries/regions, which mostly used HbA$_{1c}$ <7% (53 mmol/mol), BP <130/80 mmHg, and LDL cholesterol (LDL-C) <2.6 mmol/L (100 mg/dL) as the "ABC" treatment goals (11), there was a huge discrepancy between populations, ranging from up to 60% of patients attaining any goal in Western Europe and North America to less than 40% among patients from developing countries in Asia. Of note, even in developed countries, less than 10% of patients attained all three ABC goals (Fig. 2A).

Given the silent and progressive nature of diabetes and its complications, clinical inertia (12) and poor treatment adherence (13) are major barriers. Due to its phenotypic heterogeneity along with the growing number of technologies and changing needs of patients with diabetes throughout their clinical course, most professional organizations, including the American Diabetes Association and the European Association for the Study of Diabetes, recommend regular assessment of risk factors and complications for individualizing goals and treatment strategies (14). Given the low health care provider (HCP)-to-patient ratio of less than 1–4 per 1,000 population for physicians and 2–11 per 1,000 population for nurses, especially in developing countries (Fig. 2B), there is an urgent need to reform the delivery of diabetes care in order to address the decades of pluralistic needs of hundreds of millions of people with diabetes.

Growing evidence indicates the benefits of quality improvement (QI) strategies targeted at the health systems, HCPs, and patients on top of usual care in reducing multiple risk factors. In a recent meta-analysis of 181 RCTs that included 130,000 patients with T2D, using task delegation to deliver team-based care, patient education to improve self-management, and relay (technology or nonphysician personnel) to facilitate patient-HCP communication had the largest independent effects in reducing HbA$_{1c}$, BP, and LDL-C. These effects were most evident in Asia, where care is often fragmented, and in young patients, who often have poor control due to nonadherence (15).

DIABETES CARE IN HONG KONG—USING DATA TO MEASURE PERFORMANCE AND DRIVE ACTIONS

Hong Kong is a cosmopolitan city in southern China with a population of 7.5 million, mainly of Han descent, who have undergone rapid socioeconomic and lifestyle changes since the early 1980s. In the 1990s, a survey conducted in a public utility company using 75-g oral glucose tolerance tests found that 4.5% of people of working age had diabetes, portending a growing epidemic with increasing westernization and personal affluence (16).

Rising to this challenge, a group of academic researchers combined science and practice to gather and use data to drive actions at the patient, system, and policy levels. This large body of evidence has motivated the introduction of a territory-wide diabetes risk assessment and management program, as well as a regional collaborative effort to improve diabetes care in Asia. Figure 3A shows the conceptualization and implementation of the research-driven QI program, and Fig. 4 summarizes the evolution of diabetes care in Hong Kong over the past two decades.

Challenges and Opportunities of an Epidemic of Diabetes

Hong Kong adopts a free-market economy with a low income taxation scheme capped at 17%, with 17% of the government revenue capped for health care expenditure, which is equivalent to 3% of GDP (17). In this dual-track health care system, another 3% of GDP is spent in the private market, although health insurance is not mandatory (17). The public sector is adapted from the U.K. National Health Service, which serves as a safety net with universal health coverage. The Hospital Authority (HA) is a statutory administrative body that manages all public health care services, which are heavily subsidized. Among the 76,000 staff, most of whom are fully employed, 6,000 are doctors who make up half of the medical force but provide more than 90% of hospital and ambulatory outpatient care (18). In the HA clinics/hospitals, a nominal fee is charged that covers most of the laboratory tests, medications, procedures, and hospitalizations (e.g., US$10–15 per clinic visit, US$1.50 per drug item for 3–4 months, US$15 per hospitalization night). Given the high
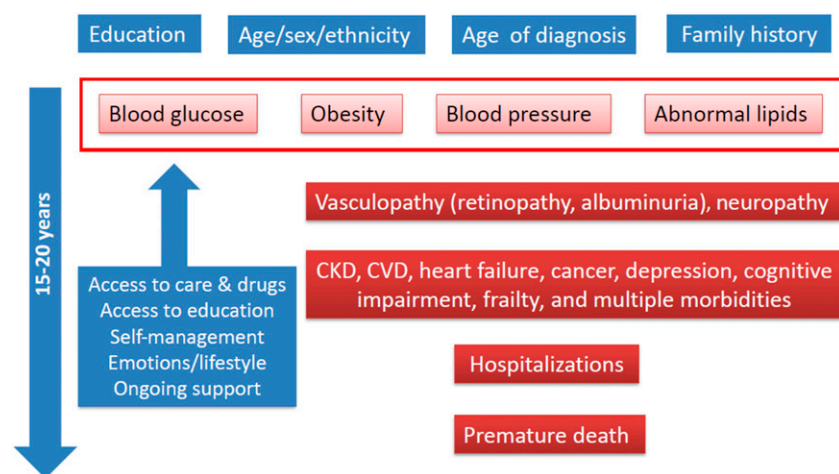
Figure 1—The complex interactions among demographics, family history (e.g., genetics or shared environment), lifestyles (e.g., tobacco, alcohol), cardiometabolic conditions, and psychosocial-behavioral risk factors can give rise to different trajectories of comorbidities and premature death, depending on access to education, care, and medications. A multicomponent strategy is needed to define these risk factors, identify needs, and individualize care in order to improve health outcomes.

service demands on the public health care system in Hong Kong, patients typically have different attending doctors whom they see in outpatient consultations lasting up to 10 min every 3–4 months.

From Clinical Trials to Structured Care
In the midst of this growing epidemic of diabetes, in 1989, the Chinese University of Hong Kong (CUHK) diabetes team based at the HA-affiliated Prince of Wales Hospital (PWH) (the CUHK teaching hospital), with additional support from a research nurse, together with a protocol, conducted a 1-year, double-blind, placebo-controlled RCT comparing the renal effects of enalapril versus nifedipine slow release in 102 patients with T2D and hypertension at the Metabolic Investigation Unit (forerunner of the Diabetes Mellitus and Endocrine Center). Having confirmed the independent antialbuminuric effect of enalapril at 1 year (19), the patients received open-labeled medications with the same assignment and continued to be followed up by the original doctor-nurse team at regular intervals (20). These patients received structured care with predefined measurement at each visit and yearly assessment of complications by the research nurse. With these data, the doctor was able to make informed decisions despite the short consultation time, while the nurse reinforced adherence to the care plan and self-management. This contrasts to the usual care setting where patients were followed up by different

doctors at 4- to 6-month intervals in an overcrowded setting with uncertain adherence to recommended practices. At the end of 7 years of follow-up, compared with a matched cohort followed up during the same period who received usual care, the structured care group had more frequent measurements of risk factors and lower fasting blood glucose, BP, and serum creatinine. While 24.7% (20 of 81) of the patients in the usual care group had died, only 8.8% (8 of 91) died in the structured care group, with an adjusted relative risk of 0.21 (21).

IDF St. Vincent Declaration and Hong Kong Diabetes Register
In 1989, the World Health Organization and the International Diabetes Federation (IDF) jointly launched the St. Vincent Declaration, calling for active partnerships and commitments from organizations, HCPs, patients, families, and communities to tackle the diabetes epidemic (22). One of the proposed actions in the Declaration was to establish a monitoring system to detect risk factors for early intervention in type 1 diabetes (23). Inspired by the Declaration and IDF recommendations on comprehensive, standard and basic care models (23,24) and driven by the low HCP-to-patient ratio (Fig. 2*B*), the CUHK-PWH team initiated a research-driven QI initiative to reorganize the diabetes service. Meanwhile, our clinical observations suggested differences between Chinese and Caucasian patients, with the former developing diabetes at low BMI and high

prevalence of T2D even in young patients, as well as a propensity for developing chronic kidney disease (CKD) (25,26). Thus, one of the objectives of the QI program was to gather data to close our knowledge gaps in diabetes in Chinese populations.

From the outset, we changed the care setting by introducing a weekly complication screening session at the ambulatory diabetes center, away from the busy clinics/wards. By adopting the component of RCTs of using nurses to assist in delivery of protocol-guided care, we standardized the workflow and used structured case report forms to collect data (demographics, age of diagnosis, type of diabetes, medical history, family history, lifestyles, self-care, and medication use and adherence) to establish the Hong Kong Diabetes Register (HKDR) (27). Apart from collecting data, nurses were trained by diabetologists to perform structured assessment including anthropometric measurements, foot examination using simple equipment (e.g., 10-g monofilament, graduated tuning fork), and collection of blood and urine samples. Initially, they were asked to dilate pupils for fundoscopic examination by doctors, which was later replaced by the use of a fundus camera with the photos read by trained doctors. These data were entered into a database initially written in dBASE and later Microsoft Access with data recoding to generate definitions and algorithms for issuing a one-page report containing a summary of risk factors, complications, risk levels, and target values. Based on these personalized reports, the diabetologists were able to comment on care gaps and recommend that referring doctors adjust or intensify treatment, as appropriate. Some of the key information was transferred to a patient booklet listing treatment goals, rights, and responsibilities. After the structured assessment, patients returned to the diabetes center 4–6 weeks later to collect their booklet with personalized results and attend a 2-h, nurse-led empowerment class with explanation of their results and reinforcement of self-care, including self-monitoring of blood glucose with particular focus on adherence to medications (27).

From HKDR to Team-Based Integrated Care
Based on their risk levels defined by the status of risk factors and complications, the patients were triaged to their

A   Treatment goals attainment
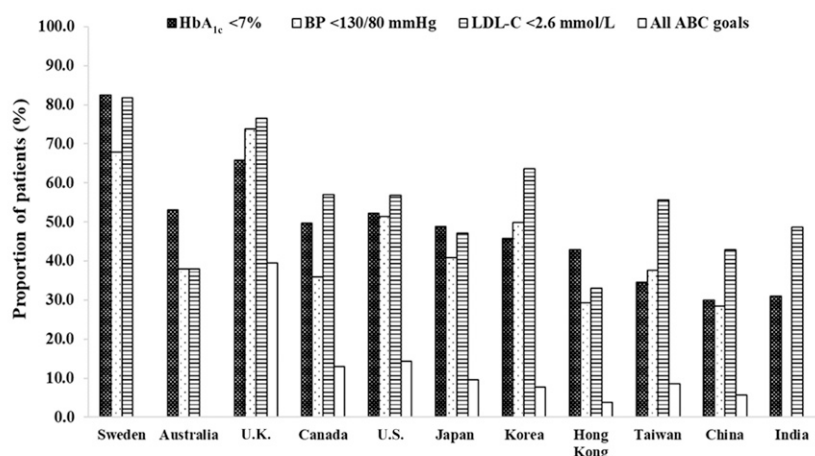
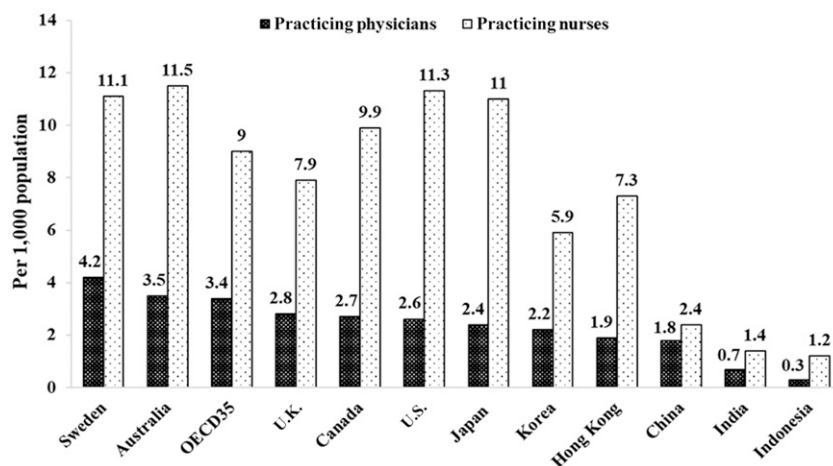## B   Health workforce availability

Figure 2—Comparisons of the treatment goals attainment (*A*) and health workforce availability (*B*) between countries and regions. ABC goals refer to HbA$_{1c}$ <7% (53 mmol/mol), BP <130/80 mmHg, and LDL-C <2.6 mmol/L (100 mg/dL). The rates of treatment goals attainment were based on national audits and epidemiological surveys with some variations in data reporting and health care settings (refer to Supplementary Data for further details). Health workforce data were retrieved from the Organisation for Economic Co-operation and Development (OECD) *Health at a Glance 2017: OECD Indicators* (62). OECD35, 35 member countries of the OECD.

community-based family clinics, hospital-based internists, or diabetes specialist teams for continuing care. Patients were prebooked for structured risk assessment every 2–3 years at the diabetes center for quality assurance. While these data were entered into the program by nonphysician staff to establish the HKDR for ongoing evaluation, written consent was sought from patients for donating their biosamples to help us understand the genotype-phenotype interactions and the effects of interventions on clinical outcomes (27). The establishment of the HKDR coincided with the introduction of a territory-wide electronic medical record (EMR)

system by the HA. Through the unique identifier of all citizens used by all government-funded services, we were able to periodically link the HKDR to the laboratory, medication, procedures, and hospitalization data of the EMR to ascertain clinical events and death data for analysis (27).

In a series of QI programs and postgraduate theses, we observed the marked slowing of the rate of decline of renal function in patients with CKD managed in an RCT setting (28). We also reported over 50% reduction in risk of the composite of ESRD or all-cause death in patients with CKD and multiple morbidities

managed by a doctor-pharmacist team (29), whose actions included the use of telephone reminders (30). In the Effects of Structured versus Usual Care for Renal Endpoints in type 2 diabetes (SURE) Study, patients with T2D and CKD were recruited from nine public diabetes centers and randomized into either the structured care or usual care group between 2004 and 2007 (31). Both groups had structured assessment at randomization and at the end of the 2-year study. The structured care group was managed by a diabetologist-nurse team using preprinted record forms specifying follow-up schedules and treatment goals (ABC: HbA$_{1c}$ <7% [53 mmol/mol], BP <130/80 mmHg, LDL-C <2.6 mmol/L [100 mg/dL]; triglycerides <2 mmol/L [180 mg/dL]; and persistent use of RASi) with telephone reminders by nurses between visits. After 2 years, the structured care group was three times more likely to attain multiple treatment goals than the usual care group (31). Patients attaining three or more goals had 60% reduced risk of ESRD and/or death than those who attained fewer than three goals (31), with potential cost savings (32).

From HKDR to Risk Prediction and Real-world Evidence

From a research perspective, the establishment of the HKDR has provided invaluable insights in confirming our clinical observations in Chinese patients with T2D. Several lines of evidence have now confirmed that Asians have reduced β-cell capacity to overcome insulin resistance, often due to inflammation resulting from excess visceral fat accumulation and endemic low-grade infections such as chronic hepatitis B (33,34). This double burden of insulin insufficiency and resistance may contribute toward an abnormal milieu of glucolipotoxicity and inflammation, resulting in β-cell dysfunction with high prevalence of gestational diabetes, young-onset diabetes (YOD), CKD, and cancer in Asian populations (33,34). This phenotype is likely relevant to populations who undergo rapid transition from a "hunter-gatherer" to an energy-rich lifestyle with low levels of physical activity (35).

After 10 years of data accrual from more than 6,000 patients followed up for a mean period of 6 years, we developed and validated a series of risk algorithms to estimate 5-year probabilities of major events, including coronary
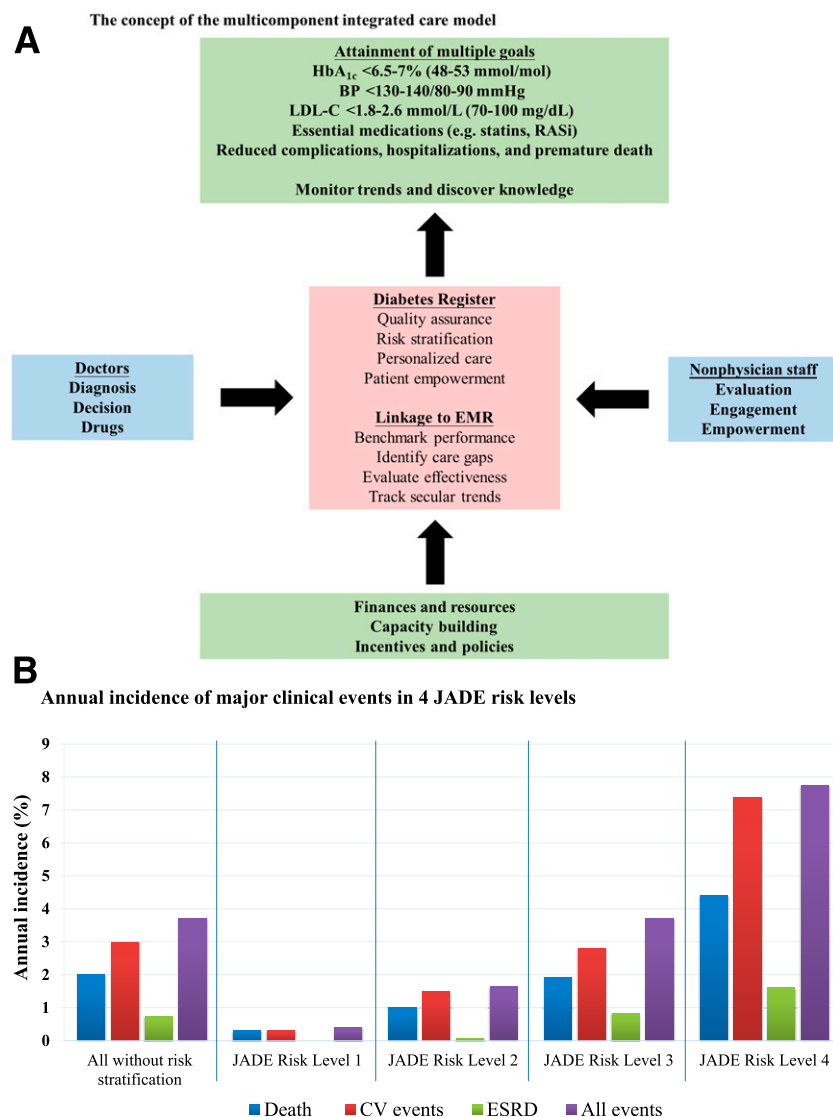
A

The concept of the multicomponent integrated care model

Attainment of multiple goals
HbA$_{1c}$ <6.5-7% (48-53 mmol/mol)
BP <130-140/80-90 mmHg
LDL-C <1.8-2.6 mmol/L (70-100 mg/dL)
Essential medications (e.g. statins, RASi)
Reduced complications, hospitalizations, and premature death

Monitor trends and discover knowledge

Doctors
Diagnosis
Decision
Drugs

Diabetes Register
Quality assurance
Risk stratification
Personalized care
Patient empowerment

Linkage to EMR
Benchmark performance
Identify care gaps
Evaluate effectiveness
Track secular trends

Nonphysician staff
Evaluation
Engagement
Empowerment

Finances and resources
Capacity building
Incentives and policies

B

Annual incidence of major clinical events in 4 JADE risk levels

Figure 3—*A*: The data-to-action framework of the territory-wide diabetes care model in Hong Kong aimed at enabling attainment of multiple goals through patient empowerment and early intervention with ongoing data collection to influence practice and policies. Depending on the resources available, the nonphysician staff can include nurses, dietitians, pharmacists, podiatrists, health care assistants, office workers, community workers, trained peers, etc., as appropriate. *B*: The annual incidence of four JADE risk levels based on different combinations of risk factors and complications with the following annual event rates: risk level 1 (low risk, 1%), risk level 2 (moderate risk, 3%), risk level 3 (high risk, 5%), and risk level 4 (very high risk, 8%). The definitions of JADE risk levels are as follows: level 1—no CVD or ESRD and having other condition fulfilling the "low risk" criteria (≤1 stratification parameter, risk scores below the high-sensitivity cutoff in all of the risk equations, and estimated glomerular filtration rate [eGFR] ≥90 mL/min/1.73 m^2); level 2—no CVD or ESRD and none of the conditions (risk score, stratification parameters, eGFR) defined in the "high risk" category but not belonging to the "low risk" category; level 3—no CVD or ESRD and having three or more stratification parameters (smoking, BP, HbA$_{1c}$, lipids, BMI, waist circumference, albuminuria, retinopathy, foot at risk) and/or risk scores above the high-specificity cutoff in any one of the risk equations and/or eGFR <60 mL/min/1.73 m^2; level 4—presence of any CVD (coronary heart disease, heart failure, stroke, and/or peripheral vascular disease with or without interventions or medications) and/or ESRD (eGFR <15 mL/min/1.73 m^2 or need for renal replacement therapy). In the HKDR, 25% of patients belonged to risk level 1–2, 60% to risk level 3, and 15% to risk level 4. The JADE risk level provides an easy-to-understand concept regarding the trajectories of diabetes over two to three decades that can be modified by good self-care and attainment of multiple treatment goals (42). CV, cardiovascular.

associated with 30% reduction in risk of CHD compared with that of those not meeting any goal (41).

From HKDR to the Joint Asia Diabetes Evaluation (JADE) Program

In 2000, the CUHK-PWH diabetes risk assessment and management program was adopted by the HA, which incorporated the HKDR structured data collection form into the EMR. At the same time, diabetes nurses were trained and 18 hospital-based diabetes centers were established to provide assessment, education, and supporting services to all patients with diabetes referred from medical clinics. This service reform has turned diabetes centers into focal action points for promoting collaborative care between specialists and other HCPs. Depending on institutional support and staffing levels, each of these centers provides structured assessment services to 30–80 patients weekly along with other services, such as insulin initiation and titration, telephone counseling, group/individualized education, nurse review, and peer support programs, reaching over 0.4 million patients with diabetes attending the HA clinics/hospitals. With ongoing data collection, the HA has created a growing database to benchmark performance, and administrators provide regular feedback to frontline operators and managers for QI purposes.

In 2007, supported by an educational grant, the CUHK-PWH diabetes team founded the Asia Diabetes Foundation (ADF), a nonprofit research organization under the governance of the CUHK Foundation, to design the state-of-the-art web-based JADE portal that incorporates the care protocol and HKDR-derived risk algorithms. Based on insights learned from the HKDR, we used different combinations of risk factors, complications, and risk scores to create four JADE risk levels with internal validation with the following annual event rates: risk level 1 (low risk, 1%), risk level 2 (moderate risk, 3%), risk level 3 (high risk, 5%), and risk level 4 (very high risk, 8%) (42) (Fig. 3*B*). Using data collected from the JADE portal, we further integrated the data to issue a self-explanatory personalized report including risk levels, risk factors, complications, and 5-year probabilities of major clinical events (CHD, stroke, heart failure, and ESRD) to inform the patients regarding their risk profiles

heart disease (CHD) (36), stroke (37), heart failure (38), ESRD (39), and death (40), to improve risk stratification for care

triage. Using this real-world evidence, we also confirmed that attainment of two or more of the ABC goals was independently
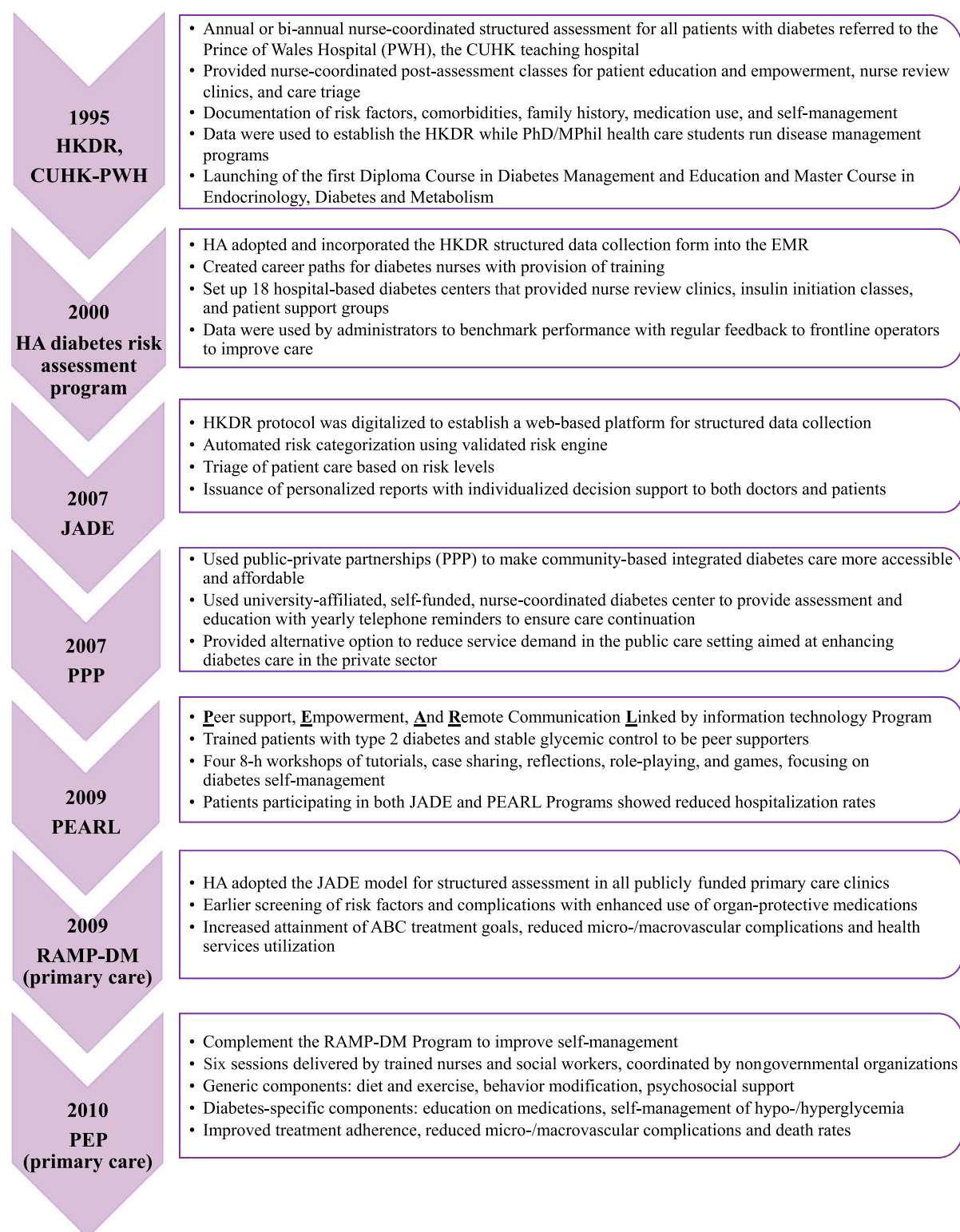
1995
HKDR,
CUHK-PWH

- Annual or bi-annual nurse-coordinated structured assessment for all patients with diabetes referred to the Prince of Wales Hospital (PWH), the CUHK teaching hospital
- Provided nurse-coordinated post-assessment classes for patient education and empowerment, nurse review clinics, and care triage
- Documentation of risk factors, comorbidities, family history, medication use, and self-management
- Data were used to establish the HKDR while PhD/MPhil health care students run disease management programs
- Launching of the first Diploma Course in Diabetes Management and Education and Master Course in Endocrinology, Diabetes and Metabolism

2000
HA diabetes risk assessment program

- HA adopted and incorporated the HKDR structured data collection form into the EMR
- Created career paths for diabetes nurses with provision of training
- Set up 18 hospital-based diabetes centers that provided nurse review clinics, insulin initiation classes, and patient support groups
- Data were used by administrators to benchmark performance with regular feedback to frontline operators to improve care

2007
JADE

- HKDR protocol was digitalized to establish a web-based platform for structured data collection
- Automated risk categorization using validated risk engine
- Triage of patient care based on risk levels
- Issuance of personalized reports with individualized decision support to both doctors and patients

2007
PPP

- Used public-private partnerships (PPP) to make community-based integrated diabetes care more accessible and affordable
- Used university-affiliated, self-funded, nurse-coordinated diabetes center to provide assessment and education with yearly telephone reminders to ensure care continuation
- Provided alternative option to reduce service demand in the public care setting aimed at enhancing diabetes care in the private sector

2009
PEARL

- **P**eer support, **E**mpowerment, **A**nd **R**emote Communication **L**inked by information technology Program
- Trained patients with type 2 diabetes and stable glycemic control to be peer supporters
- Four 8-h workshops of tutorials, case sharing, reflections, role-playing, and games, focusing on diabetes self-management
- Patients participating in both JADE and PEARL Programs showed reduced hospitalization rates

2009
RAMP-DM
(primary care)

- HA adopted the JADE model for structured assessment in all publicly funded primary care clinics
- Earlier screening of risk factors and complications with enhanced use of organ-protective medications
- Increased attainment of ABC treatment goals, reduced micro-/macrovascular complications and health services utilization

2010
PEP
(primary care)

- Complement the RAMP-DM Program to improve self-management
- Six sessions delivered by trained nurses and social workers, coordinated by nongovernmental organizations
- Generic components: diet and exercise, behavior modification, psychosocial support
- Diabetes-specific components: education on medications, self-management of hypo-/hyperglycemia
- Improved treatment adherence, reduced micro-/macrovascular complications and death rates

Figure 4—The evolution of diabetes care in Hong Kong, modified from Ng et al. (61). ABC goals refer to $HbA_{1c} < 7\%$ (53 mmol/mol), BP <130/80 mmHg, and LDL-C <2.6 mmol/L (100 mg/dL).

(Supplementary Fig. 1). At the same time, we emphasized the importance of controlling the four most modifiable risk factors (HbA_{1c}, BP, LDL-C, and body weight) by using charts and trend lines indicating the recommended goals and attained values, along with decision support aimed at promoting self-management and early intervention (42). To this end, this technologically assisted JADE Program has integrated multiple care components proven to improve risk factors (15). Through task delegation, trained nurses gathered data during structured assessment to establish a

register with built-in matrices to monitor performance, trends, and care gaps. By issuing a personalized report, one for the patient and one for the HCP, we were able to improve patient empowerment and patient-HCP communication with reduced clinical inertia and treatment nonadherence (42).

Using Technology and Nonphysician Personnel to Provide Information and Ongoing Support

By combining technology and team-based care with ongoing data collection, it has become possible to conduct pragmatic trials in a naturalistic environment. In 2009, we conducted the multicenter Peer support, Empowerment, And Remote communication Linked by information technology (PEARL) Study (43). We invited motivated patients with HbA_{1c} <8% (64 mmol/mol) to join a "Train-the-Trainer" program with pre- and post-evaluation in order to become peer supporters. The tutors including nurses, neurolinguists, and dietitians who used role play and workshops to improve the listening and communication skills of these peer supporters (43). After undergoing the JADE-assisted assessment, 628 consenting patients with T2D were randomized into two groups, with the PEARL group receiving telephone-based support by their assigned peer supporters. After 1 year, both groups had improved self-care, adherence, emotions, and control of multiple risk factors (43). In a post hoc analysis, patients with negative emotions and/or cardiovascular-renal complications benefited most, having 50% relative risk reduction in hospitalizations compared with their counterparts without peer support (44).

Between 2015 and 2018, supported by a government grant, we conducted a multicenter, telephone-based peer support program coordinated by seven public hospital–based diabetes centers and a nongovernmental organization (NGO) (45). A total of 319 patients with T2D who were identified by nurses as having emotional distress or social isolation received regular phone calls from 69 trained peer supporters (45). After 1 year, the attainment rates of HbA_{1c} <7% (53 mmol/mol) improved from 7% to 24%, those for LDL-C <2.6 mmol/L (100 mg/dL) increased from 69% to 77%, and the proportion of patients with emotional burden (assessed by the Chinese version of the Diabetes Distress Scale) fell from 39% to 30%; the

improvements were especially seen in those with HbA_{1c} ≥8% (64 mmol/mol) at baseline and frequent contacts with peer supporters (45).

In addition to the full JADE report for structured comprehensive assessment, the portal also generates brief follow-up reports that display trends of risk factors with updated values. In an RCT of 1,200 Chinese patients who underwent JADE-assisted assessment, patients who received additional JADE follow-up reports through the mail after their clinic visit had 0.23% (2.5 mmol/mol) lower HbA_{1c} than nonrecipients. In high-risk patients, recipients of these additional follow-up reports, averaging 1–2 during a 12-month period, had a 50% reduced risk of hospitalization compared with nonrecipients (46).

Because of the growing number of patients requiring chronic care, the HA clinics face increasingly long waiting lists with long intervals between follow-up visits and frequent changes of doctors. Thus, many patients also see private doctors for more personalized care while collecting heavily subsidized medications in the public sector. However, many private doctors cannot afford to employ a multidisciplinary team or nurses with training in diabetes to maximize the impact of their care. In 2007, supported by philanthropic funds, we established a CUHK-affiliated, nurse-led, self-funded diabetes assessment center (the Yao Chung Kit Diabetes Assessment Center) to improve access to JADE-assisted assessment followed by individualized explanation by nurses and written comments by endocrinologists (a total of US$300 per assessment package per patient). To ensure continuation of care, the nurses also give a yearly telephone reminder to patients to have a repeat comprehensive assessment. Doctors from private and public sectors can refer patients, and patients can refer themselves, to the center for assessment, thereby offering an affordable alternative for increasing access to this data-driven care model. After a median follow-up of 8 years, compared with those who received structured assessment in the HA clinics but with variable standards of care thereafter, patients who were managed through this public-private partnership scheme had 30–50% relative risk reductions of cardiovascular-renal complications and death. Depending on their risk factors and complications, the hospitalization rate ranged from 1.5 to 7 nights

per patient per year. Patients who received JADE-assisted care in the public-private partnership scheme had a 50% lower hospitalization rate than those managed in the public clinics, yielding a potential saving of US$650–1,500 per patient per year (47).

From JADE to Risk Assessment and Management Program in Diabetes Mellitus (RAMP-DM)

Despite the proven benefits of these integrated care models, institutional support and capacity building are needed to scale up their operation and impacts. Since 2000, these research-driven programs have provided a reference for the introduction of a territory-wide staged implementation plan to reform the outpatient diabetes services in Hong Kong (Fig. 4). Career paths were created for nurse specialists to assist diabetologists in setting up hospital-based diabetes centers to provide structured assessment and patient empowerment classes along with nurse review clinics. Apart from providing space, equipment, and supplies (e.g., fundus camera), health care assistants and clerical staff are employed to provide logistics support (e.g., appointment booking, telephone reminders, data entry) and perform simple clinical assessment (e.g., BP, anthropometric assessment, blood and urine collection) at the hospital-based diabetes centers.

To date, Hong Kong has over 150 diabetes-certified nurse practitioners/consultants, many of whom work in 18 hospital-based diabetes centers across all district clusters. In 2009, the HA adopted the multicomponent integrated care model derived from the HKDR and JADE to establish the RAMP-DM Program in all 73 public primary care clinics. Through the supply of additional equipment (e.g., fundus camera) and the retraining of many of the primary care nurses by hospital-based nurse specialists, the implementation of nurse-coordinated structured assessment has increased from 3% in 2009 to 82% of all primary care clinics in 2013 (48). Using the JADE risk levels, high-risk patients with multiple risk factors were comanaged by the RAMP-DM nurse and family medicine specialists before referral to hospital specialists as needed (49).

In 2003–2012, 340,000 patients with T2D underwent structured assessment in HA diabetes centers or family clinics, and there was increased usage of RASi (22.2%

in 2000–2003 to 32.2% in 2010–2012), statins (8.8% to 26.1%), and antiplatelet drugs (10.3% to 14.7%), as well as a higher proportion of patients who attained two or more ABC goals (10.7% and 23.3%) (50). With continuing investment and capacity building, there is increasing awareness and care improvement at all levels. Based on the territory-wide diabetes database, compared with the outcomes in cohorts registered in 2003, there was progressive decline in all events—notably MI, stroke, ESRD, and all-cause death—in subsequent cohorts, especially in those with disease duration over 15 years (50).

Meanwhile, academic researchers in family medicine were commissioned to evaluate the cost-effectiveness of the RAMP-DM Program using the HA primary care database as referent. Based on a propensity score–matched analysis of more than 53,000 patients with 8 years of diabetes duration, the respective mean HbA_{1c}, BP, and LDL-C values were 7.4% (57 mmol/mol), 136/75 mmHg, and 3.1 mmol/L (120 mg/dL) (49). After a median follow-up of 4.5 years, there was increased usage of blood glucose–lowering drugs (including insulin) and organ-protective medications in both groups, albeit less so in the non–RAMP-DM group (49). On the other hand, patients in the RAMP-DM group had more contacts with HCPs and were more likely to join a patient empowerment program (PEP) delivered by an NGO commissioned by the HA to complement the RAMP-DM program (49).

After 4.5 years, the RAMP-DM group had lower incidence of CVD (11.4% vs. 23.6%), heart failure (3.4% vs. 8.2%), CKD (7.1% vs. 10.3%), and all-cause death (8.2% vs. 24.6%) than the propensity score–matched non-RAMP-DM group (49). There was also lower health services utilization in the RAMP-DM group, including hospitalizations, emergency department visits, and specialist clinic visits (49). Despite a slight excess risk of diabetic retinopathy, there was reduced incidence of sight-threatening retinopathy, likely due to early detection followed by prompt referral to ophthalmologists in the RAMP-DM group (49). Taking into account the implementation costs estimated at US$157 per patient and lower cumulative incidence of diabetes-related complications over 4.5 years, the researchers estimated a net cost saving of US$7,294 per patient (51). Of note, the

RAMP-DM Program is built on existing infrastructure and resources and is focused on workflow re-engineering, team reorganization, and retraining of nurses, which has kept the set-up and operation costs relatively low (51).

Although the RAMP-DM Program adopted the JADE protocol, technical issues prevent it having the feature of personalized reporting, despite the latter's proven benefits in improving patients' knowledge, self-management, risk factors, and outcomes (46,52). Patients who participated in the RAMP-DM Program were invited to join the territory-wide PEP run by an NGO since 2010. This program used a validated curriculum to promote awareness and self-care efficacy among stable, non–insulin-treated patients. It consists of six patient education and support sessions delivered by nurses and social workers, with each session facilitated by a diabetes-skilled doctor (Fig. 4) (53,54). In several propensity score–matched analyses of up to 24,000 patients, although there was an upward drift of HbA_{1c} in both PEP and non-PEP groups over a median follow-up of 2.5 years, the rate was slower in the PEP group (53). Despite a 50% completion rate, the PEP group had 41%, 22%, and 10–12% risk reductions of all-cause death, macro- and microvascular complications, and health services utilization, respectively, compared with the non-PEP group (53,54).

USING THE JADE PROGRAM TO IMPROVE CARE AND PROMOTE RESEARCH IN ASIA

By distilling the lessons learned from more than two decades of implementation research, the web-based JADE Program was designed to provide a platform for promulgating data-driven integrated care in Asia. The JADE reports are available in eight languages. Supported by various research grants, investigators in Asia received funding to employ a nurse to recruit 300–600 patients for structured assessment with data entry into the JADE portal, and half of the patients received additional nurse support through telephone calls or face-to-face visits between medical visits. To date, more than 300 sites in 10 Asian countries/regions, including mainland China, India, Indonesia, Malaysia, the Philippines, South Korea, Singapore, Taiwan, Thailand, and Vietnam, have been exposed to this JADE-

assisted multicomponent integrated care model. In an RCT conducted in China, 3,586 patients with T2D from six tertiary hospitals underwent structured assessment followed by issuance of the JADE report, with half of them receiving additional follow-up by nurses. After 1 year of intervention, both groups had improved control of risk factors and attainment of treatment goals. Patients receiving additional nurse follow-up had better self-care efficacy and less default than the usual care group (52).

Importantly, this structured data collection continues to bring new insights regarding the pattern of diabetes in Asia. Using the Asia diabetes register along with the territory-wide diabetes database in Hong Kong, we have reported differences in attainment of treatment goals in different health care settings (55,56), the high prevalence of YOD and CKD and the consistent care gaps in these patients across all countries (55–58), the high burden of hospitalizations due to mental illness in patients with YOD (59), and the poor outcomes in patients with low education and socioeconomical status (60).

CONCLUSIONS

Diabetes is a complex disease requiring a multicomponent strategy targeted at the patients, HCPs, health systems, communities, and society. Despite their potential devastating consequences, diabetes-related complications are highly preventable and treatable. Based on more than two decades of combining research and practice, we have confirmed the utility of using a team approach to deliver structured care, with particular focus on data collection, interpretation, and communication to drive actions at personal, system, and policy levels. The universal health care coverage and the availability of a unique identifier together with a territory-wide EMR have provided an opportunity for academics to evaluate the impact of this integrated assessment, care, and education program on health outcomes. In this review article, we have summarized the impacts of a territory-wide diabetes risk assessment and management program now benefiting more than 0.4 million people with diabetes in Hong Kong and its influence on practice in Asia. At the same time, one of the most comprehensive diabetes registers has been created, linking risk factors to

outcomes to inform practices and policies as well as monitor secular trends and discover new knowledge.

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