Improving health outcomes of people with diabetes

Global Health and Population Project on Access to Care for Cardiometabolic Diseases

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Improving Health Outcomes of People with Diabetes Mellitus: Global Target Setting for the WHO Diabetes Compact

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ABSTRACT

The Global Diabetes Compact is a World Health Organization-driven initiative uniting stakeholders around goals of reducing diabetes risk and ensuring that those with diabetes have equitable access to comprehensive, affordable care and prevention. In this report we describe the development and scientific basis for key health metrics and coverage and treatment target levels accompanying the *Compact*. We considered metrics across four domains (structural, system- or policy-level factors; processes of care; biomarkers and behaviours; and health events and outcomes) and three risk tiers (diagnosed diabetes, high risk, or whole population) and reviewed and prioritized them according to their health importance, modifiability, data availability and global inequality. We reviewed global distributions of levels for each metric to set target levels for future attainment. This process led to 5 country-level core metrics and target levels for UN member states: 1) at least 80% of the persons with diabetes are diagnosed; 2) 80% of those with diagnosed diabetes having HbA1c levels below 8.0%; 3) 80% with diagnosed diabetes having blood pressure levels below 140/90 mmHg; 4) 60% with persons aged ≥ 40 with diagnosed diabetes using statins, and, 5) 100% of persons with type 1 diabetes having continuous access to insulin, blood glucose meters and test strips. We also propose several complementary metrics that currently have limited global coverage but warrant scale-up in population-based surveillance systems, including collection of data and estimation of cause-specific mortality, and incidence of end-stage kidney disease, lower-extremity amputations, and incidence of diabetes. Primary prevention of diabetes and integrated care to prevent long-term complications remain important areas to develop and validate new metrics. These metrics and targets are intended to drive multi-sectoral action applied to individuals, health systems, policies, and country-level health care access to achieve the goals of the *Global Diabetes Compact*. Although ambitious, their achievement can result in broad health benefits for the growing global population with diabetes.

Introduction

Diabetes mellitus is one of the world's most challenging public health problems due to its high and growing prevalence and the extensive morbidity it causes, impacting individuals, health systems, and national economies (1, 2). Recent global estimates indicate that 537 million adults have the condition, of whom 80% live in low- and middle-income countries (LMICs) (1, 3). Further, the global impact and costs of diabetes are expected to grow considerably, disproportionately affecting LMICs and the most disadvantaged people of high-income countries (HICs) (4-6).

Despite the relentless growth of diabetes, the pathways to its adverse outcomes are highly modifiable across a broad continuum of its pathogenesis, and many of interventions are cost-effective and feasible to implement. For people with diagnosed diabetes, delivery of essential medications, management of glycaemia and cardiometabolic risk factors, alongside early screening for complications via well-organized care reduce acute and chronic complications and extend life (2, 7-10). Further, type 2 diabetes can be delayed or prevented through intensive lifestyle interventions and medications directed at high-risk individuals alongside population-wide changes to dietary quality, physical activity levels, and levels of obesity (11-15).

Unfortunately, population-based studies have shown that the delivery of evidence-based care for people with diabetes is sub-optimal even in well-resourced health systems. Many countries have high proportions of their populations with diabetes undiagnosed and without timely care for extended periods (16-19). In HICs, the achievement of recommended targets of risk factors or biomarkers for complications such as HbA1c and blood pressure control ranges from 50-70% and only about 20% meet all recommended targets (20-22). Levels are worse in LMICs, where only about half have good glycaemic control and about one in four have good blood pressure control (6, 18, 23). Multicomponent quality-improvement initiatives have shown sustained benefits in achievement of diabetes care goals and reducing vascular complications, even in low resource settings, but have had limited global reach (24). Similarly, the implementation of primary prevention programmes has been variable and non-systematic at best (2, 25).

In the context of a large and growing burden of diabetes-related morbidity and missed opportunities to employ evidence-based care and prevention, the World Health Organization (WHO) recently announced the *Global Diabetes Compact* (26). The *Compact* is intended to stimulate implementation of the Global Action Plan for the Prevention and Control of Non-communicable Diseases (NCDs) 2013-2020 endorsed by World Health Assembly Resolution 74.4 (27). The Global Action Plan calls for formulation of specific coverage and treatment targets to drive action, and assess progress at global and national levels, with attainment by 2030. To do this, it aims to unite diverse stakeholders to achieve targets which reflect common goals of reducing the risk of diabetes and ensuring that all people who are diagnosed with diabetes have equitable access to comprehensive, affordable and quality treatment and care (26). This is inspired by prior successes in HIV and the premise that measurement drives action, including prioritisation of interventions and resources for diabetes at the national, regional, and global levels (28). It also build on recommendations of a recent Lancet Commission that highlighted better measurement at multiple levels as a crucial component of health policy to drive action and reduce the global burden of diabetes (2).

To prioritize metrics and target levels for the *Compact*, WHO assembled a group of experts (the authors) and followed a systematic process (details in the appendix) to organize potential metrics across four domains (policy and system-level factors, processes of care, biomarkers and behaviours, and long-term health outcomes) and three risk tiers (diagnosed diabetes, high risk for diabetes, whole population) and then prioritized metrics according to their health importance, modifiability, data availability, and the degree to which they represent areas of global inequality (29). In this report we propose core and complementary metrics, their definitions, and target levels for the *Global Diabetes Compact* to stimulate global action and describe the scientific basis and justification.

Types and Range of Options for Health Metrics

Target-setting for public health efforts is credited with influencing major successes in public health, ranging from vaccine delivery to the reductions in HIV and CVD-related mortality and has used diverse criteria to establish health metrics and their targets (28, 30). Metrics, or standardized health measurements, can be applied to individuals (e.g. clinical health conditions, biomarkers, or behaviours), or to health care providers and health systems (e.g. indicators of the delivery of interventions, or the

presence of policies, or processes) (31). Metrics may also represent actions or policies taken by broader institutions or governments. For the *Compact*, we organized metrics into four domains: s*tructural, system- or policy-level factors; processes of care; biomarkers and behaviours; and health events and outcomes* (Table 1).

In this framework, structural, system- or policy-level factors address multiple aspects of health services delivery or can target the entire population. For example, multi-disciplinary teams for care management and decision-support via patient registries improves risk factors and management that should improve health outcomes (32-35). Processes of care are essential procedures, such as testing for HbA1c, eye examinations, or foot examinations, conducted by health care providers or individuals on the pathway to affecting biomarkers, behaviours, and long-term health outcomes (36). Intermediate biomarkers and behaviours such as HbA1c, blood pressure, and lipids are prioritised if they are independently associated with long-term diabetes-related health outcomes like microvascular and macrovascular complications, ideally established through randomized controlled trials (2, 7, 8, 37, 38). Finally, diabetes-related health events and outcomes indicators such as incidence of diabetes or its complications (e.g., lower extremity amputations (LEAs), end stage kidney disease (ESKD) represent the key essence of diabetes morbidity that affect quality and length of life that clinical and public health efforts aim to affect (39).

Metrics can also be organized according to a risk tier, defined by the stage of disease that they primarily affect, including persons with diagnosed diabetes, persons at high risk (such as intermediate hyperglycaemia), or the whole population (Table 1). For example, managing blood glucose is particularly important in persons with diagnosed diabetes while improving overall dietary quality and physical activity, and applying taxation or incentivisation policies to promote healthy behaviours is important for the general population (40).

Criteria for Prioritizing Metrics for Diabetes

The selection of any given metric has advantages and disadvantages. For example, reducing health events and outcomes comes closest to the ultimate goals of clinical and public health practices, but can be difficult to measure, difficult to modify in the short term, and is uninformative about what factors are driving change (41). Processes of care may be immediately measurable and responsive to interventions but may not predict health changes well (42, 43). Biomarkers and behaviours are both modifiable and predictive of long-term outcomes and have generally standardized measurement approaches with reasonable global reach (38); however, they often lack consensus on the appropriate target thresholds, and obtaining reliable and comparable measures across different settings is difficult. System and policy-level metrics have wide variation in adoption, can be difficult to implement in the short-term, have modest effect sizes, or inconsistently predict health outcomes at the individual level when achieved (10, 42, 43). However, they have the potential to efficiently affect multiple risk factors and large segments of the population.

The selection of different population risk tiers also has trade-offs. Focusing on people with established disease or high risk may meet immediate health system demands and have more evidence for short-term effectiveness but not achieve the long-term goal of preventing the condition itself. Interventions aimed at the whole population depend upon policy-level interventions that can be difficult to measure and have unclear magnitudes of effect but may have important benefits over longer time horizons (43). Focusing on prevention among at-risk adults with individualized prevention approaches has established effectiveness, but few examples of successful population-wide scale-up exist.

Metrics for *the Compact* have been considered against four main criteria (Appendix page 2). First, priority metrics should be of *intrinsic health importance* or else be a factor or intervention that strongly predicts major health events or outcomes. Second, a good metric should be *modifiable via scalable interventions across diverse settings*. Third, priority metrics should have good global *data availability and acceptable measurement properties,* be reasonably consistent across settings and be measurable through practical surveillance approaches. Fourth, priority metrics should ideally represent a *gap and area of global inequality* that is modifiable. We also classified metrics into "core" metrics for prioritisation by national, regional, or facility-level monitoring systems that can currently be assessed in many countries using health surveys or registries and additional promising "complementary" metrics that require more surveillance infrastructure, scale-up, or international consensus on operational definitions.

Prioritisation and Justification for Metrics

Using the domains of metrics and criteria described above, we propose five core and ten complementary metrics that have the best chance of driving improved care and prevention due to their combination of health importance, modifiability, global data availability, and equity (Figure 1). These metrics can also be organized along a continuum, from the metrics of primary prevention, processes of care, to intermediate and long-term health outcomes. The proposed core metrics and their basic definitions include the following:

1. The proportion of cases that are diagnosed out of the total number with diabetes, with total cases defined by either self-report, taking medications, or having glycemic levels diagnostic of diabetes (FPG > >7mmoll/l(126 mg/dl), random plasma glucose ≥11.1 mmol/l (200 mg/dl), or glycated haemoglobin (HbA1c) ≥6.5%. (44).

2: The proportion of adults with diagnosed diabetes with controlled HbA1c, defined as less than 8% (63.9 mmol/mol).

3: The proportion of adults with diagnosed diabetes who have controlled blood pressure, defined as less than 140/90 mmHg.

4: The proportion of adults with diagnosed diabetes aged ≥ 40 years taking a statin.

5: The proportion of the population with type 1 diabetes having continuous access to insulin, blood glucose meters, and test strips.

The proportion of cases that are diagnosed out of the total number with diabetes (metric #1) is an essential step linking those affected with treatments and preventive screenings for diabetes complications. Although the effectiveness of community-based testing and population-wide screening remains unclear and not established by randomized controlled trials (RCTs) (45, 46), opportunistic testing in clinical practice is recommended if the health care system has capacity to handle increasing case-loads. It has also been shown to be cost-effective in some HICs if paired with identification of high-risk individuals for lifestyle change (9, 47, 48). Further, the levels of diagnosis have been shown to be starkly low in many LMICs (18). The proportion meeting HbA1c levels <8% (metric #2), blood pressure < 140/90 (metric #3), and taking a statin (metric #4) are based on their established importance in reducing risk of acute, microvascular, and macrovascular outcomes (2, 7, 8). Improving blood pressure levels and taking statins reduce risk for CVD events in persons with diagnosed diabetes (2, 49). Ensuring access to insulin and essential monitoring equipment (metric #5) is warranted by the recognized lack of availability and affordability in some settings, with the result of deaths and high complication rates, often among children and young adults (50, 51). Three of the metrics (glycaemic control, blood pressure, and statin use) are highly modifiable using affordable medications available in primary care, particularly if supported by team-based care. Diabetes diagnosis and insulin availability can each be improved through concerted health system or policy-level interventions.

Several additional complementary metrics warrant scale-up in population monitoring settings. *All-cause mortality, end-stage kidney disease,* and *lower-extremity amputations (LEAs)* among the population with diagnosed diabetes (Figure 1) are intrinsically important health outcomes, highly modifiable via established evidence-based practices, and lend themselves to standardized, objective, population-based monitoring. They also represent good sentinel indicators of secondary prevention because they are affected by multiple aspects of recommended care. *Incidence of diagnosed diabetes* is more sensitive to the changes of the diabetes epidemic and is less affected by mortality than is prevalence. However, its assessment requires either very large panel surveys or health system-based registries that are available only in a few countries (52, 53). The percent of cases of type 1 diabetes who have diabetic ketoacidosis (DKA) at diagnosis, is a recognized proxy for timely diagnosis of type 1 diabetes (54). In addition to DKA being a cause of morbidity, subsequent DKA, and mortality, timely diagnosis of type 1 diabetes is considered to be modifiable through improved community awareness about signs and symptoms (54).

Some metrics could conceivably drive important improvements in care and prevention but lack consensus in how to define, quantify, and measure success. For example, improving the delivery and effectiveness of both primary prevention and integrated care are essential to reduce incidence of diabetes, and its complications, respectively. The WHO has recommended goals of reducing by 10% the prevalence of insufficient physical activity and halting the rise in diabetes and obesity, along with

recommending numerous policy and health promotion approaches to improve healthy diet to reduce diabetes risk (27). In addition, the WHO Package of Essential Non-communicable (PEN) disease interventions includes recommendations for healthy lifestyle counselling for diabetes prevention, as well as for organization of care to improve risk factor management (51). In some settings, the proportion of high-risk adults with access to diabetes prevention interventions may be considered for monitoring (14, 55, 56). Similarly, the proportion of patients receiving team-based care with registry-driven decision support are important to facilitate attainment of core targets (2). However, to operationalize both of these metrics, there would need to be investments in adequate data systems and agreement about the standardized definitions and measurement approaches (2, 57).

As diabetes is affected by multiple aetiologies and evidence-based options across stages of disease, there are many other potential metrics. For example, gestational diabetes is an important contributor to the diabetes burden and a potential target for prevention of morbidity, but there remains inadequate global consensus on definition and diagnostic criteria, and there is uncertainty over benefits of screening and long-term benefits of treatment (58). Treatment with guideline-directed medical therapy, such as taking blood pressure- and glucose-lowering medications, are often assessed in cascades of care, and available data suggests that the primary gap in treatment is due to people who have not been diagnosed. Further, the accuracy of treatment status using self-report is unclear and is complicated by the increasing number of medications and drug classes available. In addition, some individuals may be appropriate for management using lifestyle interventions only, which is generally not captured in questions on treatment. Processes of care, including receipt of HbA1c tests, foot, and eye exams are considered essential elements of high-quality diabetes care but are not consistently associated with later health outcomes (10, 36, 43, 59). Additional policy or system-level factors such as policies to increase physical activity remain difficult to measure and there is a lack of agreement about intervention effectiveness (43).

Current Global Status of Metrics: Variation, Levels, and Coverage:

Within metrics, selecting target levels for the *Compact* can be informed by several sources. We synthesized three types of evidence: 1) Recent and current population-based national estimates to provide realistic baselines; 2) Estimates of trends in rates of metrics over time from various settings to identify a plausible and realistic magnitude of change over time; 3) Estimates of projected health benefit and costs associated with meeting versus not meeting targets.

We assembled data from systematic reviews, published sources, and a subset of studies from 65 LMICs from the Global Health and Population Project on Access to Care for Cardiometabolic diseases (HPACC) collaborators using methods described in the Appendix (18, 25, 60). For the complementary metrics, we also assembled data from previously published reviews of diabetes incidence, all-cause and CVD mortality, and incidence of diabetes-related complications (52, 61, 62).

Tables 2 and appendix pages 4-8 present regional and country-specific estimates for core metrics. Levels of each of the core metrics varied considerably around the world. Among all countries, the median percent diagnosed was 61%. Of diagnosed individuals, the median percent with HbA1c <8%, blood pressure <140/90mmHg, and using statins were 68%, 56%, and 12% respectively. Regional median levels of attainment vary considerably, particularly for blood pressure and statin use. Few studies exist on trends in the attainment of these targets over time. As most countries of the world lack any published estimates for these metrics, these medians could underestimate the true global coverage of these targets. Where they exist, they tend to find large increases during the 1990s and 2000s but generally flat or marginally increasing trends since 2010. In the U.S., for example, the proportion meeting targets increased 12-13 percentage points (PPTs) from 1999-2009 but have been relatively stagnant since (20, 22, 63-65).

Published data for LEAs, CVD, and all-cause mortality among persons with diabetes, and incidence of diagnosed diabetes is mostly limited to high-income countries (53, 61, 62, 66) (Table 3). For example, rates of LEAs across most countries range from 4 to 35 per 10,000 per year with an average of about 16-18 per 10,000 per year. Annual rates of all-cause mortality vary from 10 to 60 per 1000, with an average of about 23. Estimates for diabetes related ESKD use the overall population as the denominator; thus, the increase in ESKD incidence observed across most countries is affected by the increasing prevalence of diabetes. The annual incidence of diagnosed diabetes tends to range from 1 to 10 per 1000, with an average of roughly 7 per 1000. Although these metrics lend themselves to

international standardization, existing published estimates are difficult to compare because of variations in sampling methods and denominators, outcome definitions, and population standardization approaches (67). For these reasons, as well as the lack of availability in current surveillance systems, the *Compact* did not set global targets for the complementary metrics.

Few studies have examined the health effects that could be achieved by changing target levels. Each of the core metrics has established cost-effectiveness or is cost saving with the exception of screening for undiagnosed diabetes, wherein some degree of targeting by age and risk is required to make it cost-effective (47, 60). Quality improvement programs have achieved reductions in HbA1c, blood pressure, and lipid levels that would be expected to reduce CVD incidence and all-cause mortality by 40% (68). Similarly, model-based estimates from a recent Lancet Commission also suggest that the application of integrated care to improve diabetes care and prevention targets could reduce cardiovascular (CVD) complications of diabetes by half and for those with poor control, increase life expectancy by 5 years from age 40 (2). A recent study using STEPwise approach to NCD risk factor surveillance data from 67 LMICs and microsimulation modelling found that enhancing diagnosis and glycaemic control leads to 8 to 18% reduction in microvascular outcomes (neuropathy, ESKD, retinopathy) while meeting blood pressure and statin targets has similar effects on macrovascular outcomes (60). Achieving 60% on diagnosis, treatment, and all three control metrics (glycaemia, blood pressure, and statin use) reduces CVD deaths by >40%, consistent with findings from a recent Lancet Commission (2).

Recommending Target Levels for Metrics

Selection of target levels ultimately requires a difficult balance between being ambitious yet attainable. Table 4 presents proposed target levels for the core metrics. Our review suggests that target levels of 80% for the proportion of persons with diabetes who are diagnosed, and among those with diagnosed diabetes, 80%, 80%, and 60% meeting targets for HbA1c (<8%), blood pressure (<140/90mmHg), and statin use, respectively are achievable and would have large health benefits in many countries of the world. The gaps between current levels of attainment and the proposed targets vary considerably by region and country of the world. These target levels are generally consistent with the top 85 to the 100th percentile of countries of the world that currently have data.

Based on current estimates, meeting the target of 80% of persons with diabetes being diagnosed will require an average 19 percentage point (PPT) increase, ranging from 6 to 25 PPT across regions. Current levels of attainment of 80% of patients with diagnosed diabetes having glycemic control < 8% will require a 12% PPT increase, ranging from 3 to 25 PPTs across regions; achieving the goal of blood pressure <140/80mmHg are highly variable and will require a 24 PPT increase globally and require an increase of 2 to 35 PPTs across regions. Current levels of attainment of the statin target are considerably below 60%, ranging from 10% to 25% across all regions outside of North America, where it is 57%. Thus, meeting the statin target will likely require substantial country-level policy actions, and country-specific target setting may again be appropriate. For the insulin availability metric, we propose an ambitious target of 100% because of insulin's essential role in survival of persons with type 1 diabetes.

Setting targets for the complementary targets of incidence of diagnosed diabetes, and among persons with diagnosed diabetes, LEAs, ESKD, and mortality rates is difficult because of the high degree of baseline variability and the further needs in standardization of metrics. However, preliminary data suggests that country-level relative reductions of 50% over 10 years may be appropriate.

Monitoring and Achieving Global Targets

Long-term success of the *Global Diabetes Compact* will also depend upon consistent and accurate monitoring of the targets accompanied by continued support and strengthening of comprehensive NCD surveillance systems. The assessment of core targets of percent diagnosed and percent with HbA1c and blood pressure control and statin use can be conducted via population-based surveys such as STEPs with inclusion of HbA1c and blood pressure measurement for people with previously diagnosed diabetes. However, many STEPS surveys lack adequate sample sizes to monitor trends within countries, with precision, over time. Additionally, frequency and country-coverage of STEPs surveys is limited. Although population monitoring of insulin availability remains a challenge, it can be improved via other surveillance systems such as the WHO biennial Country Capacity survey and the WHO MedMon surveys for monitoring health service availability and prices of medicines (50, 69)

(70-73). However, to be effective for monitoring, many of these surveys require increased geographical reach and frequency of data collection. Thus, for optimal monitoring of core, complementary, and future metrics should be complemented by other national surveys, data pooling studies, health systems-based registries, and new WHO efforts supporting facility-based monitoring of quality of care. Such expansion will also require further consensus-based development of standardized definitions, methods, and target levels. Unfortunately, there is great variation and disparities in the availability of population-based data; LMICs often lack population data apart from in those who conduct STEPs surveys, making the complementary metrics especially lacking. This underscores the need for concentrated efforts to develop new efficient ways of measuring levels of risk, care, and disease in populations.

The *Compact* focuses most on metrics which reflect diagnosis and reduction of reducing complications through risk factor control and access to essential medications for persons with diabetes. However, they should be viewed in the context of broader approaches to prevent and control NCDs by ensuring health care access and strengthening health systems around primary care to reduce modifiable risk factors and address underlying social determinants of health (27). The Compact supports the implementation of the six work streams and complements NCD targets of the WHO Global action plan for the prevention and control of NCDs. It is also supported by recent Lancet Commissions addressing the global challenges of using data to transform diabetes care globally and in Sub-Saharan Africa (2, 6, 27, 74). Priorities of the Global Action Plan range from scaling up diagnosis and medication availability to improving skills and competencies, and to building clinical decision supports and population monitoring systems (Table 5). They are also an extension of the targets on treatment coverage of people at risk of heart attacks and strokes; reduction in the prevalence of raised blood pressure and availability and affordability of essential medicines and basic technologies to treat major noncommunicable diseases. The breadth of the diabetes challenge also calls for efforts to reduce diabetes incidence through a combination of individual-targeted and population-wide approaches. Thus, the metrics should not be viewed as covering the comprehensive set of objectives necessary to impact the full breadth of the current diabetes problem. However, achieving them can be expected to make an important impact on the global burden caused by diabetes.

Summary: The WHO Global Diabetes Compact aims to unite key international stakeholders around ambitious but achievable goals that will lead to a reduction in the diabetes burden. This report prioritises the core and complementary metrics to serve as catalysts for action and a framework for monitoring progress toward the core metrics of improving diagnosis, HbA1c, blood pressure, statin use, and for T1DM, ensuring insulin and supplies. The targets represent key conduits to long-term health for people with diabetes, achieving them can be expected to lead to substantial population-level reductions of diverse macrovascular, microvascular, acute complications for both T1DM and T2DM. In addition, developing improved data systems that can measure complementary metrics will be of great value in LMICs as such data are currently lacking. Most important, the development and innovation in health financing, access to care, improving health systems and promotion can pay off in health outcomes for the metrics being promoted. Achieving the overarching goals of the *Global Diabetes Compact* will require multi-sectoral efforts applied to individuals, health systems, policies, and country-level actions.

FIGURE AND TABLE LEGENDS

Figure 1. Proposed core, complementary, and base metrics for the *Global Diabetes Compact.*

Legend: Recommended core metrics shown in black, complementary metrics in blue, and base metrics in green. The core metrics are intended for priority implementation by UN member states and monitoring by the *Global Diabetes Compact*. The complementary metrics currently lack adequate global data availability or consensus-based definitions but should be considered for scale-up in population health data and surveillance systems.

Table 1. Range of potential metrics for the *Global Diabetes Compact*, stratified by domain and risk tiers.

Table 2. Median levels of percent of the population attaining target levels for core metrics for all regions of the world, and according to world region.

Legend: Estimates assembled from four primary types of sources: IDF Diabetes Atlas, Global Health and Population Project on Access to Care for Cardiometabolic diseases (HPACC) collaborators, literature reviews, and web-sites containing estimates from national diabetes surveillance systems. References listed in Appendix.

Table 3. Published estimates for complementary metrics among people with diabetes in WHO member states.

Legend: DM: diabetes mellitus; IR: Incidence rate; ESRD: End stage renal disease; DKA: diabetes keto-acidosis.(39, 54, 75-107) (108)

Table 4. Summary of global medians, 90th percentiles, and proposed targets for core metrics of the *Global Diabetes Compact*.

Legend: Estimates assembled from four primary types of sources: IDF Diabetes Atlas, Global Health and Population Project on Access to Care for Cardiometabolic diseases (HPACC) collaborators, literature reviews, and web-sites containing estimates from national diabetes surveillance systems. References listed in Appendix.

Box 1. Diabetes-relevant priorities of the Global Action Plan for the Prevention of Non-Communicable Diseases.

Legend: Based on World Health Organization. Global action plan for the prevention and control of noncommunicable diseases 2013-2020. World Health Organization. 2013.

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EG designed and wrote most of the manuscript and coordinated data collection. JB, BG, and RM collected data and conducted literature reviews. MA, JD, LL, JMG, NS, GR, SS, and JPS served on consensus-based work group prioritising metrics, reviewed data, and contributed to writing and reviewing the manuscript. JM, DF, and JD assimilated data for HPACC and DF analysed data and coordinated contributions of the HPAAC team.

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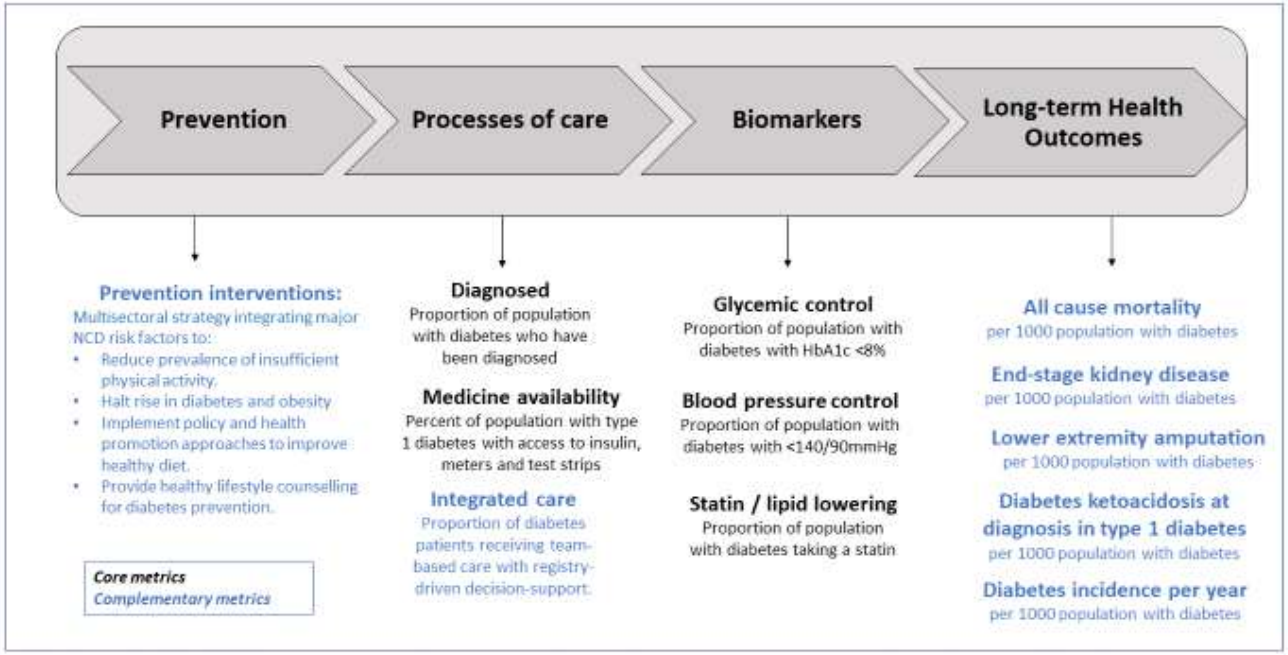
Table 1: Potential metrics for the *Global Diabetes Compact*, stratified by domain and risk tiers.

Population Segment	Structural, system, or policy factors	Processes of care	Biomarkers and Behaviours	Health events and outcomes
Diagnosed diabetes	National or regional DM registry Guidelines and dissemination efforts Presence of Decision support tools Facilities with essential medicines Policies for low cost medication availability	Diagnosis of diabetes Receiving treatment among diagnosed Availability of essential medicines Team-based care Statin use Diabetes education Vaccinations Foot exam Eye exam Renal testing	Glycaemic control Controlled blood pressure Controlled lipids Microalbuminuria	Diabetes prevalence Diabetes incidence Hyperglycaemic emergencies DM-related death DM-related hospitalisation CKD prevalence Incidence of LEA Retinopathy prevalence Incidence of ESKD Incidence of CVD events Incidence of CVD death
High risk	Support for nutritional counselling Support for structured LSI Guidelines for testing and referral	Structured lifestyle programme Counselling for diet/exercise Testing for diabetes Metformin prescriptions Glycaemic assessments for GDM	Intermediate hyperglycaemia Controlled blood pressure Controlled Lipids Body mass index	Diabetes prevalence Diabetes incidence
Whole population	Facilities with essential medicines Promotion of healthy diet Policy to increase physical activity Incentives for healthy diet programmes Food policy taxation (SSBs) Policies for smoking prevention	Smoking cessation services Proportion of population with healthcare coverage for DM and CVD risk factors	Physical activity levels Body mass index Fruit and vegetable consumption	Diabetes prevalence Diabetes incidence

GDM: gestational diabetes mellitus; LEA: lower extremity amputation; CKD: chronic kidney disease; ESKD: end stage kidney disease; SSB: sugar-sweetened beverages; LSI lifestyle intervention; DM: diabetes mellitus

Figure 1. Proposed core, complementary, and base metrics for the *Global Diabetes Compact*.



Recommended core metrics shown in black and complementary metrics in blue. The core metrics are intended for priority implementation by UN member states and monitoring by the *Global Diabetes Compact*. The complementary metrics currently lack adequate global data availability or consensus-based definitions but should be considered for scale-up in population health data and surveillance systems.

Table 2. Median levels of percent of the population attaining target levels for core metrics for all regions of the world, and according to world region.

		Diagnosed / total diabetes population	Glycaemic control (HbA1c <8%) / diagnosed diabetes (%)	Blood pressure control (<140/90mmHg) / diagnosed diabetes	Statin / diagnosed diabetes population
All regions	Mean	61.1	66.8	54.0	22.8
All regions	Median	61.4	67.6	55.6	12.3
All regions	IQR	22.2	15.3	20.9	25.8
East Asia & Pacific		54.9	58.9	54.7	12.3
Europe & Central Asia		74.0	77.1	50.0	12.1
Latin America & Caribbean		71.8	68.2	65.4	10.0
Middle East & North Africa		58.9	67.6	50.8	25.1
North America		69.7	75.5	78.3	56.8
South Asia		56.3	67.3	52.8	13.4
Sub-Saharan Africa		57.6	54.7	44.8	23

Table 3. Summary of developmental metrics among people with diabetes in WHO member states.

Country	Income	DM IR†	All-cause mortality rate §		ESRD IR†	LEA IR†	DKA Prevalence
			Male	Female			
East Asia & Pacific							
Australia	HIC	30.0	3070	2630	-	35.0	24.9
Japan	HIC	88	-	-	-	-	-
New Zealand	HIC	-	-	-	-	-	26.3
Singapore	HIC	70.2	-	-	-	-	-
South Korea	HIC	54.9	940*	-	-	-	-
Data unavailable for 24 countries							
Europe & Central Asia							
Austria	HIC	-	-	-	-	-	38.0
Czechia	HIC	-	-	-	-	-	28.8
Denmark	HIC	31.6	4560	4460	-	-	20.7
Finland	HIC	35	4260*	-	-	4.8	-
France	HIC	79.5	-	-	-	15.8	-
Germany	HIC	87	-	-	16.7	4.8	26.8
Hungary	HIC	40.2	4380	4000	-	-	-
Ireland	HIC	-	-	-	-	17.6	-
Italy	HIC	40	3450*	-	10.4	15.3	41.2
Latvia	HIC	31.6	5470	4380	-	-	-
Lithuania	HIC	25.5	5000	4350	-	-	-
Luxembourg	HIC	-	-	-	-	-	43.8
Netherlands	HIC	37.3	970	880	-	25.1	-
Norway	HIC	39.8	3470	3620	-	-	22.1
Portugal	HIC	97.2	-	-	-	-	-
Slovenia	HIC	-	-	-	-	-	40.3
Spain	HIC	47.1	3460	3550	5.9	34.4	-
Sweden	HIC	-	3380*	-	-	-	19.5
UK	HIC	36.9	2100	2240	15.5	4.2	25.0
Ukraine	LMIC	11.1	-	-	-	-	-
Russia	UMIC	-	2320	-	-	-	-
Data unavailable for 28 countries							
Latin America & Caribbean							
Brazil	UMIC	200			-	-	-
Colombia	UMIC	-			-	-	-
Mexico	UMIC	144	-	-	-	-	-
Peru	UMIC	195	-	-	-	-	-
Data unavailable for 27 countries							
Middle East & North Africa							
Israel	HIC	108	1070*	-	-	-	-
Data unavailable for 18 countries							
North America							
Canada	HIC	62.1	1220*	-	13.3	-	-
USA	HIC	71	6400*	-	20	28.4	36.9
South Asia: Data unavailable							
Sub-Saharan Africa: Data unavailable							

†Incidence Rates per 10,000 person-years; § Mortality rate per 100,000 people; *Total for both sexes

Table 4: Summary of global medians, 90th percentiles, and proposed targets for core metrics of the *Global Diabetes Compact*.

Core Metric	Definition	Global median (%)	Global 90th percentile (%)	Proposed Global Target (%)
Percent diagnosed	Number diagnosed divided by number with clinical diabetes	64	76	**80**
Glycaemic control	Number controlled (HbA1c < 8%) divided by total diagnosed diabetes	68	84	**80**
Blood pressure control	Number controlled (BP < 140/90) divided by total diagnosed diabetes	53	70	**80**
Statin treated	Number treated with statin divided by total with diagnosed diabetes	12	47	**60**
Medicine availability	Availability of insulin, meters, and glucose test-strips for persons with type 1 diabetes	N/A	N/A	**100**

Box 1. Diabetes-relevant priorities of the Global Action Plan for the Prevention of Non-Communicable Diseases.

- Scaling up diagnosis of diabetes to initiate cost-effective medical and behavioral risk factor management.
- Improving availability, affordability, and equitable access to essential medicines, including life-saving insulin, and technologies.
- Enhancing skills and capacity of health care providers to provide team-based comprehensive care for diabetes management.
- Establishing continuous quality improvement systems for disease management and prevention with an emphasis on evidence-based guidelines, treatment protocols, and decision tools.
- Improving information management and sharing across settings to optimize the ability of local data registries and electronic medical records to support clinical and health services decisions.
- Development of facility- or health-system level diabetes registries where feasible to assist in both patient care and population monitoring.

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