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Improving Health Outcomes of People with Diabetes Mellitus: Global Target Setting to Reduce the Burden of Diabetes Mellitus by 2030

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Abstract

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) has initiated the *Global Diabetes Compact* to prioritize evidence-based interventions, resources, and objective-setting to reduce the global burden of diabetes. In this report we describe the scientific basis that informed the recommendations of the key health objectives and target

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levels for the *Compact*. We considered metrics across 4 domains (structural, system- or policy-level factors; processes of care; biomarkers and behaviours; and health events and outcomes) and risk tiers (diagnosed diabetes, high risk, or whole population). An expert group reviewed and prioritized metrics according to their health importance, modifiability, data availability, and the degree to which they represent gaps and areas of global inequality. We reviewed global distributions of levels for each metric of interest 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 should be 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 diagnosed diabetes using statins, and, 5) 100% of persons with type 1 diabetes having continuous access to insulin, blood glucose meters andtest strips. In addition, we propose several complementary metrics that currently have limited global coverage but warrant surveillance scale-up. These include, among persons with diabetes, documentation and routine collection of all-cause and cause-specific mortality estimates, and incidence of end-stage kidney disease, lower-extremity amputations, and incidence of diabetes. We also identified important areas for which the development of metrics is still required, including primary prevention of diabetes and integrated care. Achieving the overarching goals of the *Global Diabetes Compact* will require multi-sectoral efforts applied to individuals, health systems, policies, and country-level actions.

BACKGROUND AND RATIONALE

Diabetes mellitus is one of the world's most challenging public health problems due to its high and growing prevalence and the diverse and 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 continue 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 other 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 or through 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 diabetes[16] populations undiagnosed and without timely care for extended periods[17–19]. In HICs, the achievement of recommended targets of risk factor for complications such 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[6,18,23,24]. Multicomponent quality-improvement initiatives have shown sustained benefits in achievement of diabetes care goals and vascular complications, even in low resource settings, but have had limited global reach[25,26]. Similarly, the implementation of primary prevention programmes has been variable and non-systematic at best[2,27].

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 *Compact*[18,27,28]. Building on the Global Action Plan for the Prevention and Control of NCDs and on resolution 74.4 of World Health Assembly (Reducing the burden of non-communicable diseases through strengthening the prevention and control of diabetes), the Global *Diabetes Compact* sets priority metrics and target levels to serve as diabetes-related health objectives for all countries of the world to achieve by 2030. Based on prior successes in HIV[29] and the premise that measurement drives action, the *Compact* targets are intended to drive prioritisation of interventions and resources for diabetes at the national, regional, and global levels[30,31].

Setting targets for diabetes is challenging because of the breadth and diversity of the problem, as there are opportunities to affect risk for diabetes, progression, and outcomes across the disease course. The various targets include risk factors for diabetes in the whole population, progression to diabetes in high-risk populations, and preventing complications and mortality among those with diabetes. At the same time, it is important that health objectives be focused, parsimonious, simple, and relatively easy to measure.

In this report we describe the scientific basis that informed the selection of key health objectives and target levels for the *Global Diabetes Compact*. To do this, we review and describe the range of options for target metrics, including their strengths, weaknesses, and feasibility to measure and implement. Based on this literature synthesis and systematic prioritization process, we propose core and complementary metrics, their definitions, and target levels for the *Compact* to stimulate global action.

SUMMARY OF METHODS AND APPROACH:

To prioritize metrics and target levels, we used the following process (Figure 1). First, we organized potential metrics across 4 domains (policy and system-level factors, processes of care, biomarkers and behaviours, and long-term health outcomes) and risk tiers (diagnosed diabetes, high risk for diabetes, whole population)[32]. Second, the authors reviewed, scored and filtered, and then prioritized metrics through a consensus-based process according to their health importance, modifiability, data availability, and the degree to which they represent areas of global inequality. This led to a set of “core”, “complementary”, and “base” metrics. 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, and thus are currently unsuitable for recommendation as core *Compact* metrics but should be considered for scale-up in population health data and surveillance systems. Base metrics

are additional processes or health indicators that are essential for the calculation of core and complementary metrics. Third, we reviewed published and unpublished data on the current levels of attainment of the chosen metrics, by global region and country and evidence from modelling-based studies to estimate the expected health impact of meeting different target levels. Fourth, we used the information and evidence from these steps to propose a set of *target levels* for core metrics. Finally, the proposed metrics and target levels were presented to a WHO-convened, international review panel and reviewed by member states' ministries of health and WHO regional offices. Our recommendations incorporate input from all steps in this process.

SCIENTIFIC RATIONALE AND OPTIONS FOR METRICS AND TARGETS

Taxonomy 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[29] Numerous criteria have been used to establish health metrics and their targets. Metrics 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)[33]. Metrics may also represent actions or policies taken by broader institutions or governments. For the *Compact*, we have organized metrics into four domains: s*tructural, system- or policy-level factors; processes of care, intermediate outcomes, 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, systematic reviews have shown that the assembly of multi-disciplinary teams for care management and decision-support via patient registries improves risk factors and management that should improve health outcomes [34–38]. *Processes of care* are procedures conducted by health care providers or individuals or steps that are considered essential on the pathway to affecting biomarkers, behaviours, and long-term health outcomes[39]. For example, dilated eye exams, foot exams, and regular monitoring of cardiovascular, renal, and metabolic indices are considered crucial to the prevention of diabetes complications. Similarly, monitoring the uptake of lifestyle interventions is important, as such interventions reduce the incidence of diabetes [13,14]. Intermediate outcomes are *biomarkers and behaviours* that were selected if they have been shown to be independently associated with long-term diabetes-related health outcomes, ideally established through randomized controlled trials. For example, reducing HbA1c, blood pressure, and lipids are associated with reduced microvascular and macrovascular health outcomes and related mortality[2,7,8,40,41]Finally, diabetes-related *health events and outcomes* are defined as those that have a direct impact on individual-level quality of life or health system burden and differentiate health outcomes in the diabetes population from those without diabetes (Table 1). They may include indicators of disease burden like diabetes prevalence and incidence, as well as the incidence of diabetes-related complications like lower extremity amputations (LEAs), end-stage kidney disease (ESKD), or CVD mortality[42]..

The metrics can also be organized according to the *risk tier* or stage of the 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 likely most important in persons with diagnosed diabetes and improving overall dietary quality and physical activity, or applying policies such as taxes or incentives to promote healthful behaviours may be particularly important in the general population[43].

Criteria for Prioritizing Metrics for Diabetes

The selection of any given metric has advantages and disadvantages. For example, reducing *health events and outcomes* are 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 are uninformative about what factors are driving change[44]. *Processes of care* may be immediately measurable and responsive to interventions in the short term but may not predict health changes well[1,45,46]. *Biomarkers and behaviours* are both modifiable and predictive of long-term outcomes, have generally standardized measurement approaches with reasonable global reach[41]; however, there is a lack of consensus on the appropriate target thresholds, and obtaining reliable and comparable measures across different settings can be 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[10,45,47]. 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[45]. Focusing on prevention among at-risk adults with individualized prevention approaches has established efficacy but few examples of successful population-wide scale-up exist.

To prioritize metrics for *the Compact*, we considered their performance against four main criteria (Table 2)[16,33]. 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. The best core metrics should score well on all criteria, but data availability is a particular limiting factor. For the *Compact* to proceed with 2030 targets and determine recent or current levels as a baseline it is essential to use metrics that do not require new infrastructure development to collect.

Once metrics are identified, the selection of appropriate target levels presents an additional challenge. Health targets should ideally be specific, measurable, achievable, realistic, and time bound (SMART)[48], [16,33] They should also be ambitious enough to affect health

outcomes, which can present a difficult balance to achieve alongside the need to be realistic and achievable. Many approaches have been used to set targets in public health efforts[33]. Some approaches start with a static baseline level and then assign a relative or absolute percentage improvement, or calculate a target based on the minimally statistically significant change. Other methods evaluate the baseline trend and set the target to either maintain or add a percentage improvement to the slope. Others assign targets to be consistent with clinical guidelines. Finally, other approaches set fixed targets to be applied universally across settings, using the best current level across the subgroups, or else by setting an optimal level based on consensus and multiple criteria. If biomarkers are to be expressed as dichotomous targets, they also require a decision about the threshold to be used. This is typically based on clinical guidelines but sometimes aims to identify a level of risk that represents poor care or high risk for which virtually all settings should aim to reach. We considered each of these methods and data summarized below to arrive at consensus-based recommendations.

PRIORITIZATION OF METRICS AND TARGETS

Using the categories of metrics described in Table 1 and the criteria described in Table 2, these led to 5 core, 10 complementary, and two base metrics that have the best combination of health importance, modifiability, global data availability, and equity (Figure 2). These metrics can also be organized along a continuum, from the base metrics that are essential to understand the general status of the epidemic (e.g., prevalence) and to assemble essential data to calculate metrics, to metrics of prevention, processes of care, and then to the outcomes essential to estimate health impact. The primary distinction between core and complementary metrics are that core metrics can currently be assessed in many countries using health surveys or registries, whereas complementary metrics require more surveillance infrastructure, scale-up, or international consensus on operational definitions and measurement specification.

Core Metrics

The proposed core metrics include the following:

1. *The proportion of cases that are diagnosed out of the total number with diabetes*. The total number with diabetes is defined by either self-reported prior diagnosis, taking diabetes medications, or having elevated HbA1c or fasting glucose.
2. The proportion of adults with diagnosed diabetes with controlled HbA1c, defined as less than 8%.
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..

Diagnosis of diabetes was selected as a core metric because it is an essential step in 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)[49,50], opportunistic testing in clinical practice is recommended if the health care system is considered sufficient 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[9,51,52]. Further, the levels of diagnosis have been shown to be starkly low in many LMICs[18,24]. Attaining good HbA1c control reduces risk of acute, microvascular, and to a lesser extent, macrovascular outcomes [2,7,8]. Improving blood pressure levels and taking statins reduce risk for CVD events in persons with diagnosed diabetes[2,53]. Ensuring insulin access was prioritized because of its recognized lack of availability in some settings, with the result of deaths and high complication rates, often among children and young adults,[54,55].

Three of the metrics (glycaemic control, blood pressure, 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. The metrics can be quantified with STEPs surveys or other nationally representative surveys[56] or via other WHO surveillance systems such as the WHO biennial Country Capacity survey[57–59].

These metrics may also be specified in different ways. If data are collected from respondents with both diagnosed diabetes and undiagnosed diabetes, countries will have the option of considering levels of control among the total population with diabetes as the denominator instead of those with diagnosed diabetes[60]. A potentially more precise formulation of diagnosis over time is the number of undiagnosed cases divided by the number without diagnosed diabetes (i.e, undiagnosed cases plus non-cases)[61], but this alternative metric is less intuitive to policy makers and has not been applied internationally.

Complementary and Base Metrics:

Several additional complementary and base metrics are important to monitor delivery of evidence-based interventions or are long-term health outcomes of diabetes. *All-cause mortality in people with diabetes, end-stage kidney disease*, and *lower-extremity amputations* among the population with diagnosed diabetes were each prioritized because they 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 an important metric because it reflects a change in the direction of the diabetes epidemic with more sensitivity and is less affected by mortality than is prevalence. However, its assessment requires either very large panel surveys or population-based registries that are available only in a few countries[62,63]. A fifth metric, 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[64]. In addition to being a cause of morbidity, subsequent DKA, and mortality, timely diagnosis of type 1 diabetes is considered modifiable through improved community awareness about signs and symptoms of type 1 diabetes[64].

Improving the delivery and effectiveness of both primary prevention and integrated care are also essential to reduce incidence of diabetes, and its complications, respectively. However, both areas lack consensus in how to quantify and measure success. 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[30]. In addition, the WHO Package of Essential Noncommunicable (PEN) disease interventions includes recommendations for healthy lifestyle counselling for diabetes prevention, as well as for organization of care to improve risk factor management[65]. In some settings, the proportion of high-risk adults with access to diabetes prevention interventions may be considered[14,66,67]. 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 of these interventions as well about measurement approaches[68,69]. In addition to the core and complementary metrics, having a national or sub-national population survey in place and measuring diabetes prevalence (Figure 1) with both self-report and some type of glycaemic measures are essential base metrics for the calculation of core metrics, as well as for ongoing monitoring.

Additional potential metrics:

As diabetes is affected by multiple aetiologies and evidence-based options across stages of disease, there are many other potential metrics. *Gestational diabetes* is an important contributor to the diabetes burden and a key target for prevention of morbidity, but there remains little global consensus on definition and diagnostic criteria, and there is uncertainty over benefits of screening and long-term benefits of treatment[70]. *Treatment with guideline-directed medical therapy, such as taking blood pressure- and glucose-lowering medications*, are often used as metrics 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. However, they were not prioritized because they are inconsistently associated with later health outcomes [10,45,46]. Additional *policy or system-level factors* such as policies to increase physical activity were not prioritized because of difficulties in measurement and lack of agreement about intervention effectiveness[45]. *Upstream risk factors* such as body mass index, physical activity levels, and dietary behaviours were also considered but not prioritized because of either difficulty in measurement or lack of agreement about the feasibility of altering them, or inadequate specificity in predicting diabetes incidence or complications.

CURRENT GLOBAL STATUS OF METRICS; VARIATION, LEVELS, AND COVERAGE

To inform the selection of target levels for the metrics for the *Compact*, 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.

Region and country-specific estimates.

We assembled data from systematic reviews, a subset of studies from 65 LMICs from the Global Health and Population Project on Access to Care for Cardiometabolic diseases (HPACC) collaborators, and from published estimates from 26 HIC estimates containing levels for the metrics specified and selected for *the Compact*[18,71 24 60]. The HPACC is a pooled dataset of WHO STEPS and other nationally representative population-based surveys. As the sample size of persons with diagnosed diabetes was small for many studies, we only used the subset of studied with at least 150 persons in the metric denominator[18,24]. 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[62,72,73].

Tables 3–4 and appendix tables and figures 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 64% (interquartile range 14%). Of diagnosed individuals, the median percent with HbA1c <8%, blood pressure <140/90mmHg, and using statins were 68%, 52%, and 12% respectively. Few studies exist on trends in the attainment of these targets over time. 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 [20,22,74–76].

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[63,72,73,77] (Table 4). Where data exist, absolute rates vary considerably due to variation in the sampling approach, the outcome definition, and in the true underlying rate. For example, rates of LEAs across most countries range from 5 to 34 per 10,000 per year with an average of about 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[78]. For these

reasons, as well as the lack of availability in current surveillance systems, the *Compact* did not set global targets for these conditions.

Estimating health impact of meeting core metrics

Few studies have examined the health effects that could be achieved by changing target levels. Each of the core metrics has well-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[51]. 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%[79]. 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 comprehensive study using STEPs data from 67 LMICs and microsimulation modelling found that increasing the percentage of the diabetes population that is diagnosed or who achieve glycaemic control by 10 PPTs reduced 10-year risk of microvascular disease complications (neuropathy, ESKD, retinopathy) but has a negligible effect on CVD[60]. An equivalent improvement in the proportion having controlled blood pressure control decreases 10-year risk of CVD events, ESRD and retinopathy by 8-18% while increasing the proportion meeting lipid goals by the same magnitude decreases 10-year CVD risk by 10%. 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[68]. The study also found that achieving targets was cost-effective below WHO thresholds for cost-effectiveness [71].

RECOMMENDED TARGET LEVELS FOR CORE METRICS

Selection of target levels ultimately requires a difficult balance between being ambitious, realistic, and obtainable. Table 5 presents recommended 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 ambitious but 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.

Our review suggests that for the percent diagnosed metric, meeting the 80% target will require increases of 10 to 28 PPT improvements across regions. Meeting the target of 80% of persons with diagnosed diabetes having HbA1c levels <8% will require an average 12 PPT increase, ranging from 0 to 22 PPT across countries. Current levels of attainment of 80% of patients with diagnosed diabetes having blood pressure <140/80mmHg are highly variable and will require a 27 PPT increase globally; current gaps range from 10 PPT in North America to ~25-35 PPT in most 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 60%. 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 *Compact* targets as well as continued support and strengthening of comprehensive NCD surveillance systems. The assessment of core targets can be conducted via population-based surveys such as STEPs with inclusion of HbA1c measurement. However, few STEPs surveys have adequate sample sizes to assess metrics with high precision. Typical cross-sectional surveys with 2000 to 4000 participants have between 100 and 500 participants with diagnosed diabetes, which yields confidence intervals around core metrics of 10 to 20 percentage points. This may be adequate to assess whether a country is meeting a target at a single point in time, but generally insufficient to monitor trends over time. Thus, it will be important for member states to evaluate sample sizes and consider additional strategies (e.g., aggregating successive surveys; over-sampling) or monitoring systems in their evaluation plans. Additionally, to assess progress to achieving these targets will require repeated surveys, which many countries have yet to conduct. Alternatively, a sampling of sentinel facility or health systems may be considered.

The *Global Diabetes Compact* is intended to drive country-level efforts to strengthen national capacity, leadership, and multi-sectoral action, with a particular focus on achieving universal health coverage, strengthening and orienting health systems around NCDs through primary care, reducing modifiable risk factors and underlying social determinants of health, and strengthening surveillance and monitoring. Adoption of the complementary targets related to long-term health outcomes (i.e., diabetes complications) will generally require new surveillance systems, such as condition-specific or population registries based on linkage of primary and secondary care, medications and laboratory values, as well as additional consensus-based agreement on specific epidemiologic definitions. The proposed metrics for prevention interventions and integrated care are conceivably attainable through modification of current surveys and surveillance systems but require further consensus-based development of definitions, methods of assessment, and target levels.

Although the *Global Diabetes Compact* focuses on diagnosis and reducing complications through risk factor control and access to essential medications for persons with diabetes, the breadth of the diabetes challenge calls for efforts to reduce diabetes incidence through a combination of individual-targeted and population-wide approaches. Effective lifestyle-based prevention will relieve the burden on health systems while improving metabolic and

cardiovascular risk factor profiles. Thus, the *Compact* should be viewed in the context of broader approaches to reduce the burden of diabetes through prevention as well as through efforts to ensure health care access and strengthening of health systems. As such, it is related to and builds on UN roadmaps for NCD prevention and is supported by recent Lancet Commissions addressing the global challenges of using data to transform diabetes care globally and in Sub-Saharan Africa[2,6,30,31] . The priority actions range from scaling up diagnosis and medication availability to improving skills and competencies, to building clinical decision supports and population monitoring systems (Table 6). The metrics and targets are not intended to cover the full range of health objectives and actions to address the needs of the diabetes epidemic. Rather, they are intended to capture areas of missed opportunity and be an important first step. The goals are clearly measurable and, if attained, will have significant impact on health outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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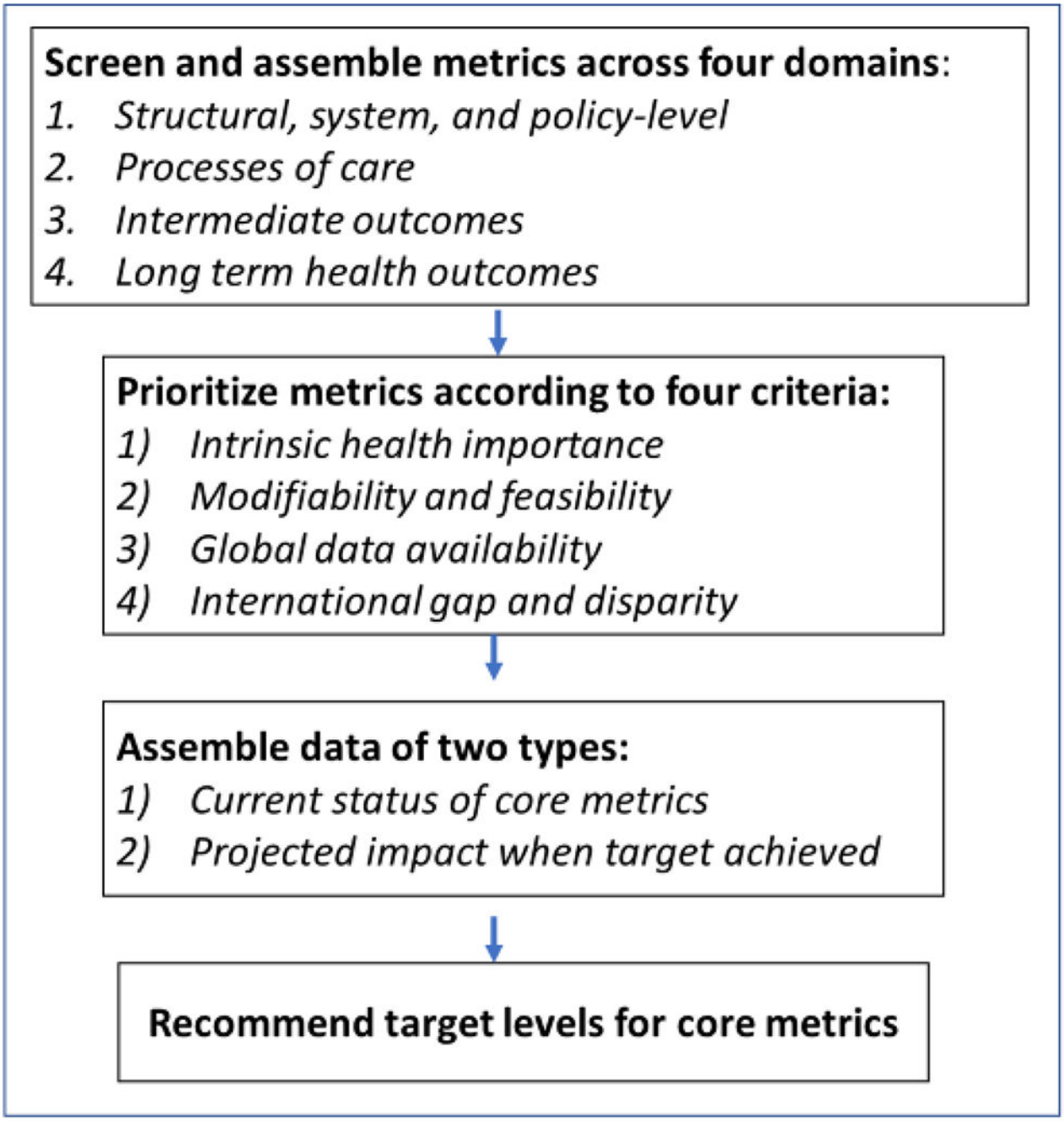

Figure 1.
Methods and steps to recommend *Global Diabetes Compact* metrics and targets.

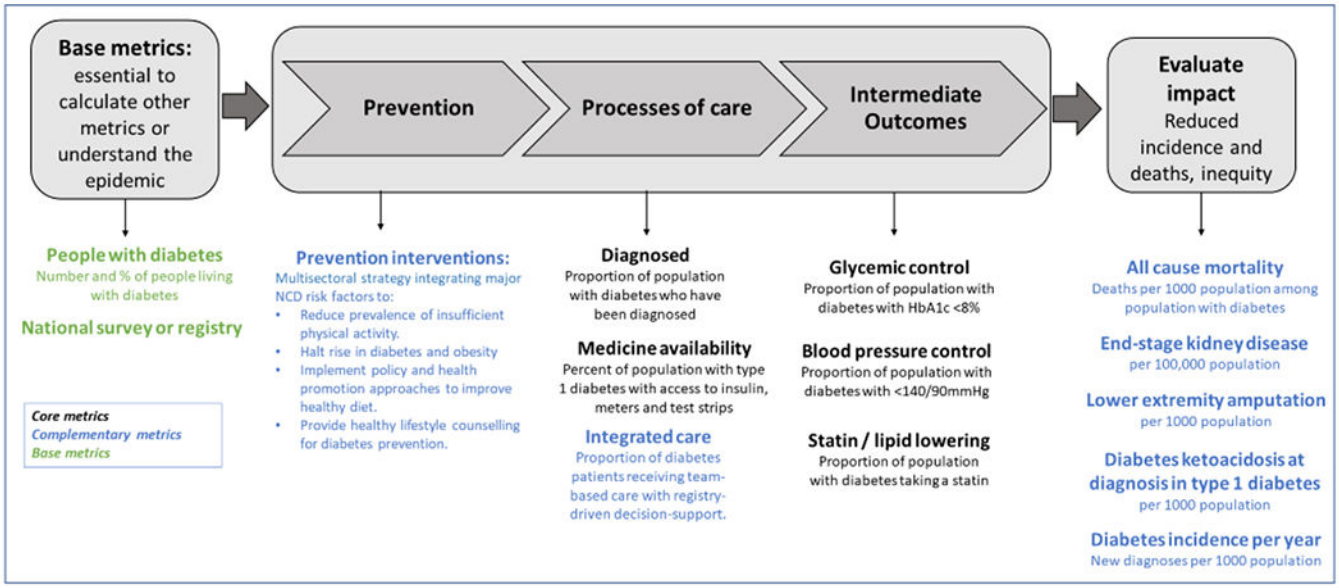

Figure 2. Proposed core, complementary, and base metrics for the *Global Diabetes Compact*.

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. Base metrics are additional processes or health indicators that are essential for the calculation of core and complementary metrics.

Table 1.

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

	Structural, system, or policy factors	**Processes of care**	**Intermediate outcomes**	**Health events and outcomes**
Diagnosed diabetes	National or regional health system diabetes registry Guidelines and dissemination efforts Presence of Decision support tools Facilities with essential medicines	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 hospitalisation CKD prevalence Incidence of lower extremity amputation Retinopathy prevalence Incidence of end stage kidney disease Incidence of CVD events Incidence of CVD death
High risk	Programmes or support for nutritional counselling Programmes/support for structured lifestyle interventions Guidelines for testing and referral	Structured lifestyle programme Counselling for diet/ exercise Testing for diabetes Metformin prescriptions Glycaemic assessments for gestational DM	Intermediate hyperglycaemia Controlled blood pressure Controlled Lipids Body mass index	Diabetes prevalence Diabetes incidence
Whole population	Facilities with essential medicines Population-based survey with blood glucose Presence of a policy to increase physical activity Presence of incentives for healthy diet programmes Food policy taxation (sugar sweetened beverages) 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

Table 2.

Criterion and rating scale for potential metrics of the *Global Diabetes Compact*.

Criterion	Excellent	Good	Fair
Intrinsic **health importance** or strong evidence for prediction or benefit on major health outcomes.	Major health outcome affecting QOL (e.g., MI, LEA).	Biomarker or intervention with clear causal linkage to health outcome.	Process, intervention, or factor with potential linkage.
Modifiable with scalable interventions targeting the metric.	Clearly efficacious and scalable via evidence-based means.	Moderately efficacious and scalable.	Lacking clear scalability – or – clear health effect if scalable.
Strong global **data availability** with acceptable measurement properties.	Currently available for 75% of countries.	Currently available for 25 - 75% of countries.	Available for fewer than 25% of countries.
International gap and disparity	Large proportion of population affected and large international variation	Large proportion of population affected – OR - large international variation	Modest international gap or limited variation

Table 3.

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

		Total diabetes prevalence	Diagnosed / total diabetes population	Glycaemic control (HbA1c <8%) / diagnosed diabetes (%)	Blood pressure control (<140/90mmHg) / diagnosed diabetes	Statin / diagnosed diabetes population
All regions	Mean	9.5	61.1	67.1	51.9	25.9
All regions	Median	8.3	63.7	68.1	52.8	12.3
All regions	IQR	5.7	14.1	13.4	21.9	27.0
East Asia & Pacific		12.2	53.4	58	52.2	12.3
Europe & Central Asia		8.3	63.7	80.1	43.7	23.6
Latin America & Caribbean		9.8	69.9	68.2	65.4	10.0
Middle East & North Africa		11.5	63.7	67.6	50.8	25.1
North America		11.7	74.1	69.9	76.4	60
South Asia		8.6	51.6	67.3	52.8	13.4
Sub-Saharan Africa		6.6	56.7	61.6	44.8	11

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

Table 4.

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

Country	Income	DM IR ¤	All-cause mortality rate §		ESKD IR ¤	LEA IR ¤	DKA Prevalence
			Male	Female			
East Asia & Pacific							
Australia	HIC	-	790 *	-	-	-	24.9
Japan	HIC	88	-	-	-	-	-
New Zealand	HIC	-	-	-	-	-	26.3
South Korea	HIC	-	940 *	-	-	-	-
Data unavailable for 25 countries							
Europe & Central Asia							
Austria	HIC	-	-	-	-	-	38.0
Czechia	HIC	-	-	-	-	-	28.8
Denmark	HIC	6.2	4070	3680	-	-	20.7
Finland	HIC	35	4260 *	-	-	4.8	-
France	HIC	96	-	-	-	15.8	-
Germany	HIC	87	-	-	16.7	4.8	26.8
Ireland	HIC	-	-	-	-	17.6	-
Italy	HIC	40	3450 *	-	10.4	15.3	41.2
Latvia	HIC	-	5470	4380	-	-	-
Luxembourg	HIC	-	-	-	-	-	43.8
Netherlands	HIC	37.3	970	880	-	25.1	-
Norway	HIC	39.8	4500	4760	-	-	22.1
Portugal	HIC	97.2	-	-	-	-	-
Slovenia	HIC	-	-	-	-	-	40.3
Spain	HIC	-	-	-	5.9	34.4	-
Sweden	HIC	-	3380 *	-	-	-	19.5
UK	HIC	36.9	2100	2240	-	17.6	25.0
Russia	UMIC	-	2320	-	-	-	-
Data unavailable for 31 countries							
Latin America & Caribbean							
Chile	HIC	-	19.9 *	-	-	-	-
Brazil	UMIC	200	-	-	-	-	-
Mexico	UMIC	140	-	-	-	-	-
Peru	UMIC	194.9	-	-	-	-	-
Data unavailable for 29 countries							
Middle East & North Africa							
Israel	HIC	108	1070 *	-	-	-	-
Data unavailable for 18 countries							

Country	Income	DM IR ¤	All-cause mortality rate §		ESKD IR ¤	LEA IR ¤	DKA Prevalence
			Male	Female			
North America							
Canada	HIC	61.6	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

DKA, diabetic ketoacidosis; DM: diabetes mellitus; ESKD, end stage kidney disease; HIC, high income countries; IR: Incidence rate; UMIC, upper middle-income countries. ESRD: End stage renal disease; (42,64,80–112 113)

Table 5.

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	75	**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**
Lipid 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**

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

Table 6.

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 povide 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.

Based on references 30 (World Health Organization. Global action plan for the prevention and control of noncommunicable diseases 2013-2020. World Health Organization. 2013.) and 31 (World Health Organization. Reducing the burden of noncommunicable diseases through strengthengin prevention and control of diabetes. 2021)