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Review

Gestational diabetes: The public health relevance and approach

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SUMMARY

The prevalence of diabetes is increasing globally and the causes attributed are the ageing population, urbanization, obesity epidemic, physical inactivity and stressful modern life. While all these factors contribute to the epidemic of DM, intra-uterine exposures and gestational programming are emerging as potential risk factors. Gestational programming is a process whereby stimuli or stresses that occur at critical or sensitive periods of foetal development, permanently change structure, physiology, and metabolism, which predispose individuals to disease in adult life. If the stimulus happens to be glucose intolerance in pregnancy, gestational diabetes mellitus (GDM) manifests. Diagnosis of GDM in a woman predisposes her and her offspring for increased risk of developing glucose intolerance and obesity in the future. GDM may play a crucial role in the increasing prevalence of diabetes and obesity and hence has become a public health priority issue. There has to be an excellent coordination and cooperation between all the stake holders of health delivery care system. A great understanding of the importance of GDM and its consequences by the Government and public will go a long way in containing the epidemic of diabetes.

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The rising burden of diabetes is impacting all people in all societies; men, women and children; rich as well as poor. According to the IDF Diabetes Atlas 5th edition there are already 366 million people (184 million women) with diabetes an increase of almost 80 million over 2010 estimation. In addition there are about 280 million with pre diabetes. The number is likely to grow to over 550 million people with diabetes and almost 400 million with pre diabetes. Asia pacific region seems to be at the heart of this rising trend for diabetes and accounts for about half the global burden of diabetes. China, India, Indonesia, Pakistan and Bangladesh figure

amongst the list of ten countries with highest number of people with diabetes [1].

1. Diabetes during pregnancy

1.1. Epidemiology

Worldwide, one in 10 pregnancies may be associated with diabetes, 90% of which are gestational diabetes (GDM). In high-risk groups, up to 30% of pregnancies may involve diabetes

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[2,3]. In the two most populous countries China and India rates of GDM are 12.2% and 14.3%, respectively [Kapur A, Personal Communication, Data on record World Diabetes Foundation]. The age adjusted prevalence of GDM in women in USA shows that the rates are higher for women with Asian or Pacific island origin but more so (almost three fold compared to non-Hispanic whites) for migrant women born in the country of their origin [4].

In 2010 there were an estimated 22 million women with diabetes in the reproductive age group of 20–39 years; an additional 54 million in this age group had IGT or pre diabetes with potential to develop gestational diabetes if they become pregnant [5]. Thus over 76 million women are at risk of their pregnancy being complicated with pre gestational (existing) diabetes or gestational diabetes (diabetes occurring or first recognized during pregnancy).

1.2. Complications for the mother and child

Haemorrhage, hypertensive disorders, obstructed labour, and infection/sepsis are among the leading global causes of maternal mortality [6]. High blood pressure and gestational hyperglycaemia are linked directly or indirectly to all of them. According to WHO's report on Women and Health, high blood pressure and high blood glucose are two leading risk factors for death from chronic conditions in women above 20 years of age [7] yet women are not routinely screened for hyperglycaemia during pregnancy and the diagnosis of gestational diabetes is often missed; maternal mortality and morbidity attributable to diabetes in women may therefore actually be considerably higher than current estimates.

Diabetes in pregnancy is associated with serious complications for both the mother and child, adverse consequences on the foetus and the mother increase linearly with increasing maternal blood glucose [8]. It is now recognized that a proportion of women diagnosed during pregnancy may have had diabetes before pregnancy (type 1 or type 2), also called pre-gestational diabetes. Infants of mothers with pre-gestational diabetes have higher rates of malformation [9–11]. Good blood-glucose control before conception and throughout pregnancy reduces these risks substantially [12,13]. Major problems related to high blood glucose during pregnancy are shown in Table 1. Many women with past history of spontaneous abortions often get diagnosed with GDM in subsequent pregnancies. While several risk factors have been described to clinically identify women with GDM, in practice they fail to correctly identify more than half the women with GDM [3,14].

1.3. Possible causes for the risk of non communicable diseases

Mounting evidence shows that prenatal and early-life developments influence the risks of NCD in later life [15–17] and this might be especially relevant to low-resource countries [17–20]. Mother's diet, body composition, and health determine foetal environment and are shown to affect risk factors. Improvements in access to care in many low- and middle-income countries have led to improved survival for even the "at risk" small for gestational age (SGA) babies born to undernourished mothers in rural settings. These babies programmed to survive under-nutrition continue to be malnourished and stunted during childhood and as long as they have subsistence lifestyle, they remain at a relatively low risk for NCDs in adult life. Improved life conditions as a consequence of economic development or migration to towns or cities in adult life and the change in the macro environment for which they were not programmed; under the change of life circumstances these individuals manifest insulin resistance and higher risk of diabetes and other NCDs at much lower body weight, body mass index (BMI) and central adiposity threshold [21,22]. In young women, these effects may first present during pregnancy, resulting in gestational diabetes and/or pregnancy induced hypertension. Seshiah et al. [23] reported GDM prevalence rates of 8–10% among women of low socioeconomic status with pre-pregnancy BMI of even less than 19, and significantly higher rates at higher BMIs and in urban environments [24].

At the same time, rising levels of obesity and IGT amongst urban women in the reproductive age group particularly in the middle and upper income countries makes them vulnerable to GDM. Over the last two to three decades, the age of onset of diabetes has been declining while at the same time the age of marriage and child bearing is increasing, as a consequence we may see more women entering pregnancy with pre-existing diabetes in the future [24,25]. Offspring's of mothers with uncontrolled diabetes – either pre-existing or originating during pregnancy are 4–8 times more likely to develop diabetes in later life [26,27] compared to their siblings born to the same parents in a non GDM pregnancy. This shows that the environment in the uterine life contributes significantly to the higher risk than can be explained by genetic inheritance alone. A recent study suggests that a significant proportion (47.2%) of diabetes and obesity in the youth can be attributed to maternal GDM and obesity [28]. Another study suggests that GDM may be responsible for 19–30% of all type 2 diabetes seen among Saskatchewan First Nations people in Canada [29]. GDM thus creates a vicious cycle in which diabetes begets more diabetes.

Table 1 – Foetal and maternal risk in pregnancy with hyperglycaemia.

Foetal risks	Maternal risks
Spontaneous abortion, intrauterine death and still birth	Hydroamnios
Lethal or handicapping congenital malformation	Pregnancy induced hypertension and preeclampsia
Shoulder dystocia and birth injuries	Prolonged labour, obstructed labour, assisted delivery and C-section
Neonatal hypoglycaemia	Uterine atonia and post-partum haemorrhage
Infant respiratory distress syndrome (IRDS)	Infections
	Progression of retinopathy

1.4. Health care system

Whatever the underlying reason for the observed increases in the prevalence of GDM, the health care system will require additional resources to provide care during pregnancy and reduce adverse perinatal outcomes [12]. As about 50% of women with GDM are expected to develop type 2 diabetes within 5 years of the index pregnancy [30] healthy post-partum life style and follow up is necessary to prevent or delay development of diabetes and recurrent GDM. Most people (over 70%), initially seek care with non-specialist primary care physician who is the most important link in early diagnosis and guiding patients, but are often ill-trained to handle diabetes, let alone GDM related issues, unaware of the latest trends, or unable to devote time due to several reasons, so GDM is often mismanaged with inadequate postpartum follow-up and care. As reported in a survey conducted in 1998, only 62% of the American College of Obstetrics and Gynaecology members believed that women with GDM were at increased risk of diabetes [31] GDM is a grave public health concern as it plays a crucial role in the increasing prevalence of diabetes and obesity [32]. Infants of women with GDM or diabetes are at increased risk of developing obesity, impaired glucose tolerance, and diabetes as children or young adults [33–35] and the increased risk may be independent of genetic factors [36].

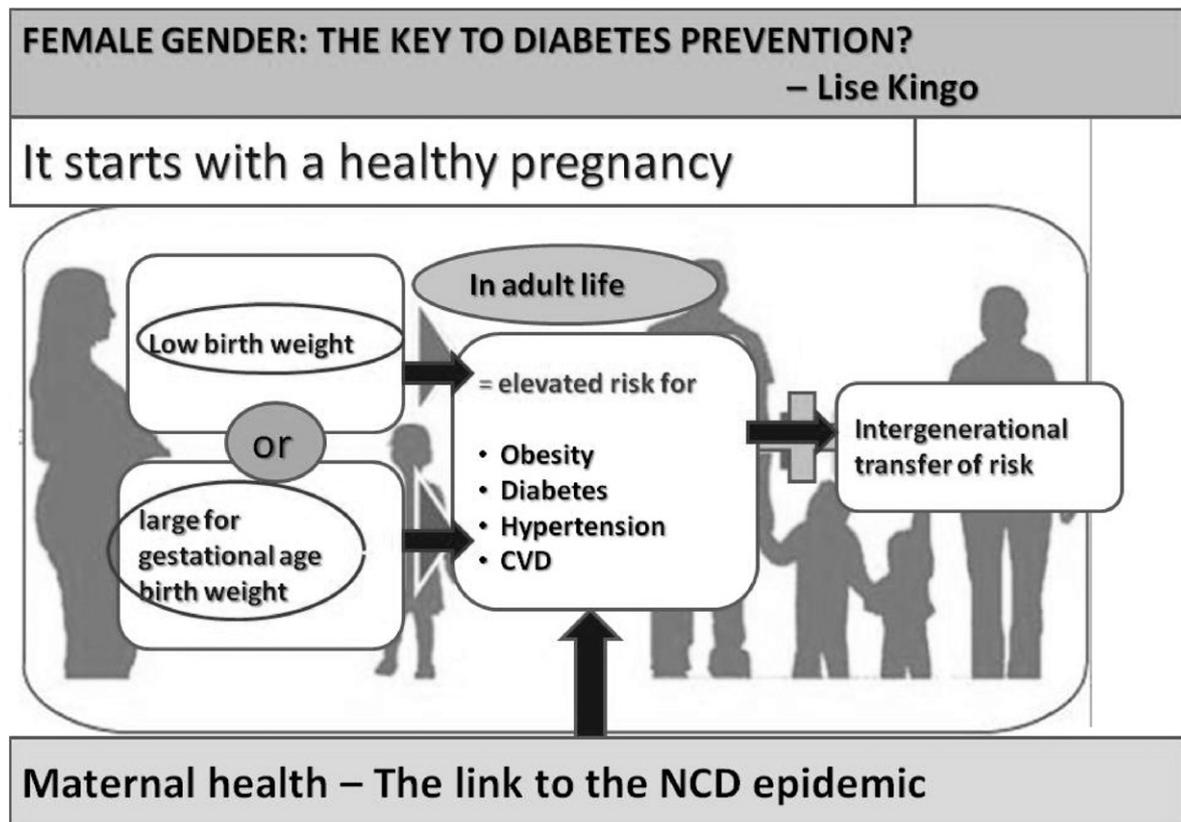
1.5. Hypothesis and implications of GDM

The “foetal origin of diabetes” hypothesis proposes that gestational programming may critically influence adult health and disease [37]. The concept of foetal programming and its consequences is a paradigm changing. It highlights that pregnancy offers a window of opportunity to provide maternal care services, not only to reduce the traditionally known maternal and perinatal morbidity and mortality indicators, but also has great potential for intergenerational prevention of several chronic diseases, such as diabetes, arterial hypertension, cardiovascular disease, and stroke (Fig. 1). Thus, with one high-quality intervention related to maternal and child health services, it is now possible to achieve several objectives with far reaching health and economic benefits [3].

However, while advocating the cause for increasing attention to GDM one needs to be careful not to create a platform for women to be blamed for adverse effects on their children and create another agenda for stigmatization of women in some cultures.

1.5.1. Public health approach

A comprehensive strategy for the prevention and control of GDM must integrate proven and effective public health interventions to minimize risk factor exposure at the level



Adapted from: The Female Gender: The Key to Diabetes Prevention: presented by Lise Kingo at the 6th International Symposium on Diabetes & Pregnancy. Mar 23–26, 2011, Salzburg Austria

Fig. 1 – Female gender: the key to diabetes prevention?

of the population and reduce risk of disease related events in individuals at high risk. Such a combination of the population approach and the high risk approach is synergistically complementary, cost-effective, and sustainable and provides the basis for early, medium and long term impact on GDM. There is emerging evidence that health education, awareness and improving motivation for self-care improves disease outcomes, reduces complications but there is paucity of such studies regarding GDM.

1. *Positioning GDM as a priority and maximizing political opportunities:* within the MDG framework most governments are paying increasing attention to maternal and reproductive health, unfortunately the attention is targeted to lowering maternal morbidity and mortality, not addressing the risks. As mentioned earlier maternal hyperglycaemia and hypertension is linked to all four main causes of maternal death yet women are not routinely screened for GDM. GDM will only gain the attention and political commitment it deserves when the available data and solutions are put forth in a compelling case and the vital link between maternal and child health care and NCD prevention and care is established. It is essential to elucidate the complex array of social, financial, behavioural, and organizational barriers that impede delivery of high-quality NCD healthcare services including GDM. Some of the key research areas include: impact and cost effectiveness of innovative interventions to reduce GDM risk through health policy action and health services delivery such as integration of GDM care within the existing maternal and child health programmes including tagging of GDM mothers and their offspring's for special post-partum attention – weight loss, breast feeding etc.; appropriate health financing to address GDM; and effective methods for translating existing scientific knowledge to the development, implementation and evaluation of NCD programmes including diabetes and GDM control programmes [38].

2. *Development and implementation of GDM clinical standards and guidelines:* the value of a diagnostic procedure is not only to identify women with GDM but also exclude normal glucose tolerant (NGT) women. The test procedure has to be economical, pragmatic, simple, and feasible on a large scale in low resource settings as well as evidence based. There is currently no universally agreed standard and guideline.

2.1. *Rationale for universal screening:* due to economic and health system workload reasons, previous guidelines recommended selective screening for GDM. It is now quite apparent that selective screening based on risk factors scores poorly in predicting GDM [39–41] and results in about a third of GDM women going undetected [39]. Moreover the applicability of the risk factors is a big problem as many women are unable to provide the right information or the information may not be accurate. For example family history of diabetes or history of GDM in previous pregnancy are very important factors in risk assessment however in a situation where often half the people with diabetes remain undetected a negative family history is of no consequence and if the women was not screened in the previous pregnancy she would have no history of GDM; selective screening maybe relevant in populations with proven low rates of GDM. Universal screening for GDM detects more cases and improves maternal and offspring prognosis [42]. If one is to recommend universal screening the test

should be simple and cost effective. The two step procedure of screening test with 50 g glucose challenge (GCT) and then diagnosing GDM based on 75 g OGTT is not feasible in low resource settings. Pregnant women may have to visit the antenatal clinic twice and at least 3–5 blood samples have to be drawn, which is generally resented.

2.2. Diagnosis of GDM

2.2.1. *A single step procedure to diagnose GDM:* for successful implementation of universal screening the test must be casual and reliable – a procedure that does not impose restriction and is able to diagnose GDM, as women walk into the antenatal clinic or clinical laboratory irrespective of their last meal timings. All current diagnostic criteria require women to be fasting over night, but most pregnant women do not come to the antenatal clinic in the fasting state because of long commutes, inconvenient clinic timing and belief not to fast for long hours during pregnancy. Attending the first prenatal visit in the fasting state is impractical in many settings [43]. The dropout rate is very high when pregnant women are asked to come again for the glucose tolerance test [44,45]. In a large study of over 800 subjects Anjalakshi et al. [46] evaluated, whether a 2-h 75 g oral glucose test done in a non-fasting state, irrespective of last meal timing, is as efficacious as 2-h 75 g oral glucose test done in the fasting state recommended by WHO in detecting GDM. The study showed all women diagnosed as GDM ($n = 87$) by 75 g glucose non fasting test also satisfied the diagnostic criteria of 75-g oral glucose test performed in the fasting state recommended by WHO. No difference in the plasma glucose levels of the 75 g glucose test in fasting and non-fasting state was noted, in GDM and normal glucose tolerant (NGT) pregnant women ($p > 0.05$). The rationale is that, normal glucose tolerant women are able to maintain euglycaemia despite glucose challenge due to adequate insulin response, whereas in women with GDM, impaired insulin secretion [47] increases glycemic level with a meal and the glucose challenge is expected to exaggerate the glycemic excursion. This cascading effect is advantageous as it increases specificity and eliminates false positive diagnosis of GDM. Gough et al. [48] reported that glucose concentrations during the glucose tolerance are affected little by the time since the last meal. Pettitt et al. [49] observed that WHO criteria based on the glucose concentration 2-h after 75 g oral glucose administered to non-fasting women correctly identified subjects with GDM. The non-fasting 2-h post 75 g glucose concentration strongly predicts adverse outcome for the mother and her offspring [50]. Philips et al. [51] also observed that plasma glucose value with a glucose challenge test was unaffected by the time after a meal or time of the day in normal glucose tolerant non pregnant subjects. Thus, this single test procedure performed irrespective of the last meal timing is rational, pragmatic and patient friendly. This procedure is a modified version of WHO criteria in that, only 2-h plasma glucose is taken into consideration for the diagnosis of GDM and is being followed by the Diabetes In Pregnancy Study Group India (DIPSI) [52].

2.2.2. *Comparison of WHO and IADPSG criteria:* to standardize the diagnosis of GDM, the WHO has proposed using a 2-h 75-g OGTT, with a threshold plasma glucose concentration of greater than 7.8 mmol/L at 120 min, similar to that for IGT outside pregnancy [53].

The existing diagnostic criteria, except WHO 2-h plasma glucose (PG) ≥ 7.8 mmol/L with 75 g oral glucose load [53], are country specific or recommended by various associations. Based on the results of the HAPO study, the International Association of Diabetes and Pregnancy Study Groups (IADPSG) consensus panel recently recommended that using a 75 g oral glucose tolerance test (OGTT), GDM can be diagnosed, if any one value of either the fasting plasma glucose (FPG), 1-h and 2-h PG concentrations meet or exceed 5.1 mmol/L, 10.0 mmol/L and 8.5 mmol/L, respectively [43]. IADPSG recommendation necessarily requires estimation of PG in three blood samples after administering 75 g oral glucose load. Pregnant women despise this procedure, as venous blood is drawn three times. A study compared the performance capacity to diagnose GDM by DIPSI criterion (WHO criterion) in that one blood sample at 2-h is required and IADPSG recommendation which requires three blood samples. Seshiah et al. [54] in a study on 1463 consecutive pregnant women with no previous history of GDM/pre GDM showed no significant difference ($p > 0.05$) in the discordant pair of diagnosing GDM by the two criteria – DIPSI criterion, 196 (13.4%), applying IADPSG recommendation the cumulative prevalence of GDM was 14.6% ($n = 214$). This implies, that the disagreement in diagnosing GDM by both criteria was not significant ($p = 0.21$, by Mc Nemar test). The 1.2% difference in the diagnostic capability between IADPSG and DIPSI was not significant ($p > 0.02$). DIPSI procedure based on WHO criterion is feasible, evidence based, cost-effective and the best buy to diagnose GDM in any country but particularly in low resource nations. Incidentally, the performance of both IADPSG and WHO criteria are similar as per GRADE ratings. IADPSG recommendations are suitable in clinical settings where financial and technical support is available.

2.2.3. *The validation of WHO criterion (DIPSI criterion 2-h PG ≥ 7.8 mmol/L) based on the foetal outcome:* macrosomia is the most common morbidity of GDM [55]. Balaji et al. [56] have shown no statistically significant difference in the mean birth weight of neonates born to women in the normal glucose tolerance (NGT) group and with intervention in GDM group diagnosed by 2-h PG ≥ 7.8 mmol/L ($p = 0.705$) after controlling

for maternal age, gestational age, family history of diabetes and BMI. The distribution of birth weight of neonates born to GDM and NGT women were similar (Fig. 2). Gayle et al. [57] also observed that diagnosis of GDM with OGTT 2-h PG ≥ 7.8 mmol/L and treatment in a combined diabetes antenatal clinic is worthwhile as it results in decreased macrosomia rates and fewer emergency cesarean sections. In pregnancy, the decision to perform a placebo controlled trial requires clinical equipoise [58] hence having a control group of untreated pregnant women with 2-h PG ≥ 7.8 mmol/L when there are studies confirming that treatment of GDM women as defined by WHO criterion is associated with a reduced risk of pregnancy outcome [12,57] is difficult to justify ethically. The policy of not treating women with 2-h PG ≥ 7.8 mmol/L amounts to exposing the pregnant women to un-physiological glycemic level despite our extensive knowledge of the benefits of treatment of mild hyperglycaemia during pregnancy [13,59–61]. Wahi et al. observed in their prospective study, the advantage of adhering to a cut-off level of 2-h PG ≥ 7.8 mmol/L in diagnosis and management of GDM for a significantly positive effect on pregnancy outcomes [62].

2.2.4. *Diabetes In Pregnancy Study group in India (DIPSI) guidelines:* the HAPO and other studies show that maternal and foetal risks associated with hyperglycaemia are continuous and cut off point for diagnosis has to be based on pragmatism as is also the case with the IADPSG guideline. Based on the studies done in India [46] and keeping in mind the high and growing burden of diabetes, the ground realities and resource constraints, the Diabetes In Pregnancy Study group in India (DIPSI) has developed the following guideline for diagnosis of GDM which has been endorsed by the Ministry of Health, Government of India

- In the antenatal clinic, a pregnant woman is given a 75 g oral glucose load, irrespective of whether she is in the fasting or non fasting state, without regard to the time of the last meal.
- GDM is diagnosed if 2-h plasma glucose is ≥ 7.8 mmol/L.
- If the test is negative in the first trimester or in the first visit, the test has to be repeated in subsequent trimesters/visits.

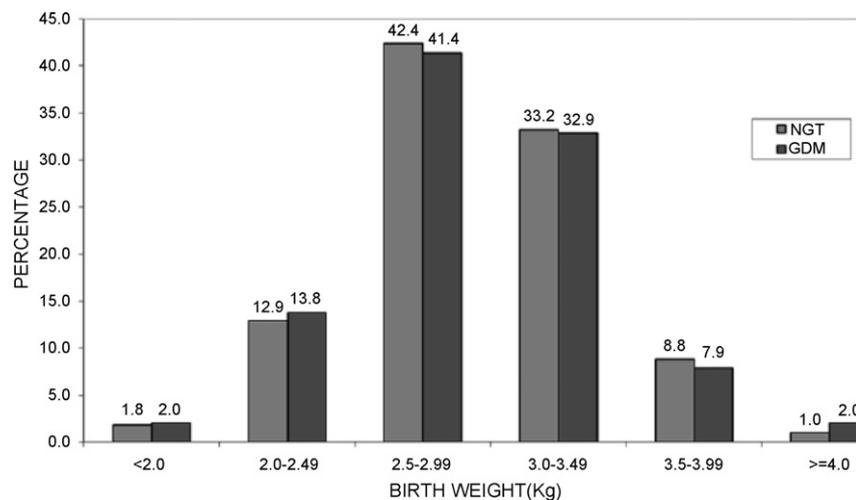


Fig. 2 – Neonate birth weight distribution of women with NGT and GDM. The birth weight distribution was similar between NGT and GDM women. The GDM status (2-h PG ≥ 7.8 mmol/L) of the pregnant women after intervention was not associated with macrosomia [adjusted OR 0.752; 95% CI (0.406–1.390); $p = 0.363$].

While these criteria are specific for India they may be equally relevant for other countries in South Asia with similar ethnicity, culture and socio economic circumstances compared to criteria based on studies that have no or limited South Asian subjects. FPG has limitations in diagnosing GDM due to the high insulin resistance in Asian Indians [63]. A similar observation was documented in the Hongkong and Bangkok population [64].

3. *Building regular surveillance systems*: the rising burden of diabetes and GDM calls for continued and concerted public health action based on sound scientific evidence as well as contextual factors. There is a paucity of nationally representative and standardized data for GDM in many countries. Given the size and diversity of the population and the varied health transitions that are occurring, large nationally representative studies and surveillance systems, to measure and monitor trends of GDM, their risks and associated morbidity and mortality on a regular systematic basis are required to enable adequate and appropriate policies and timely public health action. The absence of an international approach in generating GDM prevalence data, is a key barrier in understanding the true scale of GDM, at both the regional and global levels [65]. Fortunately there is an increasing momentum from different groups and organizations to overcome this critical gap in the evidence base.

4. *Coordination of NCD initiatives and integration into other national programmes*: Major NCDs have shared risks and offer multiple opportunities for prevention and control. An overarching policy, which links actions in different sectors (health and non-health) and adopting a holistic approach in prevention and reduction of common risk factors, is essential. This is vital given the shared risks and healthcare needs. Low birth weight and under nutrition during early childhood increases the risk of CVD and diabetes subsequently in adulthood. Thus, existing maternal and child health programmes must be leveraged to improve nutritional status of mothers and children to prevent transgenerational transmission of NCD risk. At the same time antenatal services and clinics as well as well baby clinics should be utilized to provide education on healthy diets and harm of obesity, etc. [38,66].

5. *Strengthening the health system*: to meet the increasing demands of delivering diabetes and GDM related care, there is a critical need for incorporating elements of prevention, surveillance, screening and management into all levels of healthcare (primary, secondary, and tertiary). Improvement of the public health care system will help provide more equitable delivery of services that is likely to have a large impact on reducing the disease burden and preventing much of the avertable mortality.

6. *Establishing referral and follow-up systems*: given that diabetes and GDM require long term continued care and follow up, effective referral linkages and follow-up processes, across different levels of the healthcare system (primary, secondary, and tertiary), are essential to increase operative efficiency, optimize costs, timely treatment and follow-up interventions.

7. *Providing patient education for enabling self-care and management*: public health system constraints, due to shortage of resources and providers, can be addressed to a great extent by empowering community health workers, mid wives, women self-help groups and patients and communities with

necessary information on GDM and diabetes prevention that they can utilize for self-monitoring and self-care. This can facilitate achievement of improved health outcomes; reduce unnecessary hospital visits, admissions/hospitalizations and lower periodicity of follow-up visits, contributing to considerable cost savings for the health system. It is well known fact that enhanced patient knowledge and awareness of any health problem plays an important role in prevention, increasing treatment compliance and prevention of complications.

8. Policy recommendations

- A. *Building awareness*: Based on the magnitude of the problem, the seriousness of the consequences and the opportunity for improving health that it provides clearly the top priority is raising awareness of the risks and consequences of diabetes in women including GDM. Awareness needs to be heightened amongst future mothers, general public, health professionals and policy makers not only about the specific issue but also about the importance of good health of women in general and during pregnancy in particular.
- B. *Advocacy*: ensure due attention is accorded to diabetes and women including GDM and programme interventions are put in place. There are several platforms that provide the opportunity for advocacy. These include
- The International Conference on Population & Development (ICPD) (1994) recommendations, one of which was “All countries should strive to make accessible through the Primary Health Care system, reproductive health to all individuals of appropriate age, as soon as possible and no later than 2015”.
 - Millennium development goals (MDGs). Although diabetes is not a specific goal in the MDGs, countries are encouraged to implement programmes for achieving MDGs according to their own needs and situations, and indeed the issue can clearly be taken up under MDG 5, “improve maternal health”. Besides MDG 5, the management of GDM and diabetes in women in general will also contribute to MDG 4 (child survival) and MDG 3 (gender equality).
 - The Global Reproductive Health Strategy endorsed by the World Health Assembly in 2004, calls for strengthening and ensuring access to reproductive health and for reducing maternal morbidity and mortality. Again although specific mention of diabetes is not made, the strategies to improve reproductive health will have to take into account all matters that affect sexual and reproductive health, such as diabetes and GDM.
 - The political declaration at the UN high level meeting in September 2011 and the report of the UN Secretary General to the General Assembly before the UN high level meeting on NCDs clearly states the need to create linkages between NCDs and maternal and child health programmes. The report also raises concern that the rising prevalence of high blood pressure and GDM is increasing the adverse outcomes of pregnancy and maternal health [67]. Therefore addressing prevention, screening and care of GDM is complementary to the agenda of lowering maternal mortality and morbidity and is not an attempt to take focus away from it as some activists mistakenly believe.

- C. *Mainstreaming or integrating diabetes into sexual and reproductive health and rights agenda*: this is crucial in building and sustaining action – managers and providers of reproductive health services are in an advantageous position to integrate diabetes into their programmes. There is need to systematically deliberate on appropriate interventions. A fitting beginning would be making policies for all pregnant women, with priority to high-risk women, to be tested for diabetes and to take the appropriate follow-up actions. In many developing countries where the problem of GDM is significant and requires intervention, and health systems are weak, it may call for concerted efforts among international development partners to provide support. To get it right will require strengthening of health systems to further reinforce maternal and child care services at primary care level and integrating elements of NCD prevention and health promotion [66].
- D. *Using information technology*: having saved a mother with GDM with preeclampsia from dying of obstructed labour or post-partum haemorrhage and her large-for-gestational age baby; or, a mother with severe malnutrition and anaemia and her low birth weight baby, what can we do to ensure their future good health and prevent or significantly delay the onset of hypertension or type 2 diabetes? This will require integration of services and cost effective investments in information technology to identify and track high-risk individuals to enlighten, empower, and encourage them to adopt healthy living throughout life as well as empowering local community health workers to support and follow their progress. Enrolling, monitoring and tracking women during pregnancy and their offspring using information technology may be the most appropriate place to begin this health system transformation [66].
- E. *Operational research*: evidence generation through pilot programmes is urgently needed to provide answers to several questions regarding policy formulation, programme planning and implementation.

Public health approach to improve pregnancy outcomes among women with diabetes should include:

1. Development and implementation of guidelines for screening and diagnosis of GDM using feasible, cost effective and pragmatic point of care tests such as the single step diagnostic procedure.
2. Identification of women with established diabetes who may become pregnant;
3. Ensuring appropriate care for women with diagnosed diabetes (either established or gestational) with appropriate treatment, education and nutrition counselling, on-site or through referral.
4. Postpartum follow-up and continuing care of women with diabetes and GDM to maintain good blood-glucose control, healthy weight and life style in between and throughout subsequent pregnancies and of offspring's of GDM mothers during neonatal and early childhood.
5. Increasing provider awareness through professional education.

2. Conclusion

Given the enormous but not insurmountable challenge posed by the escalating burden of diabetes and GDM, strong public health action and commitment in implementing proven and effective interventions are required. In the milieu of a resource constrained public health system, a combined strategy, incorporating interventions targeted at the whole population as well as those focused on individuals at high risk of developing GDM and those with established diabetes, will help reverse the rising tide of diabetes and GDM. Strategic directions are needed for comprehensive action on GDM with a focus on health development in all policies, a) community-wide primary prevention programmes, b) accessible services for the prevention of diabetes and GDM in individuals at increased risk, c) accessible services for the optimal early detection and management of GDM, d) integrated care for GDM, e) qualified and motivated workforce, f) enhanced surveillance system and research, g) evaluation and knowledge exchange. Multidisciplinary coordination of services must be person centered, incorporate prevention, self-management and be responsive to changing patient needs. More importantly political will and commitment is critical for revitalization of public health care and the challenge is to marshal and organize potential support in ways that are practical, effective and sustainable in a pursuit to prevent, control and treat GDM and thereby effectively deal with diabetes. In this direction, it is laudable, that the Ministry of Health Govt of India has included GDM under the NCD programme in the 12th five year plan.

Conflict of interest

The authors declare that they have no conflict of interest.

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