Diabetes in Socioeconomically Vulnerable Populations

Guest Editors: Alberto Barceló, Maria I. Schmidt, Anil Kapur, and Edward W. Gregg
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Diabetes mellitus (DM) is a global epidemic that is increasing rapidly. An estimated 415 million people worldwide currently live with DM and another 318 million people have impaired glucose tolerance (IGT), a marker for future DM. By 2040 these numbers are likely to grow to 642 million and 481 million, respectively. Over 75% of prevalent cases live in low and middle income countries. Economic transition (from extreme poverty to sustenance living), urbanization, technology, and globalization are changing the way we live and work. Societies in rapid transition show these changes most visibly; here lifestyles, diets, eating habits, and culture are changing rapidly with the changing urban landscapes and new economic realities. Traditional diets are being replaced by poor quality, relatively less expensive, easily accessible, highly processed food with more fat, salt, and sugar. This is paralleled by increased use of motorized transport and decrease in physical activity.

The mismatch between the predicted environment for survival programming and the actual environment in adult life may be a critical factor driving type 2 diabetes and obesity epidemic. Mounting evidence shows that prenatal and early life development influenced by parent's health, particularly the mother's body composition and nutritional and metabolic status during pregnancy, affect risk for noncommunicable diseases (NCDs) including diabetes in later life through fetal programming. This is especially relevant to low-resource countries. Studies on survivors of the Dutch and Chinese famine show that individuals exposed to intrauterine under nutrition had significantly higher rates of diabetes, with the risk being highest in the subgroup that were relatively well off in adult life. As millions are lifted out of abject poverty in China and India, diabetes rates have started rising dramatically with a lag of three to four decades in these countries.

Young women, born small as a consequence of their mothers’ undernutrition during pregnancy, may have difficulty in coping with the insulin resistance and metabolic demands of pregnancy, resulting in hyperglycemia and higher rates of gestational diabetes mellitus (GDM). Hyperglycemia in pregnancy is associated with serious complications for both the mother and child contributing to poor pregnancy outcomes and maternal and neonatal morbidity and mortality. Maternal health and diabetes are closely linked; poor maternal nutrition and health increases vulnerability to hyperglycemia and hyperglycemia increases risk of poor pregnancy outcome as well as future risk of obesity and diabetes in both the mother and her offspring. GDM creates a vicious cycle in which diabetes begets diabetes. The cycle of vulnerability is repeated with increasing risk accumulation in subsequent generations.

Poor access to care particularly among the less fortunate and vulnerable sections of the society exaggerates the health and economic problem when diabetes appears. Studies show that uneducated, unemployed people, especially those living in semiurban or rural areas who cannot afford or do not have access to even bare minimum health care, are likely to be diagnosed late and likely to develop or have at presentation diabetes related complications. Financial status has been shown to be a strong predictor of diagnosis and effective management of diabetes. This has remarkable socioeconomic significance: those who need more advanced/more expensive care for diabetes related complications are the ones who can
ill afford such care forcing many of them to borrow and enter the debt trap with disastrous consequences to the individual and society. Data suggests that poverty is a predictor of higher mortality among people with diabetes and the risk of dying among the poor is not completely explained by a higher frequency of chronic complications.

The rise of diabetes in the low and low-middle income countries has the potential of exaggerating another major public health problem affecting the poor and vulnerable sections of populations, the burden of tuberculosis. Diabetes is associated with a threefold increased risk of TB and increased risk of death during TB treatment.

Thus the overall impact of diabetes among the disadvantaged not only is a consequence of early life programming, social determinants, and higher exposure to risk factors but also is due to lower access to diagnosis and care for diabetes.

Although type 2 diabetes has been shown to be preventable, the long term impact of preventive strategies in the real world is still to be seen. The WHO Country Capacity Survey has reported that national diabetes policy plans and strategies for prevention and control programs are popular among low and middle income countries and even diabetes guidelines are available in most countries; but major gaps exist in the implementation as two-third of the countries report that guidelines are not operational or have no allocated resources for implementation.

The Sustainable Development Goals (SDGs) being launched in January 2016 will guide the development agenda, including health, up to 2030. Public health action to address the prevention and care for diabetes and other NCDs is included in SDG 3 (good health and well-being). Because of its link to maternal health and comorbidity with TB and other conditions, actions to address diabetes will require collaboration between maternal, newborn, and child health, noncommunicable diseases and communicable diseases, and seamless connection between health promotion, disease prevention, and care delivery, thereby strengthening overall health systems. These actions will also contribute to and benefit from action on several other SDG goals such as SDG 1 (ending poverty in all its forms), SDG 2 (ending hunger), SDG 5 (gender equality), SDG 6 (ensuring clean water and sanitation), SDG 10 (reducing inequalities), SDG 11 (making cities safe, resilient, and sustainable), and SDG 17 (strengthening global partnerships).

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Research Article

Challenges of Diabetes Self-Management in Adults Affected by Food Insecurity in a Large Urban Centre of Ontario, Canada

Justine Chan, Margaret DeMelo, Jacqui Gingras, and Enza Gucciardi

Objective. To explore how food insecurity affects individuals’ ability to manage their diabetes, as narrated by participants living in a large, culturally diverse urban centre. Design. Qualitative study comprising of in-depth interviews, using a semistructured interview guide. Setting. Participants were recruited from the local community, three community health centres, and a community-based diabetes education centre servicing a low-income population in Toronto, Ontario, Canada. Participants. Twenty-one English-speaking adults with a diagnosis of diabetes and having experienced food insecurity in the past year (based on three screening questions). Method. Using six phases of analysis, we used qualitative, deductive thematic analysis to transcribe, code, and analyze participant interviews. Main Findings. Three themes emerged from our analysis of participants’ experiences of living with food insecurity and diabetes: (1) barriers to accessing and preparing food, (2) social isolation, and (3) enhancing agency and resilience. Conclusion. Food insecurity appears to negatively impact diabetes self-management. Healthcare professionals need to be cognizant of resources, skills, and supports appropriate for people with diabetes affected by food insecurity. Study findings suggest foci for enhancing diabetes self-management support.

1. Introduction

By 2020, the cost to treat diabetes mellitus, its complications, and its associated loss of productivity and life will exceed CAN$19 billion a year [1]. Compelling evidence supports the benefits of intensive glycemic, lipid, and blood pressure control in the prevention and management of diabetes complications [2]. However, diabetes self-management is a challenge for many people as it involves learning and adopting self-care and self-monitoring practices [3]. For instance, medical nutrition therapy, a cornerstone in diabetes management, is one of the most challenging aspects of management [4, 5], encompassing not only healthy eating, but also insulin dose adjustment to carbohydrate consumed, as well as prevention and treatment of hypoglycaemia.

Household food insecurity is significantly more common among Canadians with diabetes (9.3%) compared to Canadians without diabetes (6.8%) [6], which is similar to that of other countries [7, 8]. Food security exists “when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life” [9]. Notably rooted in poverty, food insecurity for people with diabetes poses additional challenges, principally, the lack of adequate and appropriate food and the effect on diabetes management [10]. Studies of adults who are food insecure show that they are more likely to have poorer health, inferior social support, and more comorbid conditions (e.g., obesity, high blood pressure, heart disease, and allergies) [11] as well as greater psychological distress and unhealthy behaviours, including smoking, physical inactivity, and low consumption of fruits and vegetables [6, 11]. Specifically, food insecure adults with diabetes are more likely to have poor glycemic control, long-term complications, and severe and frequent hypoglycaemia [12–16]. While it is clear that those that are living with diabetes and are food insecure experience more health problems and poorer overall health, knowledge on how they cope and manage with this health intersection and information on
their lived experiences to date have been primarily absent in the literature. This type of knowledge can provide insight on how to better support and care for this population.

Using in-depth interviews with adults living with diabetes and food insecurity, our research paper explores these lived experiences and tries to understand how food insecurity affects people's ability to manage their diabetes. The semistructured interview guide was based on the Social Determinants of Health Framework, given the significant influence of material deprivation and financial constraints on diabetes management decisions [17]. The findings will be novel as there is very limited qualitative research in this area.

2. Materials and Methods

2.1. Qualitative Methodology. There is little contextual research on how and why individuals with diabetes coping with food insecurity are more likely to practice unhealthy behaviours and endure greater psychological distress. Using six phases of analysis, we chose qualitative, deductive thematic analysis, as it is flexible in its approach to extract themes from participants’ accounts [18].

2.2. Participant Recruitment. With the help of diabetes educators and flyers promoting the study, we conducted one-on-one interviews with clients from the local community, three community health centres, and a community-based diabetes education centre serving a low-income population in the Greater Toronto Area, Ontario, Canada. Eligibility criteria included a diagnosis of type 1 or 2 diabetes, English speaking, and having experienced food insecurity in the past year. Three questions were adapted from the Household Food Security Survey Module (HFSSM) [19] to identify participants: (1) In the past year, were you ever not able to buy your basic foods, such as fruits and vegetables? (2) In the past year, were you ever not able to buy your favourite foods? (3) In the past year, did you ever have to eat less than you felt you should have because of a limited budget? Eligibility was based on at least one affirmative response to the above questions. Homeless individuals were excluded, as the complexity of psychosocial vulnerabilities and mental health issues would extend far beyond the scope of our research question. See Table 1 for our sample demographics. Participant recruitment ended when thematic saturation was achieved [20].

Ethics approval for this research study was obtained from Ryerson University’s Research Ethics Board in Ontario, Canada (REB 2008-294). Initial data collection for this study was completed in 2009-2010. The four-member research team are comprised of one academic expert in diabetes (Enza Gucciardi), one expert in qualitative research (Jacqui Gingras), and two practice experts in diabetes (Justine Chan, Margaret DeMelo).

2.3. Procedure for Data Analysis. Eligibility, demographic information, and verbal informed consent were confirmed by the lead author prior to the interview. In total, 21 individual face-to-face interviews were conducted, lasting 30 to 90 minutes.

The semistructured interview guide is as follows.

**Introduction**

Can you remember when you were first diagnosed with diabetes? What was it like?

How did you react to the news?

**Health Services**

Think back to when you first learned about what you would need to do to manage your diabetes. How was that experience for you?

What did the doctor/nurse and so forth tell you about what you had to do to manage your diabetes? What

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**Table 1: Sociodemographic characteristics of participants.**

| Number (𝑛=21) |
|----------------|
| Gender       |
| Women        | 10 |
| Men          | 11 |
| Ethnicity    |
| Caucasian    | 12 |
| Caribbean    | 5  |
| African      | 2  |
| Middle Eastern| 2 |
| Place of birth|
| Canada       | 12 |
| Outside of Canada | 9 |
| Age          |
| 20–30        | 1  |
| 31–40        | 1  |
| 41–50        | 7  |
| 51–60        | 9  |
| 61–70        | 3  |
| Marital status |
| Married/common-law | 2 |
| Single       | 9  |
| Divorced/separated/widowed | 10 |
| Education    |
| High school or less | 7 |
| University or less | 4 |
| College or less | 9  |
| Graduate school | 1 |
| Duration of diabetes |
| ≤5 years     | 11 |
| 6–10 years   | 4  |
| 11–20 years  | 2  |
| 21–30 years  | 2  |
| >30 years    | 2  |
| Type of diabetes |
| Type 1       | 1  |
| Type 2       | 20 |
was it like learning about what you needed to do in terms of food, physical activity, and medication? What challenges did you face in trying to follow the recommendations of your physician or the diabetes health care team?

Can you tell me when you first found it difficult to buy or find food? Was this before or after you found out you had diabetes?

**Income and Social Status**

How did you manage through the times when you found it hard to buy or find food? How has this affected you in the past year? If they have kids or living with family: When providing meals for other people in the household, what were your major concerns?

**Social Environments/Social Support Networks**

Were you able to get the help/assistance/understanding/support you felt you needed during these times?

What support was available to you at this time (formal support from health/social care providers, family, friends, church group, etc.)? Would you tell a bit me about these experiences? What supports really made a difference for you; what was most helpful to you? What more can they (health care providers, government, etc.) do to better help you?

How have concerns around food affected your daily life?

**Personal Health Practices and Coping Skills**

Some of the things we've been talking about sound like they may have been very difficult/challenging for you. What have been the biggest challenges overall? What have been your "survival" strategies through all this? How confident are you now in your ability to manage your diabetes?

**Cool-Down/Wrap-Up**

Looking back on your own experiences, what would have made this whole journey easier for you?

If you could send a message to other people in your situation, what would it be?

What about healthcare providers? What would you like them to know?

Is there anything else about this experience that was important to you that we haven't talked about?

The responses you have provided may lead to some more questions. If so, can we contact you for a follow-up interview?

Probes were used to encourage participants to elaborate on their experiences. Participants received CANS30 honorarium at the end of their interviews. All interviews were digitally recorded and transcribed verbatim. Following data collection, we removed all participant identifiers to protect anonymity.

Our analysis process required six phases [21], beginning with the research team reviewing interview transcripts, while making notes for potential codes to return to at a later stage in analysis. The second phase involved developing preliminary codes, 50 in total, to capture as many potential themes as possible. We grouped transcript excerpts under these codes both manually and by NVivo data management software. Following phase two, we created clusters of codes and grouped them into ten major themes using the repetition technique where recurring topics generated the most relevant ideas [21]. In the third phase, we used thematic networks [22] to systematically present the study findings by listing our themes from specific to broad, that is, basic, organizing, and global themes, respectively. In the fourth phase, we met frequently to further refine our themes and triangulate the data. The basic themes were then grouped under three overarching themes. In the fifth phase, we refined theme wording to capture the meaning of what was said. The sixth phase involved writing and revising the manuscript report, while the research team carefully considered the most meaningful extracts.

3. Results

Our data analysis produced three main themes that captured the experiences of people with diabetes who are food insecure: (1) barriers to preparing and accessing appropriate food, (2) social isolation, and (3) enhancing agency and resilience (see Figure 1).

3.1. Themes and Additional Supporting Quotes

**Theme 1** (barriers to preparing and accessing appropriate food). Most participants could not afford foods appropriate for their diabetes management. Always buying “healthy foods,” counting carbohydrates, or tracking serving amounts were unrealistic approaches to meal planning because food supplies were often erratic due to an inconsistent and unpredictable source of income. When grocery shopping, their goal was to buy whatever cost the least (see Interviewee 1). Participants also worried about not having enough food to eat and described the additional challenges brought on by a limited budget (see Interviewee 2). Meal planning was difficult and many depended on other resources, such as food banks and community kitchens. Inappropriate foods available at food banks (i.e., high in starch, salt, and sugar) were voiced (see Interviewees 4 and 5). Unfortunately, participants still struggled with access to these food sources (see Interviewee 3). For example, a single mother modified her work hours with the food bank’s operating hours. Access to food was often better at the beginning of the month, resulting in more erratic blood sugars by month’s end.

Housing environments presented barriers to food preparation. Many did not own a stove, resorting to microwaveable foods (see Interviewee 6). A lack of proper cooking facilities resulted in greater use of higher sodium foods such as processed and canned foods.
Figure 1: The intersection of food insecurity and diabetes.

Misperception of the type of foods recommended for diabetes management was widely common. Participants discussed how specialty foods, such as those containing artificial sweeteners or labeled “diabetic,” were perceived as “better,” expensive, and, contrary to current nutrition recommendation, understood to be necessary for the management of diabetes (see Interviewees 7 and 9).

The barriers resulting from the intersection of diabetes and food insecurity were especially evident for those who had to cope with debilitating comorbidities. Retinopathy and neuropathy, in particular, greatly reduced their access and selection of both fresh and appropriate foods (see Interviewee 8). For example, many voiced the challenge of no longer being able to travel to food banks or grocery stores and had difficulty selecting and preparing food (see Interviewee 2).

Interviewee 1: I don’t have a lot of money...so I’ll buy junk food, instead of real food...because the junk food is cheaper.

Interviewee 2: I’m on [disability benefits] at the moment, so sometimes I find it’s a bit hard...I have to be very conscious of...and trying to think of not just buying food but planning meals and planning food throughout the month that will last throughout the month...sometimes I worry about running out of food and, because I’m diabetic, I can’t just skip meals...I find I have to be more conscious of what I eat and when I eat...I find that a bit troubling.

Interviewee 3: It’s all controlled by how much money you make...how much you pay rent. Most places [food banks] say you can come once every two weeks – and they give you one shopping bag of groceries and that’s supposed to last you two weeks. If you don’t have the funds, how are you supposed to eat? So you have to go to the food kitchens...you have your days kept busy running back and forth to find places to eat...some days you might not make it there...so you don’t eat properly.

Interviewee 3: A lot of my food comes from the food bank. They only give you certain types of foods that don’t really help you with diabetes, more or less go against your diabetes—a lot of sugar, cookies, stuff like that.

Interviewee 4: It’s mostly pastas, heavy in starch, pasta, rice, pasta sauce...and cereals, stuff that’s got sugar in it. There’s not an alternative they give you.

Interviewee 5: You don’t have enough fruits – juice is no good. The fruits are better, but you have zero access. They have fruit roll ups, they have junk food which I don’t eat, so I give back most of the stuff.

Interviewee 6: The fact that I have the necessary facilities to cook...I’ve got a stove...but I never use it because...the person before [was]...I found this little thing and it’d blow up on me...I mean it looks nice, it’s kept clean and it’s spotless inside, but so is a hand grenade before you pull the pin too...I bought my own microwave...I use everything microwave or I eat out of a can cold.

Interviewee 7: I have to get...artificial sweetener now, too, and that’s expensive compared to other stuff...I get the diet soft drinks, and I get juices. But then there’s a lot of sugar in the juices, so I try
and mix it with water, and then I find that not a lot of grocery stores have just a specific section. I've noticed that some of them, like the drug stores...have a certain section. Some of the items that are in the diabetic aisles...they are expensive too, right?

Interviewee 9: It'd be easier for me if I could just buy regular food, I don't have to buy special stuff that's low sugar and stuff. If I want it, I'd have to pay more for it.

Interviewee 8: For the past 4, 5 years...all the eye problems and everything else...it made it difficult to do things. You can't manage. You can't see to cook...the finger gets numb because of the diabetes. The nerves and the fingers, you cannot hold things...and even when you're buying stuff...you're holding it, but you can't really tell whether it's...good or [if] it's not good...I just...use the canned goods.

Interviewee 2: I hate going [to] the grocery store and getting...loads and loads...of groceries. I'd much prefer to shop every two or three days, but that's not really practical in terms of getting enough food and...making sure it keeps fresh...it's hard when...I've got some physical problems and hauling it around...is...difficult.

**Theme 2 (social isolation).** Most participants were single and described the impact of food and eating alone on their well-being. Socializing incurred more cost on travel and clothes (see Interviewee 5). Because lack of funds limited social interactions, many felt isolated and depressed (see Interviewee 6).

While some considered eating out a special treat, especially for those who felt lonely and isolated, the impact of limited finances and having diabetes further restricted social interactions. Feeling the need to justify their food and beverage choices and to eat and drink differently from their friends were apparent barriers (see Interviewee 9).

Community food initiatives such as community kitchens and gardens, volunteering at food distribution centres, connecting to a church group, and attending drop-in meal programs were all means of connecting with others and were considered a valuable resource that helped to ameliorate both food insecurity and social isolation (see Interviewees 10 and 11).

Interviewee 5: I've...been inverting myself more to a cocoon?...I've stopped socializing...don't feel like it...cost of going, even if it's just subway or gas, it's money. So...I finally went to [an event] last week, because...I really had the feeling that if I didn't show up this time, they weren't going to invite me again...but people don't know...yes, I'm in between, going through a hard time, but that's about it. You can't admit that you're doing what you're doing. And most people don't recognize me dressed this way...I'm really careful where I go. So I basically don't go out unless I have to.

Interviewee 6: Since I can't always get what I really want, it adds to the depression...I can't go to the restaurant with my friends, "cause the guys are, like, "C'mon let me just take you for a cup of coffee or something outside"...I don't have the money to do that. I feel bad, I can't offer. A lot of times you have to go off your diet because, one, you can't afford it or, two, you have your meds. Thank God it's [diabetes medication] been covered, to compensate for what you don't have. I might go...to get a taco...or something that I haven't had in a long while, or go into the local grocery store. They have good pizza...and other things are cheap...it's also a treat...I've got a can opener that works, but how often...[do] I go...I've been eating alone in [my] apartment.

Interviewee 9: I really can't look forward to going out to eat...I'm having lunch with a friend of mine...I couldn't do that on my own...but he's treating me...I'd like to go out more, and I really can't, you know? I'm tired of saying "Well, we can't really go out...can we do this instead?" which doesn't cost any money...I feel a little bit guilty about that...I don't know what people think of me...I can't really say "Oh I'm diabetic", and I can't do this, this, and this, without making myself look like...I'm really, really sick...and I'm not really that sick, it just means that I've got to limit myself...[if] somebody says "Let's go to a club or somewhere"...I can't drink because you know when you drink...even beer, it's got sugar in it. If I have one beer, it's going to affect me the next day...if I go to a club and order a Diet Coke, you know they're just going to say "What's wrong with him?" I'm not going to really want to get into a big explanation about how sugar affects me.

Interviewee 10: I think mostly it's the social factor of eating alone. I don't like eating alone. So...there's a community dinner that I go to, my [church group]...I've gone there for years...I go to drop-ins with my friends for two reasons: one, because I like to eat with other people, and two, because I can't afford to buy food anymore...some of the places have really good food. Some of them have food that's very high in carbohydrates, which isn't good for diabetics...plus it puts weight on you.

Interviewee 11: I go to a church and they are helpful too...if I go to church on Sunday, somebody will take me home. Most Sundays I go home with somebody...that is the next supportive group, my church...they take me home and I'm fed for the day.
Theme 3 (enhancing agency and improving resilience). Some participants considered their food insecurity to be temporary. One or more major life events, such as financial loss, job loss, marital separation, or divorce coincided with the onset of food insecurity. Many described survival strategies that buffered current adversity. For example, participants used positive self-talk, such as “Believe in your heart that it will be alright,” “My life will get back on track”, “You just live one day at a time”, and “I will survive”. Others expressed optimism through such phrases as “It's gotta be over…one way or the other”.

The role of healthcare providers is pivotal in enhancing agency and resilience. Participants drew on the heartfelt help and practical diabetes management strategies received from healthcare providers who they found to be “genuinely caring,” “gentle,” and “loving” (see Interviewee 14). Feeling cared for was referred to as “the human factor” and resonated in the examples participants gave, serving as empowerment to better manage their diabetes. Other participants appreciated when their healthcare providers inquired about issues not related to diabetes (see Interviewee 15).

Participants offered suggestions to care providers on what was helpful to them: “Keep information simple for people to understand”, “Listen to patients,” “Be positive, and encouraging and supportive”, and “Do not be judgmental”. Practical advice and counselling helped them regain their agency in managing diabetes and coping with food insecurity. More specifically, participants suggested “specific inexpensive menus,” “more lists, more recipes, and low-cost ideas of meals,” creative ways to share food, and alternatives to food insecurity. Participants considered their food insecurity to be temporary. One or more major life events, such as financial loss, job loss, marital separation, or divorce coincided with the onset of food insecurity. Many described survival strategies that buffered current adversity. For example, participants used positive self-talk, such as “Believe in your heart that it will be alright,” “My life will get back on track”, “You just live one day at a time”, and “I will survive”. Others expressed optimism through such phrases as “It's gotta be over…one way or the other”.

Interviewee 15: Every time I go see [my family doctor], he’s not just like, “Yeah, okay you’re here for the visit. Thank you very much. See you next month”. He’ll ask me…“Emotionally, how do you feel? Is anything bothering you? Are you getting the shakes? Are you taking too much salt in?” So… I listen to him. He’s good.

Interviewee 9: I'd say the most help I get is through this dietician. You know, she'll tell me…“why don't you try this or you know, mix that with that?”…and, you know, I tell her my budget is limited and she’ll say, “okay, this is cheaper, try that”, and it'd be things I would never think of.

Interviewee 6: Where the food is cheap…if you take your medication, it will counteract the stuff that you’re not supposed to have…you eat what you can get, when you can get it. A lot of times you have to go off your diet because, one, you can’t afford it or, two, you have your meds. Thank God [they're] covered, to compensate for what you don’t have.

Interviewee 2: I think just keeping a positive outlook and just…making sure I take my medications…I guess I figure that the medication will make up for some of the lapses that I’ve done, because I know that some people are able to perfectly manage diabetes.

4. Discussion

Individuals living with diabetes who are food insecure face many challenges that greatly impact their ability to self-care [10–16]. Our findings demonstrate that these individuals have a limited ability to acquire, select, and prepare appropriate foods, in addition to maintaining consistent carbohydrate intake and meal spacing throughout the day. Barriers to observing an appropriate diet for diabetes management include financial constraints, a knowledge deficit for healthy meal planning on a limited budget, housing environments unconducive to food preparation and storage, inadequate community resources, and physical disabilities associated with comorbidities. The literature in Canada [10, 23] and Australia [7] confirms that many have insufficient income left after paying rent to purchase appropriate food. This was further compounded by the misperception that a “proper” diabetes diet requires “diet” foods that are low in sugar, contain artificial sweeteners, and are labelled “diabetic” [7]. Given the rising cost of healthy food [7], the circumstances of those who are food insecure can only get worse. Many study participants relied heavily on canned and convenient, high sodium, high carbohydrate foods. They stressed the inadequacy of food banks and community kitchens in meeting their special diet needs, a finding consistent with Tarasuk’s research on community-based responses to food insecurity [23, 24]. López and Seligman suggest that the reliance on low-cost, energy dense foods and the inability to afford nutritious
food can have a cascading effect not only on glycemic control, but also on depression, distress, and fatigue, all of which can negatively impact self-management behaviors [13]. Clinicians should therefore focus their recommendations on reducing portion size of foods that are available and accessible to them rather than focusing on food and beverage substitutions that may not be attainable [13].

Individuals with diabetes are more likely to have comorbidities than those without diabetes; it is estimated that all individuals with diabetes in Canada have some form of diabetic retinopathy, a frequent cause of legal blindness, and 40 to 50% of Canadians with type 1 or type 2 diabetes will manifest painful neuropathy within 10 years of diagnosis [4]. Several of our participants reported these complications and consequently had difficulty traveling to grocery stores, selecting fresh produce, and cooking nonprocessed foods due to sight and mobility impairments, creating a food insecure state in and of itself. Clinicians should therefore keep an inventory of meal or food delivery resources such as “Meals on Wheels,” “Grocery Gateway,” or “Heart to Home Meals,” all of which can assist an individual with physical disabilities to access, budget for, and prepare healthy foods without leaving the home and this has been supported by other research [13].

Based on our findings, we recommend that clinicians systematically screen for food insecurity, refer to the registered dietitian as needed, tailor the care plan, and identify increased health risks, particularly for hypoglycemia that often results from missed meals or inadequate carbohydrate intake. Treatment regimens should incorporate medications that have a lower risk of hypoglycemia and that can be adapted to unpredictable or inadequate food intake as a result of food insecurity [13, 15].

Trying to manage diabetes in conjunction with a low income led to social isolation for many; most of them lived in single-person households, a common characteristic of food insecure individuals [23]. Our participants had no one to share and prepare meals with; they also limited social interactions to save costs, increasing their risk of depressive symptoms. They used resources such as community kitchens, church groups, and food coops to cope with their food insecurity and social isolation. Canadian research has shown decreased psychosocial distress and increased food security among community kitchen participants [18]. We also recommend that clinicians incorporate more group-based learning opportunities such as workshops that focus on food budgeting, low-cost meals, and, as other authors have suggested [13], strategies for more affordable healthier substitutions (e.g., buying frozen instead of fresh vegetables). Including a hands-on component such as a food skills demo is essential in engaging and motivating clients to try these strategies on their own.

Research suggests that food insecurity is cyclical, shifting between periods of food scarcity and food adequacy [14] and that food insecurity can be either chronic or temporary [25]. Similar to research among low-income Canadians, most participants in our study viewed their food insecurity as a temporary setback [10] and employed various survival strategies to endure this setback. Participants also valued the “genuine” care and “support” received from health care providers. Valued relationships with healthcare providers can be the key for patients to regain their agency to manage their diabetes during bouts of food insecurity. Norwegian research suggests that healthcare providers can encourage diabetes self-management by employing an empathetic, individualized approach [26]. It also has been suggested to move beyond the “patient-centered approach” to one that is “empowering and partnering” and that builds an emotional relationship between the healthcare professional and the client [27]. Furthermore, a recent study reported that food insecure clients respond well to diabetes self-management support programs as evidenced by a decrease in hemoglobin A1c and an increase in self-efficacy and fruit intake [28].

The study has the following limitations. While we acknowledge that the experience between those with type 1 and type 2 diabetes differs, the goal of our paper was not to compare but to obtain the general challenges that these people experience. Also, there currently is a lack of research available to distinguish the major differences in experience between the two groups. We interviewed participants in a large urban centre and, therefore, our findings may not be transferable to people in small towns and rural areas. Future research should examine the benefits of physician screening for food insecurity and diabetes self-management programs tailored to food insecure clients as this has the potential to save significant medical costs and influence the future of diabetes care.

5. Conclusion

Food insecurity presents a great challenge to diabetes self-management, an already complex chronic illness. In our study, participants faced multiple barriers to accessing appropriate foods: insufficient income, misperceptions about healthy food choices, multiple comorbidities, and inadequate cooking facilities that cumulatively impact food acquisition, selection, and preparation. Social isolation compounded these barriers, although it was somewhat buffered by the coping strategies they used and by the community food initiatives and social support networks they were able to access. Without access to healthy food, the identified barriers can potentially result in fatigue, decreased social well-being, and increased health problems, ultimately discouraging an individual to practice self-care behaviors (e.g., blood glucose monitoring, physical activity, and healthy coping). Healthcare providers should be aware of the challenges that food insecurity poses for people with diabetes, as well as the potential they have to optimize their encounters with patients. Our findings underpin the importance of understanding diabetes through the perspectives of patients’ lives and tailoring diabetes management plans and community programs within the context of food insecurity.

Disclosure

The funders had no role in the design or conduct of the study; in the collection, analysis, and interpretation of the data; or in the preparation or approval of the paper.
Disclaimer

All authors, external and internal, had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

Conflict of Interests

There is no potential conflict of interests.

Authors’ Contribution

Enza Gucciardi and Margaret DeMelo conceived the study. Enza Gucciardi, Justine Chan, and Margaret DeMelo were involved in designing the study and developing the methods. Justine Chan and Enza Gucciardi obtained funding. Justine Chan coordinated the study and conducted the individual interviews. Justine Chan, Margaret DeMelo, Enza Gucciardi, and Jacqui Gingras read transcripts, came to a consensus on the analytical framework, and contributed to the analysis. Justine Chan drafted the paper. All authors contributed to the interpretation of the analysis and critically revised the paper. Justine Chan is the guarantor.

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Research Article

Glycemic Control in Kenyan Children and Adolescents with Type 1 Diabetes Mellitus

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Background. Type 1 diabetes mellitus (T1DM) is the most common endocrine disorder in children and adolescents worldwide. While data about prevalence, treatment, and complications are recorded in many countries, few data exist for Sub-Saharan Africa. The aim of this study was to determine the degree of control in patients with T1DM aged 1–19 years over a 6-month period in 3 outpatient Kenyan clinics. It also sought to determine how control was influenced by parameters of patient and treatment. Methods. Eighty-two children and adolescents with T1DM were included in the study. Clinical history regarding duration of illness, type and dose of insulin, and recent symptoms of hypoglycemia/hyperglycemia were recorded. Glycaemia, HbA1c, and ketonuria were tested. HbA1c of 8.0% and below was defined as the cut-off for acceptable control. Results. The median HbA1c for the study population was 11.1% (range: 6.3–18.8). Overall, only 28% of patients had reasonable glycemic control as defined in this study. 72% therefore had poor control. It was also found that age above 12 years was significantly associated with poor control. Conclusions. African children and with T1DM are poorly controlled particularly in adolescents. Our data strongly support the necessity of Kenya children to receive more aggressive management and follow-up.

1. Introduction

T1DM is the most common endocrine-metabolic disorder in children and adolescents worldwide, with a prevalence of 190 per 100000 among school aged children in USA and an annual incidence ranging from 1.7 per 100000 (China) [1] to 40 per 100000 (Finland) [2]. Over the last three decades, the incidence of T1DM has been also on the rise worldwide [1–3].

Survey of the published information on T1DM in African populations reveals that most series do contain several children and a significant number of teenagers [4–7]. This shows that T1DM is not rare in African countries contrary to the widely held belief.

With the few data available on Sub-Saharan African children [4], incidence in Tanzania was estimated to be 1.5/100,000 [5], and an increase in incidence in Sudan from 9.5/100,000 in 1991 to 10.3/100,000 in 1995 has been shown [6].

Finally, in Africa, a global incidence of 6.4/100,000/year was reported [7].

Due to limitations in study methods and design, many of these studies do not provide reliable population data; however, International Diabetes Federation (IDF) estimates that there were a total of almost 39,000 prevalent cases of children with type 1 diabetes in Sub-Saharan Africa in 2013 [7].

The prevalence of type 1 diabetes in Kenyan children and adolescents is totally unknown. However, approximately 100 patients below the age of 20 years are being followed up in Nairobi. Despite the apparently small numbers of these patients, diabetes is a major health concern because it is a lifelong disease, which uses up substantial financial resources on both personal and national levels. On the other hand, diabetic children if well managed can enjoy reasonable well-being and personal independence [8].
The main long-term complications of T1DM result from the effects of prolonged high blood glucose. The Diabetes Control and Complications Trial (DCCT) showed conclusively that the control of blood glucose has a direct and significant effect on the development of the triad (nephropathy, retinopathy, and neuropathy) of long-term complications of T1DM. A reduction of 76% in the risk for development of retinopathy when average blood glucose and HbA1c are maintained at 8.6 mmol/L and 7.2%, respectively, over a seven-year period (intensively treated group) was demonstrated [9]. The DCCT showed that it is indeed possible to achieve adequate control to make a difference in occurrence of long-term complications. The patient must be well motivated and the healthcare system must be able to give the necessary support in terms of medications and supplies, clinical care, and advice as required. Although euglycemia was not achieved even in the DCCT, the improved control resulted in significant reductions in long-term complications. The control of blood sugar among Kenyan children and adolescents with T1DM has not been reliably evaluated. In the absence of such data, the effectiveness of therapy or any other interventions both currently and in the future cannot be ascertained.

The aim of this study was to determine the degree of glycemic control in children and adolescents with T1DM and to try correlating it with the availability of insulin, its type and dosage, and the role of patient characteristics such as age and duration of illness. This study also aimed at providing a baseline on which future work on TIDM in Kenya can build.

2. Methods

The study was carried out at the Kenyatta National Hospital (KNH) diabetic clinic, the Presbyterian Church of East Africa (P.C.E.A.) Kikuyu Hospital, and the diabetes care and training centre in Nairobi in a period of 6 months and submitted in partial fulfillment of the requirements for the degree of Master of Medicine in Pediatrics and Child Health at the University of Nairobi by the first author (Thomas Ngwiri).

Even if these clinics are not specifically designed for children and the most part of patients are adults with T2DM, children with T1DM receive appropriate treatment and education; their diabetes is monitored; and where necessary and possible they are referred to available specialists and support services. The clinics aim to educate and inform patients and their relatives to enable them to achieve best possible control of their condition in a setting with scarce resources. Generally, any patient is periodically reviewed for blood sugar, blood pressure, and body weight measurements. Home blood sugar monitoring is taught to patients who can afford the strips. Currently, none of patients can afford regular HbA1c assays.

All children and adolescents previously diagnosed with T1DM, being managed with insulin at the 3 facilities and with at least 2 clinical assessments in this period, were eligible to participate.

Signed informed consent was obtained from the parent/guardian or subjects below 18 years or from the patient himself if above 18 years of age. Authority was obtained from the local ethical committees.

Medical history of the patient in the preceding three months was taken and recorded on the basis of a structured anamnestic questionnaire with regard to hyperglycemia and/or severe hypoglycemia. Considering the fact that only few patients had glucose monitoring at home, history of polydipsia, polyuria, and nocturia was used as clinical evidence of hyperglycemia. Moreover, on the same basis, history of loss of consciousness or convulsions, dizziness, unusual sweating, or tremors requiring help from a third party and corrected by glucose administration were recorded as severe hypoglycemia.

A history of the insulin dosage, availability, and storage in the last 3 months was also noted. The patient was also being tested on his/her ability to measure the prescribed dose of insulin and these findings compared with glycemic control.

In all subjects, a sample of urine was collected and tested for ketones; moreover, a venous sample of blood was drawn from a peripheral vein and a fasting blood glucose level and HbA1c level were measured.

Fasting blood glucose was measured using the “HemoCue” blood glucose analyzer. HbA1c was determined only at the second clinical assessment using the HbA1c Tina Quant II kit (Roche Diagnostics GmbH, Mannheim, Germany) at the Chemistry Department of the Nairobi Hospital laboratory.

HbA1c normal range for this assay was 4.8–5.9%.

Urine was collected and tested for ketones using the “Bayer Diagnostics” ketone test strip.

The questionnaire and blood and urine samples were given a matching serial number and entered into the study for analysis. The patient’s level of control and its implications were explained to the patient/guardian by the attending clinician at the next clinic visit. Patients were said to have reasonable control if they had HbA1c of 8% or less and were said to have poor control if HbA1c was higher than 8%.

The information obtained in this study was discussed with the patient/primary caregivers and the healthcare providers to enhance the quality of care to the study subjects. All data were then analyzed using the Statistical Package for Social Sciences (SPSS version 11.0) using comparison of means or chi-square as appropriate. Results are shown as mean SDS.

Odds ratios were also calculated.

3. Results

The entire population of eligible patients visiting the clinics in the 6-month period was recruited. A total of 82 patients (39 males and 43 females, age range: 3–19 years, height: −0.31 ± 0.82 SDS, weight: −0.23 ± 0.53 SDS) were studied. This group represents near half of the registered patients in these clinics and the total of the patients in regular follow-up.

Thirty-nine of the 82 patients (48%) were residents of Nairobi, while the remaining 43 (52%) resided in other districts of Kenya and had to travel to the 3 facilities for treatment.

The mean age at diagnosis was 9.9 ± 4.4 years and the median duration of illness was 3.7 years.
Of the patients identified for the study after meeting the inclusion criteria nobody was excluded from analysis.

Although 90% of the patients were recruited at KNH, it was noted that patients had moved freely among the 3 facilities in the 6 months preceding the study so no attempt was made to analyze control separately for each institution.

The male to female ratio of the study population approached one.

Values of HbA1c were not normally distributed: their range was 6.4–19%, median HbA1c was 12.1%, and interquartile range was 7.20. The overall prevalence of poor control was 72% when a cut-off HbA1c of 8% was used (Figure 1). Children in the group with lowest levels of HbA1c were in honeymoon period.

The percentage of children experiencing severe hyperglycemia (53.6%) was lower than the percentage of children with hyperglycemia (86%).

Only about one-third of patients in the study had fridges to store their insulin. Control in this group was not significantly better than in those who kept their insulin at room temperature. Those patients using “pots” (improvised refrigerator) also appeared to have similar control to those who stored their insulin at room temperature.

The dose of insulin is highly individualized as it is titrated against the patients control during the course of follow-up. All children received a conventional insulin regimen (mean dose: 0.9 ± 0.4 U/kg/day; range: 0.5–1.7 U/kg/day).

In this study, control was compared between those whose insulin dose was at least 0.6 U/kg and those whose dose fell below this cut-off. Control was similar in the 2 groups.

Fifty-eight of the 82 patients, 69% of patients, used only mixed formulation insulin, while the rest used intermediate acting insulin alone or together with a short acting variety in a home-prepared mixture. In all these patients, this was necessitated by unavailability of mixed formulation and not by preference for an alternative formulation.

Eleven% of patients admitted that they took refined sugars between daily basis and weekly basis as compared to the majority who took them not more than once a month. Control was better in those children who restricted their refined sugar intake, although the difference was not significant.

In this study, only 4% of children >12 years had reasonable control compared to 78% in children <12 years of age.

Statistical analysis demonstrates that patients’ age was a determinant of glycemic control (P < 0.0001) as confirmed by odds ratio value.

No statistically significant differences were shown for sex, residence, primary care givers, family history of diabetes mellitus, insulin formulation, use of refined sugar, and duration of illness in determining the degree of metabolic control (Tables 1 and 2).

4. Discussion

Only 28% of Kenyan children and adolescents with T1DM had reasonable control. This result is partially in agreement with the few studies in African children showing the mean HbA1c above 10.5% [10–13] with a study having the mean HbA1c as high as 12.5% [14]. Our data compare to those of a study from Ethiopia where reasonable control was found in 22% of patients [13] and are better than those obtained in Sudan where reasonable control was found in only 12.5% of patients [10, 11].

As would be expected, control was poorer than that in most patients studied by Hvidøre Study Group [15], with a more prosperous economy and therefore better access to healthcare.

Most likely, the underlying cause is the association between limited insulin supply and near total lack of self-monitoring of blood glucose due to the limited availability of economic resources. The same scarcity of resources blocks the possibility of routinely assessing the level of HbA1c. Therefore, the costs of diabetes result in a formidable barrier to improve the control of this noncommunicable disease. In African countries, the global direct cost of care approaches 300$ corresponding to the annual income of many families. In the absence of a publically funded healthcare system, these costs are borne almost entirely by individuals. In this context, poor disease prognosis with high morbidity and mortality seem to be the unavoidable outcomes [16].

In our population, we showed a high prevalence of both severe hypoglycemia and hyperglycemia. However, these data have to be considered cautiously because they are based on symptoms and not always on glucose measurements. Hyperglycemia, moreover, can be reflecting the shortage of insulin. This can concur with the high recurrence of ketoacidosis in African children with T1DM [17]. Females had slightly poorer glycemic control than their male counterparts as previously shown in other pubertal African girls [14]. Similar findings were observed also in Japan, where the average HbA1c in females remained significantly higher than in males over more than 5 years of follow-up [18]. Adolescent girls experience a significant deterioration in control towards the end of growth [19].

In our study, to live in rural setting does not influence the metabolic control. Thus, the control was similar in all children independently by residing in or out of Nairobi, probably reflecting the relative importance of treatment practice over
Table 1: Sociodemographic factors and glycemic control.

| Factor                        | HbA1c < 8.0% | HbA1c ≥ 8.0% | $\chi^2$ | P value | Odds ratio (95% CI) |
|-------------------------------|-------------|-------------|---------|---------|-------------------|
| Sex                           |             |             |         |         |                   |
| Male                          | 12 (33%)    | 26 (66%)    | 0.44    | 0.623   | 1.18 (0.53–3.64)  |
| Female                        | 11 (25%)    | 33 (75%)    |         |         |                   |
| Residence                     |             |             |         |         |                   |
| Nairobi                       | 13 (33%)    | 26 (66%)    | 1.03    | 0.310   | 1.65 (0.62–4.36)  |
| Others                        | 10 (23%)    | 33 (77%)    |         |         |                   |
| Primary caregiver             |             |             |         |         |                   |
| Parent                        | 20 (30%)    | 46 (70%)    | 0.85    | 0.356   | 1.88 (0.48–7.35)  |
| Other                         | 3 (19%)     | 13 (81%)    |         |         |                   |
| Family history of DM          |             |             |         |         |                   |
| Yes                           | 9 (27%)     | 24 (73%)    | 0.02    | 0.897   | 0.94 (0.35–2.51)  |
| No                            | 14 (29%)    | 35 (71%)    |         |         |                   |
| Insulin formulation           |             |             |         |         |                   |
| Intermediate acting           | 4 (25%)     | 12 (75%)    | 0.195   | 0.6588  | 0.75 (0.22–2.64)  |
| Mixed                         | 19 (33%)    | 43 (67%)    |         |         |                   |
| Use of refined sugar          |             |             |         |         |                   |
| Frequent                      | 1 (11%)     | 8 (89%)     | 0.6     | 0.431   | 0.30 (0.04–2.53)  |
| Rare                          | 21 (30%)    | 50 (70%)    |         |         |                   |
| Age (current)                 |             |             |         |         |                   |
| <12 years                     | 21 (78%)    | 6 (22%)     | 45.73   | <0.0001 | 92.7 (17.3–496.8) |
| ≥12 years                     | 2 (4%)      | 53 (96%)    |         |         |                   |
| Age at diagnosis              |             |             |         |         |                   |
| <12 years                     | 6 (22%)     | 21 (78%)    | 0.32    | 0.448   | 0.64 (0.22–1.87)  |
| ≥12 years                     | 17 (31%)    | 38 (69%)    |         |         |                   |
| Duration of illness           |             |             |         |         |                   |
| <5 years                      | 19 (31%)    | 41 (69%)    | 1.451   | 0.2285  | 2.09 (0.62–7.01)  |
| ≥5 years                      | 4 (19%)     | 18 (81%)    |         |         |                   |

Table 2: Insulin handling and glycemic control.

| Factor                        | N  | Mean HbA1c (standard deviation) | Standard error (SE) | P value |
|-------------------------------|----|---------------------------------|---------------------|---------|
| Place of storage              |    |                                 |                     |         |
| Fridge                        | 28 | 10.189 (4.1176)                 | 0.7781              | 0.234   |
| Room temp.                    | 9  | 12.400 (4.1158)                 | 1.3719              |         |
| Place of storage              |    |                                 |                     |         |
| Pot                           | 40 | 11.433 (4.2589)                 | 0.6734              | 0.539   |
| Room temp.                    | 9  | 12.400 (4.1158)                 | 1.3719              |         |
| Insulin dose                  |    |                                 |                     |         |
| ≥0.6 U/kg/day                 | 54 | 11.041 (4.1120)                 | 0.5596              | 0.991   |
| <0.6 U/kg/day                 | 28 | 11.053 (4.2166)                 | 0.9673              |         |
| Dosing regimen                |    |                                 |                     |         |
| Twice daily                   | 76 | 11.030 (4.2464)                 | 0.4936              | 0.258   |
| Thrice daily                  | 4  | 12.850 (2.5749)                 | 1.2874              |         |
| Accurate measurement of insulin|    |                                 |                     |         |
| Yes                           | 77 | 10.997 (4.2102)                 | 0.4862              | 0.573   |
| No                            | 5  | 13.200 (2.5755)                 | 1.2878              |         |
| Missed insulin (unavailability)|    |                                 |                     |         |
| Yes                           | 12 | 12.756 (4.7101)                 | 1.5700              | 0.216   |
| No                            | 70 | 10.910 (4.1020)                 | 0.4938              |         |
the physical environment and diverse diets in the successful management of type 1 diabetes. The landmark DCCT [9] had shown that good control was achievable anywhere with aggressive management.

The majority of patients had a parent as the primary care giver. These children did not fare better with their control than those under care of siblings and other relatives. Parents are probably more committed to their children with a chronic illness and ensure better compliance with medication. Children under care of their parents also might enjoy a stable family structure that is more supportive. It has been shown that there was a direct association between parental involvement in insulin administration and metabolic control in diabetic adolescents, although no such association was found with the "wider family functioning" using the Family Assessment Device [20]. Another study [21] also established that control was indeed better in those children whom both parents lived at home. However, the relationship between family functioning (namely, at mealtimes) and children's health outcomes has to be yet fully elucidated [22].

The lack of a difference in our study might be explained by the fact that many Kenyan homes comprise an extended family whose members assume responsibility for the care of a sick sibling or other relative just like a parent would.

Families with experience in the care of another diabetic might be expected to be better suited for the care of a diabetic child by providing appropriate diet and correct and consistent administration of medication and generally offering psychosocial support. The author is not aware of studies that have specifically addressed the quality of care of children with family history of diabetes. In our study population, the control was similar in those with or without diabetic relatives.

The DCCT study [9] had established that control improved with multiple dose injections or continuous subcutaneous infusion of insulin. These recommendations caused a high proportion of children and adolescents with T1DM in developed countries to receive intensive treatment. A crossover study from conventional to flexible multiple daily insulin showed an improvement in both preadolescent control and pubertal children's control [23]. This requires a highly motivated patient who must practice home glucose monitoring several times a day. The economic problems of African countries put an obstacle in the way of intensive treatment. Wide use of mixed formulations recorded in our patients is the standard practice in Africa. As reported by Majaliwa et al. [14], it is unlikely that self-monitoring of blood glucose can be economically sustained by patients living in these countries. It is to underline, however, that all 8 patients with a limited access to self-monitoring are among those with a good metabolic control. Pawar et al. [24], on the other hand, found that the benefits of multiple dose regimens seen in research settings were not always reproducible in routine clinics. They found control was poorer in patients on four as compared to two daily injections in a routine clinic in the UK. In our study, the number of patients on thrice daily injections was extremely small (5% of study subjects). They also had been put on thrice daily injections only after failing to be controlled on twice daily regimen and so were likely to be patients with poor control in the first place.

While in other African countries the storage of insulin can play role in the overall metabolic control [14], this does not happen in our environment where temperatures remain around 25 degrees centigrade. Refrigeration where available should still remain the storage of choice especially in hotter parts of the country where temperatures frequently exceed 25 degrees centigrade. Insulin can still be safely kept at room temperature as long as it is used within one calendar month and the ambient temperature remains below 25 degrees centigrade, a situation that is difficult to guarantee in the tropics. There is no data on the temperatures achieved in “pots.” This should be ascertained and if acceptable the use of “pots” should be promoted more authoritatively as an alternative for patients without access to a refrigerator.

In Kenya and specifically at KNH which has a high turnover of patients on insulin and which must provide the drug at a highly subsidized price (15% of the price at private pharmacy outlets), insulin shortages are not uncommon. The extent and impact of shortages on the glycemic control in Kenya have not been evaluated.

Our study was not designed to verify the report of the patient's compliance and relied on recall. However, only 10 out of 82 patients reported that they had missed their prescribed dose of insulin because they lacked the drug. Those who did so had poorer control than those who reported that they had been compliant throughout the preceding 3 months. While these results are in keeping with the scientific fact that insulin is all-important in control of blood sugar, it is still significant that even those who reported good compliance still had a very poor control. Therefore, we can have some doubts on the real compliance of these patients. On the other hand, our study does not address the difference between the prescribed dose and dispensed dose of insulin and so cannot verify compliance with the prescribed dose.

Elbagir et al. [10] in Sudan had found that patients faced with scarcity of insulin actually reduced their insulin per dose or the number of doses per day in order to stretch their supply.

Tanzanian children with T1DM, in addition to limited supply, reduce spontaneously the prescribed dose of insulin to guaranty a longer period and lower cost of treatment [14]. It is not clear from our study if the same happens in Kenya.

In our patients, age was an important determinant of metabolic control. In agreement, a nationwide study of more than 2500 French children [23] showed age as the most important factor related to control followed by insulin dosage and maternal age. Pawar et al. [24] had similar findings and concluded that mean HbA1c rose with age from 10 years of age over a 6-year follow-up. In the DIABAUD2 study [21], HbA1c was significantly lower in children below 10 years as compared to those between 10 and 15 years. Children diagnosed with diabetes before 12 years of age had slightly poorer control than those diagnosed later and in adolescents the control was unacceptably impaired [25]. Gebre-Yohannes and Rahlenbeck [13] had also found that lower age of onset was a predictor of poor control in Ethiopian children with T1DM. Control was also inversely related to duration of illness. However, the correlation reported in our and other studies between HbA1C and age was not found in Tanzanian children with T1DM [14].
However, it has been shown that there was a delay in the onset of complications of diabetes in those with a longer duration of prepubertal diabetes as compared with the duration of postpubertal disease [23]. This finding has major implications in setting target HbA1C levels for young children who are prone to hypoglycemia.

Our study demonstrated that the prevalence of poor diabetic control in Kenyan children and adolescents is far from being acceptable and the great majority of patients are at high risk for the precarious development of microvascular complications. Moreover, it must be highlighted that severe hypoglycemia is often recorded in African setting and it can complicate the control. As worldwide, Kenyan adolescents with T1DM have particularly poor control so they comprise a special high-risk group in the diabetes clinic. Our data strongly have supported the necessity of children and adolescents with T1DMin Kenya receiving more aggressive management and follow-up and more resources are addressed at the care of this noncommunicable disease.

Just to overcome some structural barriers in coping with diabetes in the African setting [26], in the last years, the assistance to the children with T1DM has improved offering many free blood meters and blood strips and near-free access of insulin, with the help of the Pediatric Endocrinology Training Center, sponsored by the European Society Pediatric Endocrinology and the World Diabetes Foundation. Moreover, a more strict collaboration has been promoted between adult and pediatric diabetologists and a valuable assistance from the diabetic education unit with nurse and educator has been obtained.

Further studies should be carried out to determine the impact of these increased resources and this new attitude on the metabolic control, especially in adolescent patients.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Research Article

Reported Diabetes Mellitus Prevalence Rates in the Colombia Healthcare System from 2009 to 2012: Analysis by Regions Using Data of the Official Information Sources

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The objective of this study was to describe the reported diabetes mellitus (DM) prevalence rates of the 20–79-year-old population in Colombia from 2009 to 2012 reported by the healthcare system. Information on the number of patients treated for DM was obtained by the Integral Information System of Social Protection (SISPRO), the registry of the Ministry of Health and Social Protection, and the High Cost Account (CAC), an organization to trace high expenditure diseases. From both sources age-standardized reported DM prevalence rates per 100,000 inhabitants from 2009 to 2012 were calculated. Whereas the reported DM prevalence rates of SISPRO revealed an increase from 964/100,000 inhabitants (2009) to 1398/100,000 inhabitants in 2012 (mean annual increase 141/100,000; p value: 0.001), the respective rates in the CAC register were 1082/100,000 (2009) and 1593/100,000 in 2012 (mean annual increase 165/100,000; p value: 0.026). The number of provinces reporting not less than 19% of the highest national reported DM prevalence rates (1593/100,000) increased from two in 2009 to ten in 2012. Apparently, the registries and the information retrieving system have been improved during 2009 and 2012, resulting in a greater capacity to identify and report DM cases by the healthcare system.

1. Introduction

Diabetes mellitus (DM) is one of the fastest growing public health problems imposing a high burden on DM patients and high financial burden on healthcare systems. Recent estimates of the International Diabetes Federation (IDF) predicted that the number of adults with diabetes is expected to rise worldwide from 366 million in 2011 to 552 million by 2030 [1]. The last Colombian National Health Survey in 2007 revealed a DM prevalence of 3.5% in the Colombian population 18–69 years of age according to participant self-report [2]. However, according to the IDF there were 2.1 million DM cases in Colombia corresponding to a DM prevalence of 7.05% in 2013 for the 20–79 year-old population [1].

It has to be kept in mind that there is a remarkable gap between people diagnosed with DM and those receiving treatment. It has been shown that only approximately 50% of the people diagnosed with DM receive medical care [3, 4]. Currently, no national register exists for DM patients in Colombia. However, for the last six years, two official registers have been developed in Colombia to track the number of DM—and other relevant diseases—cases that demand healthcare attention [5–7]. These registers use the available information provided by the healthcare providers and insurers. Nevertheless, no intent has yet been made to analyze the existing information in order to see whether there are changes in the access to DM treatment within the healthcare system during the past years. Furthermore, it is important for the primary healthcare system to monitor the number of DM patients receiving treatment on a regular basis to evaluate its capacity to detect new DM cases and to follow up whether it is capable to reduce the gap between diagnosed DM cases and those receiving medical care.
The aim of this study was to describe the reported DM prevalence rates of the 20–79-year-old population in Colombia during 2009 and 2012 reported by the official information sources of the healthcare system.

2. Material and Methods

Information on number of patients with DM as primary diagnosis in the population of 20–79 years of age was obtained by the Integral Information System of Social Protection (SISPRO) and the High Cost Account (CAC), an organization to trace high expenditure diseases. The SISPRO is a register developed by the Colombian Ministry of Health and Social Protection which offers consolidated data from the healthcare services demand in Colombia. All healthcare providers (hospitals and healthcare centers) are by law obliged to send information using the ICD-10 code of the primary diagnostics of all patients placed in the SISPRO register; thus, covers the entire Colombian population that demands services within Social Security Health System. The SISPRO register is fed by different information sources of healthcare service data after careful validation of each. Data submitted to the SISPRO register is subject to continuous quality control testing [5, 6]. The data received is cross-checked against other information sources (such as population census, national health surveys, or other administrative registers) before being integrated into the SISPRO register. If inconsistencies are detected, the data is sent back to the reporting institutions for revision and correction. In addition, according to the existing regulation several specific projects are carried out to improve primary data sources in order to guarantee a better quality of data received. The SISPRO registers the primary diagnostic code of the healthcare visit of both primary care and hospital care visits. Data on healthcare services provided to DM patients of the SISPRO for the years 2009–2012 were obtained in October 2013 using the ICD10 codes E100–E149, G590, G632, H280, H360, M142, N083, O240–O244, and O249. Many DM patients contact the primary healthcare system at very advanced stage of their disease presenting already complications of DM. These patients are usually registered with an ICD-10 code related to complications of DM as primary diagnostic code. Therefore, we have included these ICD-10 codes in our search to ensure that otherwise invisible cases of DM were included in the analysis. In addition, the ICD-10 differs between insulin-dependent DM (E10) and non-insulin-dependent DM (E11). However, since a large proportion of patients with type 2 diabetes are treated with insulin, they are coded as E10. In addition, the ICD-10 codes E12, E13, or E14 refer to unspecified DM. The consequence of this is that the ICD-10 codes do not allow a genuine and credible classification of clinical types of DM at least in Colombia.

The CAC is an agency established by the Colombian State in 2008 and managed by the healthcare insurance companies. The objective of the CAC is to monitor high cost illnesses within the Social Security Health System (SSHS) in order to develop mechanisms for financial management and to promote risk management in relation to high-cost illnesses [7, 8]. By law, the healthcare insurance companies must report all cases of DM, hypertension, and chronic kidney diseases that occur within their healthcare users. The CAC register covers 90% of the Colombian population. In this study, information of all identified cases of DM was received from CAC for the years 2009, 2010, 2011, and 2012 [9–12].

It is important to mention that both of the above mentioned registers only provide information about DM cases that have required healthcare attention. Thus, DM cases that have not been in contact with healthcare services do not enter the official registries. In addition, there is no data available in regard to the type of DM.

Information regarding population size and projections was retrieved from the National Administrative Department of Statistics (DANE). DANE is the organization that processes and shares the official Colombian population statistics [13]. DANE has also been considered as the official source of information about mortality and some health indicators in Colombian [14, 15].

2.1. Statistical Analysis. Age-standardized reported DM prevalence rates per 100,000 inhabitants for the population of 20–79 years of age from 2009 to 2012 were calculated separately for the SISPRO and the CAC registers as a quotient: The numerator was number of cases of DM in people 20–79 years of age in the SISPRO and, respectively, CAC register, whereas the number of inhabitants aged 20–79 years reported DANE population projections were used as the denominator. The EpiDat software version 4.0 was used to standardize the reported DM prevalence rates according to age using as reference population estimated for Colombia for 2010 according to United Nations population. The estimation of age-standardized reported DM prevalence rates for each of the six regions (Figure 1) corresponds to the average age-standardized rates calculated for the provinces in each region. The age-standardized reported DM prevalence rates are presented per 100,000 people for the age range 20–79 years.

The statistical analyses for time trends were performed with SPSS for Windows 14.0. They were tested first for linearity using Mantel-Haenszel test and for statistical significance the Chi-square test was used. The trends in prevalence were subsequently calculated using the linear regression model log(PR) = a + bt + e, where PR refers to prevalence, t is time, e is the error term, and a and b are the regression coefficients estimated from the data. The change in prevalence per year at the time point t is a constant proportion, 100b percent of the prevalence at t. The estimated average yearly change in percent is exp(b) – 1, which is approximately b for small changes. 100 * exp(b) is presented in the tables. The level of statistical significance was set to 0.05.

Finally, for the maps presented in Figures 2(a), 2(b), 2(c), and 2(d), the annual reported DM prevalence rates of each province were categorized into five categories according to the performance in regard to the reported number of DM patients compared to the highest national reported DM prevalence rates (1593/100,000 in 2012) in the study period. The categories were as follows: (i) higher than or not more
Figure 1: The six regions of Colombia and its provinces.

than 19% lower than the highest national value of 2012 (≥1592.6/100.000); (ii) 1–20% lower than the national value of 2012; (iii) 21–40% lower than the highest national value of 2012; (iv) 41–60% lower than the highest national value of 2012, and (v) ≥60% lower than the highest national value of 2012, respectively.

3. Results

The trends of reported DM prevalence rates in each region are presented in Table 1. Both registers showed a statistically significantly linear increase in reported DM prevalence rates per 100,000 people during 2009 and 2012. Whereas the reported DM prevalence rates of SISPRO revealed an increase from 964/100,000 inhabitants (2009) to 1398/100,000 inhabitants in 2012 (mean annual increase 141/100,000; p value: 0.001), the respective rates in the CAC register were 1082/100,000 (2009) and 1593/100,000 in 2012 (mean annual increase 165/100,000; p value: 0.026). The CAC register reported between 12% and 19% more DM cases/100,000 inhabitants compared to the rate provided by the SISPRO register. This difference did not statistically significantly change between 2009 and 2012.

Table 1 shows the age-adjusted reported DM prevalence rates per 100,000 inhabitants 20–79 years old in the different regions of Colombia according to the SISPRO and the CAC register during 2009 to 2012. The reported DM prevalence rates calculated from SISPRO reported a statistically significant increase in the Andes region (p value: 0.002), the region of Orinoco (p value: 0.039), and the Pacific region (p value: 0.020) during the time period, whereas the DM prevalence rates calculated from CAC register had a statistical significant linear increase in the age-adjusted reported DM prevalence rates in the regions Andes (p value: 0.022), Pacific region (p value: 0.004), and Bogota DC (p value: 0.035). Both registers identified more DM cases/100.000 inhabitants in 2012 compared to 2009. However, the annual increase in DM rate ranged from 26 to 153/100.000 people in the SISPRO register and from 25 to 203/100.000 inhabitants in the CAC register, respectively.

As during 2009 and 2012 the reported DM prevalence rates of CAC were regularly higher than the ones provided by SISPRO, the changes in the reported DM prevalence rates of the different provinces are only shown for the CAC register. Figures 2(a)–2(d) present the development of the DM cases reported in the CAC register in the different provinces of Colombia during 2009 and 2012 compared to the national reference value of 2012 (1593/100,000). Whereas 13 provinces reported DM prevalence rates 80% or lower than the national reference value in 2009, only eight provinces remained that far away from the national reference value in 2012. Mainly, the four provinces in east of the country, Choco at the Pacific coast, and La Guajira in the north-east upper corner of Colombia did not show any improvement in detecting DM cases. Whereas in 2009 the reported DM prevalence rates of 21 provinces were below 60% of the national reference, the respective number in 2012 was 13 provinces. The number of provinces reporting at least the national reported DM prevalence rates of 2012 increased from two in 2009 to ten in 2012.

4. Discussion

Our study showed that the registries and the information retrieving system of SISPRO and CAC have been improved during 2009 and 2012 resulting into a greater capacity to identify and report DM cases by the healthcare system. However, some regions and provinces showed a slower or no increase in the reported DM prevalence rates creating a future challenge for the official healthcare information system of Colombia.

There are several possible reasons for the findings of our study. First, the capacities of the registers to identify the DM cases may have improved due to implementation of different screening or early diagnosis activities within the healthcare providers to detect people with DM. For instance, many healthcare insurance companies have recently implemented different benchmark system to catch DM patients as early as possible to offer efficient treatment, whereas others may use diabetes risk factors scores combined with laboratory tests [16]. As there is a growing awareness of the burden of DM in Colombia, many DM screening programs will be developed in Colombia in the next years that may lead to a further
Higher than or equal to the national reference value of 2012 (≥1593/100.000)
1–20% lower than the national reference value of 2012
21–40% lower than the national reference value of 2012
41–60% lower than the national reference value of 2012
≥60% lower than the national reference value of 2012

Figure 2: (a) Reported DM prevalence rates (CAC register) of the different provinces of Colombia in 2009 compared to the best national reported DM prevalence rate (1593/100.000). (b) Reported DM prevalence rates (CAC register) of the different provinces of Colombia in 2010 compared to the best national reported DM prevalence rate (1593/100.000). (c) Reported DM prevalence rates (CAC register) of the different provinces of Colombia in 2011 compared to the best national reported DM prevalence rate (1593/100.000). (d) Reported DM prevalence rates (CAC register) of the different provinces of Colombia in 2012 compared to the best national reported DM prevalence rate (1593/100.000).

A second reasonable interpretation of our results may be that the diabetes incidence has increased during the past four years in Colombia. Both obesity and physical inactivity are two of the most important risk factors for DM. Given the
Table 1: Age-adjusted reported DM prevalence rates per 100,000 inhabitants in the different regions of Colombia according to the SISPRO register during 2009 to 2012.

| Region   | 2009 | 2010 | 2011 | 2012 | Annual increase (%) | p value | 2009 | 2010 | 2011 | 2012 | Annual increase (%) | p value |
|----------|------|------|------|------|---------------------|---------|------|------|------|------|---------------------|---------|
| Amazon   | 428  | 500  | 504  | 517  | 26                  | 0.170   | 516  | 629  | 587  | 612  | 25                  | 0.362   |
| Andes    | 991  | 1148 | 1299 | 1415 | 142                 | 0.002   | 1159 | 1411 | 1500 | 1643 | 154                 | 0.022   |
| Atlantic | 661  | 726  | 779  | 1038 | 118                 | 0.075   | 733  | 949  | 1006 | 1026 | 94                  | 0.101   |
| Orinoco  | 552  | 651  | 761  | 773  | 77                  | 0.039   | 509  | 755  | 854  | 898  | 127                 | 0.060   |
| Pacific  | 544  | 696  | 855  | 906  | 125                 | 0.020   | 762  | 899  | 1049 | 1144 | 130                 | 0.004   |
| Bogota DC| 1117 | 1502 | 1448 | 1645 | 153                 | 0.116   | 1269 | 1634 | 1759 | 1905 | 203                 | 0.035   |

*p value for time trend.
increased prevalence of obesity between 2005 and 2010 in the Colombian adult population combined with low levels of physical activity this may be a reasonable explanation [19, 20]. The National Survey of the Nutritional Situation (ENSIN) of 2010 revealed that 35% of women and 34% of men 18–64 years of age were overweight. The corresponding prevalence for obesity was 20% (women) and 11.5% (men). Furthermore, only every second 18–64-year-old adult reached the current physical activity recommendations of 30 minutes of daily moderate intensity physical activity [20, 21]. Thus, the unfavorable development of the major risk factors of DM may be reflected in the increase in the DM rates of people with DM in the healthcare system. However, we would like to point out that the data present here is not a study on the true prevalence of DM in Colombia but rather about the capacity to report DM cases by the healthcare system. According to available evidence, every second a diabetes case has not been diagnosed. The government has put an emphasis on improving these registries in the past years obliging the healthcare providers to improve disease reporting by a series of new legislation. Thus, we think that the increase in the reported DM prevalence rates can rather be explained by the improved capacity of the healthcare system to detect previously unknown DM cases than an increasing prevalence of DM.

It has to be pointed out that the observed increase in reported DM cases in the Colombian population may be related to a better and easier access or higher demand to healthcare for DM patients leading to higher DM rates recorded in the reporting system. Furthermore, we hypothesize that the difference observed between the regions in regard to reported DM prevalence rates may be due to the geographical distances from the more developed urban centers. Probably, the access to healthcare services is more difficult and the healthcare provider’s information systems may have poorer development compared to the more developed regions of the country.

The IDF reported a DM prevalence of 7.05% in Colombia [1]. Thus, there is a remarkable gap between the IDF estimation and the DM prevalence found by the Colombian National Health Survey [2] in 2007 (3.59%). Besides, considering that there are about 800 000 known DM patients in Colombia, it is of great concern that only 50% of them get admitted in the healthcare system.

Naturally, our study has some limitations. The data base of SISPRO only registers the primary diagnostic code leading to an underestimation of DM cases as some patients may have DM as underlying condition to other diseases. In addition, our analysis is restricted to the DM cases officially reported and does not reflect the true prevalence of DM rather than the DM cases that have been in contact with the healthcare system. However, the objective of our study was not to estimate the true DM prevalence but to report the DM prevalence rates of the official information sources of the healthcare system. Finally, the DM type and the treatment profile that these registered patients are receiving are not described by these sources. In any case, these two registers are the only available sources of information in regard to the number of treated DM patients in Colombia as the country does not count with an official register for DM1 or DM2 at the present moment.

5. Conclusions

The official information sources to track DM patients have improved their ability to detect and record DM patients in Colombia. However, many regions are still lacking behind the national reference showing lower DM detection rates. The future challenge for the Colombian healthcare system is to identify DM patients as early as possible and provide equal access to treatment as early as possible to decrease the burden of DM.

Disclaimer

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Research Article

A Retrospective Analysis of the Relationship between Ethnicity, Body Mass Index, and the Diagnosis of Gestational Diabetes in Women Attending an Australian Antenatal Clinic

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Purpose. To estimate the prevalence of gestational diabetes mellitus (GDM) in a multiethnic population, assess the association between country of birth (COB) and GDM, and assess whether the association varies by body mass index (BMI). Methods. A retrospective study of 5260 pregnant women attending Sunshine Hospital, Australia, between 1st July 2012 and 30th June 2013. We fitted logistic regression models to assess the association between COB and GDM. An interaction between BMI and COB was assessed by likelihood ratio test. Results. In the 4610 included in our analysis, most common were women born in Australia or New Zealand (ANZ, 1932, 41.9%) and in Southeast Asia (922, 20%). GDM was diagnosed in 606 (13.2%) women. After adjusting for confounders, women from East Asia were most likely to develop GDM (37, 24.0%) and 5-fold more likely than women from ANZ (OR = 4.77, 95% CI: 3.12, 7.31, p < 0.001). Women from other Asian countries had a 3-fold increased risk of GDM compared to women from ANZ. There was no evidence of an interaction by BMI (p = 0.24). Conclusions. Women born in Asia have higher risk of GDM compared to women born in ANZ. These data provide support for including COB in GDM management policies.

1. Introduction

Gestational diabetes mellitus (GDM) is a condition that affects 6.5% of pregnant women in Australia [1] and is increasing in prevalence in Australia and worldwide [2, 3]. It is associated with wide reaching, sometimes long term and potentially severe, effects for both the mother and her child many of which can be ameliorated by lifestyle and pharmacological treatment of GDM [4]. These include increased perinatal mortality rates, major pregnancy, labour, and postdelivery complications, and an increased risk of obesity and metabolic syndrome in the offspring [2, 5–7]. However, there is increasing recognition that GDM may present and behave differently in women of different ethnicities and backgrounds. This makes it important to understand specific local population characteristics when designing and implementing local services. Australia’s multicultural composition is frequently described as being intrinsic to Australian identity. One in four Australians were born overseas and 44% were either born overseas or had a parent who was, and this number is increasing [8, 9]. The proportion of Australians born in Europe has declined in recent years while there has
been a significant increase in the populations of Australians who were born in Central, South, and Southeast Asia [9]. Western Health, in Melbourne, Victoria, Australia, services a very ethnically diverse population. In particular, the region hosts a large South Asian and Southeast Asian community who are known to be at particular risk of developing GDM [10]. Migrant women of any ethnicity are more prone to GDM in comparison to women of both their birth and host countries although reasons for this may be varied [11, 12].

Race/ethnicity and obesity are two of the strongest independent risk factors for GDM [13–17]. There is a positive association between an unhealthy weight and the development of GDM seen for all ethnicities but the strength of the association appears to be variable between ethnicities. The strongest association is found in women of South Asian origins compared to women from Australia and New Zealand (ANZ) [19]. Australia is increasingly multiethnic and the prevalence is modified by ethnicity. The World Health Organisation (WHO) has recognised that a healthy weight range, based on studies of risk factors and morbidities, varies with the ethnicity of the population studied [17] and may be lower (e.g., Southeast Asian populations) or higher (e.g., Pacific Islanders) than for Caucasians [18]. Therefore, cut-offs derived from European data do not provide an adequate basis for taking action on risks related to overweight and obesity. It suggests that the increased risk of health problems associated with increasing BMI must be regarded as being on a continuum with increasing BMI [17].

Local populations must be well understood in order to develop and implement policies that will provide the greatest benefit. A previous evaluation, in 1991, of GDM prevalence in a similar Australian population has found that rates may be tripled in women of Indian subcontinental and other Asian origins compared to women from Australia and New Zealand (ANZ) [19]. Australia is increasingly multiethnic and the prevalence of GDM is known to be increasing [2, 3, 19, 20] making reevaluation pertinent. This is particularly relevant given the changing immigration patterns over time. The current study aimed to determine the prevalence of GDM in a widely multiethnic population of women who presented to Western Health for pregnancy care and assess whether the association between body mass index (BMI) and GDM prevalence is modified by ethnicity.

2. Materials and Methods

2.1. Ethical Approval. This study has been approved by the Western Health Low Risk ethics panel (QA Reference Number: QA2014.111) and it conforms to the provisions of the Declaration of Helsinki (as revised in Seoul, 2008).

2.2. Design and Participants. All women who gave birth at Sunshine Hospital between 1st July 2012 and 30th June 2013 were included in this retrospective cohort study. Women with diabetes mellitus types one (T1DM) or two (T2DM) were excluded. We also excluded women who presented to the hospital with an already established diagnosis of GDM in the current pregnancy. Sunshine Hospital receives referrals from smaller centres of women excluded from care at these centres following their diagnosis with GDM. Excluding these women from analysis avoided overestimation of GDM as a result of these referrals. We used BOS (Birthing Outcome System), a specialised pregnancy related clinical information system, to access demographics and pregnancy outcomes data. The outcome measure was diagnosis of GDM. The maternal BMI was recorded at the first visit. Cases with missing BMI, country of birth (COB), age, or oral glucose tolerance test (OGTT) data were excluded. Also, cases with a BMI recorded as less than 16 were excluded in order to eliminate cases in which a patient’s height or weight had been omitted or incorrectly entered into the height or weight fields. Cases with a BMI greater than 50 were manually reviewed to ensure their accuracy.

Our centre used the Australian Diabetes in Pregnancy Society (ADIPS) guidelines for the testing and diagnosis of GDM initially published in 1991 [20]. In accordance with this guideline, women were diagnosed with GDM if one or both of the following criteria were met during 75 g glucose bolus OGTT:

(i) Fasting blood glucose level ≥5.5 mmol/L.

(ii) 2 hours after a 75 g glucose bolus, blood glucose level ≥8.0 mmol/L.

Women underwent risk based screening in early pregnancy. Remaining women and women in whom OGTT was negative on early screening underwent universal screening at 24 to 26 weeks gestation.

For each woman identified through BOS as having a diagnosis of GDM, we confirmed that the results of the OGTT were concordant with a diagnosis of GDM according to the ADIPS criteria. We then extracted further information regarding any prior OGTTs and the endocrinological management after diagnosis of GDM.

Patients were considered to have GDM regardless of the gestational age at diagnosis so long as pregestational T1DM or T2DM was excluded.

Screening and management protocols were consistent with the ADIPS guidelines and included routine testing with an OGTT for all women (without a prior glucose challenge test) at 26–28 weeks except where tested for and diagnosed earlier in pregnancy. Management involved early consultation with a credentialed diabetes educator and a dietician and self-monitoring of capillary blood glucose before and after meals. Insulin therapy was initiated if women were unable to meet ADIPS treatment targets with dietary and lifestyle modification. Adherence to these treatment guidelines was not assessed in this study.

COB, established by self-report at first visit, was used as a proxy for ethnicity. Women were then allocated to one
of the following 10 ethnic subgroups: Europe and North America, the Arab States, West and Central Asia, Southeast Asia, East Asia, South Asia, Africa, Latin America, Oceania, and Australia and New Zealand (ANZ). These groups are described in Table 1.

| Region                          | Country of birth                                      |
|---------------------------------|-------------------------------------------------------|
| Europe and North America        |                                                       |
| Albania                         | Herzegovina                                           |
| Belgium                         | Hungary                                               |
| Bosnia                          | Ireland                                               |
| Bulgaria                        | Italy                                                 |
| Croatia                         | Lithuania                                             |
| England                         | Malta                                                 |
| Finland                         | Montenegro                                            |
| Former Yugoslav Republic of      |                                                       |
| Macedonia                        | Norway                                               |
| France                          | Poland                                                |
| Germany                         | Portugal                                              |
| Greece                          | Romania                                              |
| Arab States                     |                                                       |
| Bahrain                         | Jordan                                               |
| Egypt                           | Jordan                                               |
| Iraq                            | Lebanon                                              |
| West and Central Asia           |                                                       |
| Afghanistan                     | Iran                                                 |
| Cyprus                          | Nepal                                                |
| South East Asia                 |                                                       |
| Cambodia                        | Laos                                                |
| East Timor                      | Malaysia                                             |
| Indonesia                       | Myanmar                                             |
| East Asia                       |                                                       |
| China                           | Japan                                                |
| Hong Kong                       | Korea (South)                                        |
| South Asia                      |                                                       |
| Bangladesh                      | India                                                |
| Africa                          |                                                       |
| Burundi                         | Ethiopia                                             |
| Chad                            | Gambia                                               |
| Comoros                         | Ghana                                                |
| Congo                           | Guinea                                               |
| Djibouti                        | Kenya                                                |
| Eritrea                         | Liberia                                              |
| Latin America                   |                                                       |
| Argentina                       | Colombia                                             |
| Brazil                          | El Salvador                                           |
| Chile                           | Guatemala                                            |
| Oceania                         |                                                       |
| Cook Islands                    | Nauru                                                |
| Fiji                            | Niue                                                 |
| ANZ                             |                                                       |
| Australia                       | New Zealand                                           |
and morbidly obese (≥35 kg/m²) according to WHO groupings [14]. Maternal age was grouped in quartiles (determined by the overall maternal ages of women delivering at the hospital during this time period), with quartile 1 defined as age ≤26 years, quartile 2 as age >26 and ≤29, quartile 3 as age >29 and ≤33, and quartile 4 as >33.

We fitted a univariable logistic regression model to assess the association between COB and presence or absence of GDM. Next, we fitted a multivariable logistic regression model to assess the above-mentioned association (i.e., the association between COB and GDM) after adjusting for age, parity, and BMI. We hypothesised a priori that the association between COB and GDM might vary by BMI. We fitted an interaction term for COB and BMI and tested the interaction with the likelihood ratio test.

We used the likelihood ratio test to test the assumption of a (log) linear association between age and GDM. We did this by fitting a model with age grouped into quartiles and compared it to a model with age as a pseudocontinuous variable (set to the median value in each quartile). There was evidence of a nonlinear association between age and (log odds) of GDM; therefore age was included as a categorical variable.

Data were collated using Excel 2013 and were analysed using SPSS v. 20 (IBM Corp., 2011).

3. Results

Of the 5260 women who attended Sunshine Hospital for delivery between 1st July 2012 and 30th June 2013, 650 were excluded from our analysis. 78 women were identified as either having pregestational T1DM or T2DM or were referred to Sunshine Hospital for care after being identified as having GDM. An additional 181 women were excluded due to incomplete BMI entries. COB was inadequately described in a further 343 women and age was missing in a further 48 cases. Of the 4610 women included in our analyses, 606 (13.2%) women were newly diagnosed with GDM (Figure 1).

The majority of women were born in Australia or New Zealand (n = 1932 (41.9%)). Other major COB groups were Southeast Asia (n = 922, 20.0%) and South Asia (n = 673, 14.6%). Overall, 40.9% of women were born in an Asian country (n = 1887). The mean age of our antenatal population was 29.2 years (Standard Deviation (SD) = 6.1 years), median BMI was 25.0 kg/m² (Interquartile range (IQR) 22.0–29.0). Also, 1998 (43.3%) were nulliparous and 2612 (56.7%) were multiparous (parity ≥ 1) (Table 2).

Table 3 presents the results from univariable and multivariable logistic regression analysis. After adjusting for age, BMI, and parity, women born in East Asia had almost 5-fold increased odds of GDM compared to women born in ANZ (OR = 4.77; 95% confidence interval (CI) = 3.12, 7.31, p value < 0.001). Similarly, women born in West and Central Asia, South Asia, and Southeast Asia had an approximately 3-fold increased risk of GDM (OR for West and Central Asia = 2.47, 95% CI 1.50–4.05, p = 0.01; OR for South Asia = 3.38, 95% CI 2.60–4.40, p < 0.001; OR for South East Asia = 3.03, 95% CI 2.34–3.93, p < 0.001). There was no evidence of an interaction between BMI and COB (p from likelihood ratio test = 0.24).

4. Discussion

This study found that women born in West and Central Asia, Southeast Asia, East Asia, or South Asia had the highest
Table 2: Demographic characteristics of women included in the study group.

| Maternal characteristics            | Number (%) |
|-------------------------------------|------------|
| Country of birth                    | (N = 4610) |
| Australia or New Zealand            | 1932 (41.9)|
| Arab States                         | 111 (2.4)  |
| West and Central Asia               | 138 (3.0)  |
| Southeast Asia                      | 922 (20.0) |
| East Asia                           | 154 (3.3)  |
| South Asia                          | 673 (14.6) |
| Africa                              | 354 (7.7)  |
| Latin America                       | 41 (0.9)   |
| Oceania                             | 83 (1.8)   |
| Europe and North America            | 202 (4.4)  |

Age (years)†: 29.2 ± 6.1

1st quartile (≤ 26 years) | 1360 (29.5) |
2nd quartile (26 and ≤ 29 years) | 1009 (21.9) |
3rd quartile (29 and ≤ 33 years) | 1186 (25.7) |
4th quartile (> 33 years) | 1055 (22.9) |

Parity
- Nulliparous (parity = 0) | 1998 (43.3) |
- Multiparous (parity 1 to 4) | 2484 (53.9) |
- Grand multiparity (parity ≥ 5) | 128 (2.8) |

Body mass index (kg/m²)
- Underweight (<18.5) | 198 (4.3) |
- Normal (18.5 and <25) | 2066 (44.8) |
- Overweight (25 and <30) | 1231 (26.7) |
- Obese (30 and <35) | 556 (12.1) |
- Morbidly obese (≥35) | 559 (12.1) |

†Mean and standard deviation.

The present study was limited by being retrospective. It is recognised that country of birth may not always reflect ethnicity. In particular, the population of women born in Australia or New Zealand may already be ethnically diverse. This may have increased the heterogeneity of our groups. We were unable to control for other factors commonly associated with the development of GDM such as diet and exercise. It has been previously suggested that diet and exercise may explain part of the association between COB and GDM (discussed above). Also, we sampled very small numbers of obese and morbidly obese women, despite a large sample size. This may have limited our ability to completely explore an interaction between BMI and COB as discussed above.

Regardless of the reasons for which ethnicity affects risk of diabetes, this study, performed in a multiethnic population, supports the need for ethnicity to be included in GDM screening as well as in management guidelines and policies. There is a need for widespread early screening in at-risk ethnic groups and for early implementation of culturally sensitive management techniques that may ameliorate the barriers identified by Bandyopadhyay et al. (2011) [3]. Future studies may investigate ethnic differences in the development of early onset GDM when all women are tested prior to 20 weeks gestation and investigate the utility of early interventions.

Conflict of Interests

The authors have no conflict of interest to disclose including specific financial interests or relationships or affiliations other than those previously mentioned relevant to the subject of this paper.
Table 3: Results of univariable and multivariable logistic regression for presence or absence of gestational diabetes mellitus (GDM) in 4610 women at Sunshine Hospital, Australia.

| Characteristics                  | GDM (𝑛) | No GDM (𝑛) | Odds ratio (95% CI) | p value | Odds ratio (95% CI) | p value |
|---------------------------------|---------|------------|--------------------|---------|--------------------|---------|
| **Country of birth**            |         |            |                    |         |                    |         |
| Australia or New Zealand        | 175     | 1757       | 1.00               |         | 1.00               |         |
| Arab States                     | 12      | 99         | 1.21 (0.65, 2.24)  | 0.55    | 1.33 (0.71, 2.50)  | 0.37    |
| West and Central Asia           | 22      | 116        | 1.89 (1.17, 3.06)  | 0.01    | 2.47 (1.50, 4.05)  | <0.001  |
| Southeast Asia                  | 161     | 761        | 2.11 (1.68, 2.66)  | <0.001  | 3.03 (2.34, 3.93)  | <0.001  |
| East Asia                       | 37      | 117        | 3.16 (2.11, 4.71)  | <0.001  | 4.77 (3.12, 7.31)  | <0.001  |
| South Asia                      | 136     | 537        | 2.59 (2.03, 3.30)  | <0.001  | 3.83 (2.60, 4.40)  | <0.001  |
| Africa                          | 34      | 320        | 1.12 (0.77, 1.63)  | 0.56    | 1.24 (0.83, 1.84)  | 0.29    |
| Latin America                   | 4       | 37         | 0.73 (0.42, 1.29)  | 0.28    | 0.90 (0.51, 1.60)  | 0.72    |
| Oceania                         | 11      | 72         | 1.06 (0.37, 3.00)  | 0.91    | 0.94 (0.33, 2.70)  | 0.91    |
| Europe and North America        | 14      | 188        | 1.52 (0.79, 2.91)  | 0.21    | 1.12 (0.57, 2.19)  | 0.74    |
| **Age (per year)**              |         |            |                    |         |                    |         |
| 25th centile (<26 years)        | 22      | 176        | 0.92 (0.64, 1.32)  | 0.64    | 0.96 (0.60, 1.54)  | 0.87    |
| 50th centile (≥26 and <29 years)| 22      | 1845       | 1.00               |         | 1.00               |         |
| 75th centile (≥29 and <33 years)| 22      | 1040       | 1.19 (0.93, 1.51)  | 0.17    | 1.05 (0.82, 1.35)  | 0.71    |
| ≥75th centile (≥33 years)       | 22      | 860        | 1.91 (1.52, 2.42)  | <0.001  | 1.70 (1.34, 2.17)  | <0.001  |
| **Body mass index (kg/m²)**     |         |            |                    |         |                    |         |
| Underweight (<18.5)             | 22      | 176        | 0.92 (0.64, 1.32)  | 0.64    | 0.96 (0.60, 1.54)  | 0.87    |
| Normal (≥18.5 and <25)          | 221     | 1845       | 1.00               |         | 1.00               |         |
| Overweight (≥25 and <30)        | 184     | 1047       | 1.47 (1.20, 1.81)  | <0.001  | 1.72 (1.38, 2.14)  | <0.001  |
| Obese (≥30 and <35)             | 84      | 472        | 1.50 (1.15, 1.95)  | 0.003   | 2.14 (1.60, 2.86)  | <0.001  |
| Morbidly obese (≥35)            | 95      | 464        | 1.70 (1.32, 2.20)  | <0.001  | 3.16 (2.34, 4.27)  | <0.001  |
| **Parity**                      |         |            |                    |         |                    |         |
| Nulliparous (parity = 0)        | 259     | 1739       | 1.00               |         | 1.00               |         |
| Multiparous (parity 1 to 4)     | 321     | 2163       | 1.01 (0.85, 1.19)  | 0.96    | 1.00 (0.83, 1.19)  | 0.98    |
| Grand multiparity (parity ≥5)   | 26      | 102        | 1.73 (1.12, 2.66)  | 0.01    | 1.80 (1.13, 2.86)  | 0.01    |
| **Total**                       | 606     | 4004       |                    |         |                    |         |

The multivariable analyses are adjusted for the other remaining maternal characteristics listed in the table. Nagelkerke \( R^2 = 0.08 \).

95% CI: 95% confidence interval.

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Diabetes Burden in Urban and Rural Senegalese Populations: A Cross-Sectional Study in 2012

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Diabetes represents a challenging global health issue in the 21st century. Data from sub-Saharan African populations are scarce and are usually restricted to urban settings. The objective of this study was to compare prevalence and risk factors of diabetes in rural and urban areas in Senegal.

Methods. In a community-based survey between January and May 2012, we included 1027 adults aged ≥18 years living in northern Senegal. Sociodemographic, clinical, and biological data were collected during household visits. Multivariate logistic regression was performed to identify factors associated with diabetes.

Results. Mean age of participants was 48.0 ± 16.9 years and 65.7% were female. Participants from urban area represented 55.7%. The age-standardized prevalence of diabetes was 7.6% (6.0% in men versus 9.0% in women). Prevalence of diabetes was higher in urban areas (8.1%) compared to rural areas (4.6%). Disease awareness rate was 43%. After multivariate analysis, age (OR = 1.63, p = 0.001), familial history of diabetes (OR = 1.42, p = 0.001), and abdominal obesity (OR = 1.17, p = 0.05) were associated with diabetes.

Conclusion. Diabetes is frequent in urban and rural areas in Senegal. Awareness rate is very low among populations. Age, family history of diabetes, and abdominal obesity are the main risk factors identified.

1. Introduction

Diabetes represents a challenging health issue in the 21st century with a growing incidence estimated to be 381.8 million patients globally in 2013 and high morbidity and mortality rates [1]. Though population data are often scarce, the African continent is expected to bear the most important burden of diabetes during the next coming decades [1–3]. However, a few countries have developed national strategies to contain this coming epidemic [2]. In many cases, lack of data is the major barrier for setting up efficient programs for prevention and management of diabetes in disadvantaged populations. In Senegal, there is not yet available data on diabetes burden at national level but one recent survey in Saint-Louis city (northern region) reported a prevalence of 10.4% with two-thirds of patients uncontrolled [4]. Moreover, marked disparities had been reported between urban and rural regions where lifestyle habits and access to care are different [2–4].
From each household a maximum of two participants were randomly recruited among those present at the day of visit.

Considering \( \alpha \)-error of 0.05 and a power \( \beta \) of 80%, the required sample size was 855 individuals and we added a 20% attrition rate to get a sample of 1026 participants. Finally, a total of 1056 persons were sampled to enter the study.

2.3. Data Collection. Data were collected on site during house-to-house visits that were conducted between 7 a.m. and 12 p.m. or at the nearest health centre when patients did not live far away from this facility.

A modified version of the WHO STEPwise questionnaire (http://www.who.int/chp/step/) was pretested and validated before its use to collect data. Researchers assisted by medical students, trained nurse practitioners, and community health workers had to fill the data collection form, to document the sociodemographic status (age, sex, marital status, education, profession, and education), personal and family health history (regarding, particularly, hypertension, diabetes, stroke, and heart and kidney disease), and lifestyle (nutritional habits, physical activity, smoking, and alcohol consumption) of each participant. Anthropometric measurements (weight, height, waist, and hip circumference) were performed using standard methods and calibrated devices. Blood pressure was measured twice at five minutes intervals by a semiautomatic sphygmomanometer and the mean of the two readings was calculated. If the difference between the readings was greater than 10 mm Hg, a third measurement was performed.

Hypertension was defined as a systolic blood pressure of 140 mm Hg or more, diastolic blood pressure of 90 mm Hg, any prescription of antihypertensive medication in the past two weeks, or any self-reported history of hypertension [5]. Obesity was defined using International Diabetes Foundation cut-offs [6].

Serum total cholesterol, LDL cholesterol, HDL cholesterol, and triglycerides were measured with colorimetric method. Fasting blood glucose (FBG) was measured with a glucose oxidase method, and serum total cholesterol, HDL cholesterol, and total triglycerides were measured by an enzymatic calorimetric method. LDL cholesterol was calculated by the Friedewald formula. Diabetes was defined as FBG \( \geq 126 \) mg/dL or by prescription of hypoglycemic agents despite fasting plasma glucose or any self-reported history of diabetes [6].

Physical inactivity was defined as less than 30 minutes of moderate activity per week or less than 20 minutes of vigorous activity three times per week, or the equivalent.

2.4. Statistical Analysis. Statistical analyses were performed with STATA 12.0 (Stata Corp, TX, USA). Continuous variables were presented as mean \( \pm \) standard deviation and categorical variables as percentage. Comparison of proportions and means were done using Pearson's Chi-square test or Student's \( t \)-test as appropriated. The age-standardized prevalence rates were calculated with the direct method, using the results of Senegalese general population census as the standard (http://www.ansd.sn/). Clinical and biochemical parameters associated with diabetes were assessed, in bivariate analysis, comparing the group with diabetes and the group without diabetes using Student's \( t \)-test or a Chi-square test. Variables significantly associated with diabetes were then included in a multivariate logistic regression model with age, gender, and urbanization as forced variable. Odds ratio (ORs) with 95% CI and \( p \) values of the final model are presented.

3. Results

A total of 1056 participants were involved in the study with a response rate of 99.1%. But 21 of them were excluded from the analysis because of incomplete collected data and 1026 individuals were finally analyzed. The majority of patients (55.3%) lived in urban area. The main clinical and biochemical characteristics are presented in Table 1.

The crude prevalence of diabetes in our sample was 10.8% (95% CI: 6.9%–14.2%). The age-adjusted prevalence of diabetes was 7.6% (95% CI: 5.4%–10.5%) with a difference between men (6.0%) and women (9.0%). The mean age of diabetic patients was 46.8 ± 13.5 years (18–76 years). The crude prevalence of diabetes in urban and rural settings was, respectively, 12.7% and 6.8%. Adjusted prevalence of diabetes was higher in urban areas (8.1%) compared to rural areas (4.6%) (Figure 1). Also, in both settings, there was an increase in diabetes prevalence with age as shown in Figure 2. Comparing cardiovascular risk of people living in urban and rural settings, we found similarly high prevalence of traditional cardiovascular risk factors such as hypertension, obesity, and physical inactivity contrasting with low proportion of smokers.

Regarding the disease awareness, 43% of patients were diagnosed during the survey, 36% were previously declared diabetic but without any medical follow-up, and 21% were regularly treated by a physician.

![Figure 1: Prevalence of diabetes and impaired glucose tolerance in different settings.](http://www.who.int/chp/steps/)
Table 1: Clinical and biochemical characteristics of participants.

| Age (years)       | All participants (n = 1027) | Urban areas (n = 572) | Rural areas (n = 455) | p value |
|-------------------|----------------------------|-----------------------|-----------------------|---------|
|                   | Crude Adjusted              | Crude Adjusted        | Crude Adjusted        |         |
|                   | 48.0 ± 16.9 (18–87)         | 51.6 ± 15.7           | 43.5 ± 17.2           | <0.01   |
|                   | 48.0 ± 16.9 (18–87)         | 51.6 ± 15.7           | 43.5 ± 17.2           | <0.01   |
|                   | ⊕ Adjusted                  | ⊕ Adjusted            | ⊕ Adjusted            |         |
| Age group         |                            |                       |                       |         |
| 18–34 years       | 25.6%                      | 16.0%                 | 37.8%                 | <0.01   |
| 35–49 years       | 25.3%                      | 26.1%                 | 24.2%                 |         |
| 50–60 years       | 23.6%                      | 28.0%                 | 18.1%                 |         |
| >60 years         | 25.5%                      | 29.9%                 | 19.9%                 |         |
| School education  | 60.7%                      | 52%                   | 63.4%                 | 47.5%   | 55.6%   | 45.8%   | 0.19    |
| Family diabetes   | 30.2%                      | 28.3%                 | 35.1%                 | 29.6%   | 28.6%   | 26.4%   | 0.04    |
| History           | 39.0%                      | 36.7%                 | 42.3%                 | 40.5%   | 34.6%   | 25.6%   | 0.05    |
| Fruits/vegetables | 4.2%                       | 2.9%                  | 5.2%                  | 3.1%    | 2.8%    | 1.7%    | 0.05    |
| Body mass index   | 26.3 ± 6.8                 | 26.9 ± 1.6            | 27.9 ± 7.3            | 24.6 ± 1.3 | 24.1 ± 5.5 | 12.7 ± 5.1 | 0.03  |
| Obesity           | 23.4%                      | 20.5%                 | 33.8%                 | 31.6%   | 10.2%   | 9.4%    | 0.01    |
| Waist circumference| 90.6 ± 16.1                | 90.1 ± 8.2            | 94.4 ± 15.6           | 91.6 ± 10 | 86.0 ± 15.6 | 82.4 ± 8.5 | 0.01  |
| Abdominal obesity | 53.1%                      | 48.6%                 | 63.9%                 | 59.5%   | 40.0%   | 33.4%   | 0.01    |
| Total cholesterol | 2.18 ± 0.5                 | 2.15 ± 0.5            | 2.25 ± 0.5            | 2.61 ± 3.2 | 2.10 ± 0.4 | 2.08 ± 1.1 | <0.01  |
| Hypercholesterolemia | 56.0%                      | 54.6%                 | 62.5%                 | 59.3%   | 46.7%   | 43.4%   | 0.53    |

* Adjusted for age.

Figure 2: Age-specific prevalence of diabetes in urban and rural areas.

The presence of diabetes was associated with common risk factors like age, gender, obesity, and familial history of diabetes (see Table 2). Univariate analysis showed that age ≥35 years (10% of diabetics versus 5.5% in people aged <35 years), female gender (9.0% of diabetics versus 6.0% in males), family history of diabetes (diabetes prevalence of 8.4% versus 5.1%), and obesity (diabetes prevalence of 13.9% versus 8.3%) were significantly associated with a higher chance to get diabetes. Conversely, physical activity and daily consumption of ≥3 fruits/vegetables were associated with lower risk of diabetes in this population (prevalence differences of 19.5% and 4.4%, resp.). After adjustment for age, gender, smoking, familial history, and obesity, the risk of diabetes was similar in individuals living in urban area compared to those living in rural areas (they presented a diabetes risk excess of 27%). Only age > 35 years (OR = 1.63, 95% CI = [1.48–2.06]), existence of family history of diabetes (OR = 1.42, 95% CI = [1.12–3.77]), and abdominal obesity (OR = 1.17, 95% CI = [1.00–1.78]) remained significantly associated with diabetes (see Table 3).

4. Discussion

Prevalence of diabetes in sub-Saharan Africa is variable across countries, ethnic groups, and settings considered. Reported data from community-based studies range from 2.8% in rural populations in Angola [7] to 28.2% found in South African mixed ancestry populations living in urban areas [8, 9].

Epidemiological studies in rural populations are scarcer but they generally show a lower prevalence [10–12] compared to surveys in urban settings [13–15].

In this study, the prevalence of diabetes in urban areas is quite twice the one in rural areas. Comparable prevalence ratios (urban/rural) were found in Kenya [12] and in Democratic Republic of Congo [15].

As already reported in the literature, we found an increasing prevalence with age which is a major risk factor for type 2 diabetes [2].

Gender distribution of diabetes is also variable. Some studies found higher prevalence in men [10, 11] and others reported the contrary [9, 16].
Table 2: Crude association between diabetes and risk factors (univariate analysis).

| Risk Factor                                      | Odds Ratio | [95% Confidence Interval] | p value |
|--------------------------------------------------|------------|---------------------------|---------|
| Age group (<35 versus ≥35 yrs)                   | 1.79       | 1.55–2.37                 | 0.001   |
| Female gender                                    | 1.14       | 1.05–3.28                 | 0.045   |
| Family history of diabetes                       | 1.60       | 0.76–1.45                 | 0.001   |
| School education                                 | 0.88       | 0.70–1.00                 | 0.038   |
| Fruits/vegetables consumption (≥3/day)           | 0.95       | 0.65–2.57                 | 0.244   |
| Smoking                                          | 1.05       | 0.92–2.68                 | 0.229   |
| Physical inactivity                              | 1.22       | 0.45–2.96                 | 0.502   |
| Hypertension                                     | 1.29       | 0.61–3.64                 | 0.073   |
| Obesity (BMI ≥ 30 kg/m²)                         | 1.10       | 0.85–1.92                 | 0.309   |
| Abdominal obesity                                | 1.66       | 1.40–2.03                 | 0.001   |
| Living in urban setting                          | 1.40       | 1.10–2.47                 | 0.039   |

BMI: body mass index.

Table 3: Adjusted association between diabetes and risk factors (multivariate regression analysis).

| Risk Factor                                      | Odds Ratio | [95% Confidence Interval] | p value |
|--------------------------------------------------|------------|---------------------------|---------|
| Age group (<35 versus ≥35 yrs)                   | 1.63       | 1.48–2.06                 | 0.001   |
| Female gender                                    | 1.42       | 0.75–1.84                 | 0.108   |
| Fruits/vegetables consumption (≥3/day)           | 0.87       | 0.25–1.43                 | 0.326   |
| Family history of diabetes                       | 1.49       | 1.12–3.77                 | 0.001   |
| Physical inactivity                              | 1.04       | 0.54–3.56                 | 0.235   |
| School education                                 | 1.02       | 0.33–1.92                 | 0.164   |
| Abdominal obesity                                | 1.17       | 1.00–1.78                 | 0.055   |
| Living in urban setting                          | 1.27       | 0.65–2.34                 | 0.073   |

N = 654, Pseudo-$R^2 = 0.152$.

In the present study, female gender, absence of school education, and living in urban setting were associated with diabetes at univariate analysis. However, these associations were no longer significant after adjustment for true risk factors that were abdominal obesity, age, and familial history of diabetes.

As underlined in many studies, we found a higher prevalence of diabetes in women compared to men and this difference was more striking among rural populations. The level of disease awareness is low in our study. However, these rates are better than what was reported in rural Tanzanians (8.3 to 13.2%) [17, 18] or South Africans (15.3%) [19] or in a previous survey in Dakar (capital city) where 90% of newly diagnosed diabetics were not aware of their disease [16].

Recent forecast suggests an alarming increase of diabetes incidence in Africa during the next decade in addition to other noncommunicable and infectious diseases [3]. In the US population between 1980 and 2011, the crude prevalence of diagnosed diabetes increased from 2.5% to 6.9% while age-adjusted prevalence rose in the same proportions indicating that changes in the population age structure do not explain the epidemic transition [20].

The true explanation of this rising burden of diabetes in both urban and rural Africa is probably multifactorial. With life expectancy increase, the most important part might be driven by lifestyle modifications (fast urbanization, physical inactivity, and dietary transition) which promote obesity and insulin resistance but also environmental and genetic factors have not been well explored [2]. Data on the changes in the $\beta$-cell function and insulin resistance in the early stages of the disease process in African populations are scarce [21]. A few genetic studies performed in small groups from northern and western Africa had identified some polymorphism associated with diabetes but epigenetic factors which should play an important role in the disease onset are still unknown [22–24].

Other conditions like HIV and sickle cell diseases are also incriminated in the current epidemics of diabetes in Africa [25, 26].

Despite its epidemiological importance of describing diabetes face in Senegalese populations, this study has many limitations. Firstly, the cross-sectional design is not suitable for inferential analysis about causality or direction of association between diabetes and other cardiovascular risk factors. Secondly, incidence of diabetes could not be calculated to estimate the disease potential progression in the population.

5. Conclusion

This study shows that diabetes is frequent in northern region of Senegal. Urban settings are more concerned than rural areas and prevalence is higher among women. The awareness rate is very low among populations. Age, familial history of diabetes, and abdominal obesity are the main risk factors
identified. Prevention program targeting both urban and rural populations are urgently needed in African countries in order to reduce the morbidity and mortality due to diabetes.

**Ethical Approval**

The study was approved by the National Committee for Ethics in Health Research.

**Consent**

A free consent form had to be signed by participants to give their approval before data collection. All participants were personally informed of their screening results and those with abnormal values were referred to a specialist for further exploration and treatment.

**Conflict of Interests**

The authors declare that there is no conflict of interests regarding the publication of this paper.

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