

Prevalence of Type 2 Diabetes Mellitus and Pre-Diabetes in Mosul City, Northern Iraq: Changes over 20 years!

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) and pre-diabetes represent a major health problem around the world, and their incidence and prevalence rates are rising. Data about changes in their prevalence rates in Iraq over the last few decades is limited.

Objectives: To determine the prevalence rates of T2DM and pre-diabetes among the adult (≥ 25 years old) population in Mosul City, Northern Iraq, and to compare them to the previous figures revealed by the previous literature.

Methods: This is a cross-sectional study that involved the screening of (410) adult subjects of both sexes from 7 different urban and rural areas in Mosul, 4 from the Mosul district itself (Al-Qahira, Al-Tise'en, Tammuz, and Althawra Quarters) and two from some rural areas surrounding the city (Al-Hamdaniyah town, and Bejwanyah village). In addition, the last sample consisted of subjects accompanying in-patients in different hospitals in the city. The study was conducted over 4 months starting from the 1st of September through 31st December 2024. Two blood tests, glycated hemoglobin (HbA1c) and fasting serum glucose (FSG) were measured after 12-16 hours of fasting and their values were used to classify participants into three groups; normal blood sugar group, pre-diabetic group, and diabetic group based on ADA diagnostic criteria. Known cases of T2DM were also included in the calculations of the prevalence of pre-diabetes and diabetes. The study followed a strict systematic randomization approach and was ethically approved.

Results: The overall prevalence of T2DM among study participants was 11.46% (14.77% for males, and 9.58 for females), and of prediabetes was 18.78%, (16.77% for males, and 19.9% among females). The prevalence of T2DM has increased by about 1.11% compared to our previous report (10.35%) published in 2002 with a dramatic increase in the rate of pre-diabetes.

Conclusion: There has been an increase in the prevalence rate of T2DM and a dramatic increase in the prevalence rate of pre-diabetes in Mosul City over the last two decades, this increment may be partly explained by changes in lifestyle and modifications in ADA diagnostic criteria for prediabetes.

Keywords: Prevalence, Pre-diabetes, Mosul City, Iraq, Diabetes

انتشار داء السكري من النوع الثاني وما قبل السكري في مدينة الموصل، شمال العراق: التغيرات على مدى ٢٠ عامًا!

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الخلاصة

الخلفية: يعتبر داء السكري من النوع الثاني وداء ما قبل السكري مشكلة صحية كبيرة في جميع أنحاء العالم، ويتميز بارتفاع معدلات الإصابة والانتشار، توجد بيانات محدودة حول التغيرات في معدلات الانتشار في العراق خلال العقود القليلة الماضية.

الأهداف: لتحديد معدلات الانتشار الحالية لداء السكري من النوع الثاني وداء ما قبل السكري بين السكان البالغين (≤ 25 سنة) في مدينة الموصل، شمال العراق، ومقارنتها بالأرقام السابقة التي كشفت عنها دراسة سابقة أجريت قبل عشرين عامًا.

المنهجية: هذه دراسة مقطعية شملت فحص ٤١٠ مشارك بالغ من كلا الجنسين من مناطق حضرية وريفية مختلفة في مدينة الموصل. شملت أربع مناطق من قضاء الموصل (أحياء القاهرة، التسعين، تموز، والثورة). كما تم شمول منطقتين ريفيتين حول مدينة الموصل هما مدينة الحمدانية وقرية البيجوانية. بالإضافة إلى شمول عدد من مرافقي المرضى الراقدين في مستشفيات

الموصل المختلفة) تم إجراء فحصين، هما الهيموجلوبين الغليكوزيلاتي (c1HbA) وتركيز السكر في مصل الدم بعد صيام ١٢-١٦ ساعة، واستخدمت قيمتهما لتصنيف المشاركين إلى ثلاثة مجموعات: غير مصابين بداء السكري، مصابين بداء ما قبل السكري، ومصابين بداء السكري من النوع الثاني، بناءً على معايير التشخيص الصادرة عن رابطة السكري الأمريكية (ADA). كما تم تضمين الحالات المعروفة من داء السكري من النوع الثاني في الحسابات لمعدل انتشار داء ما قبل السكري وداء السكري. **النتائج:** كان معدل انتشار داء السكري من النوع الثاني بين المشاركين في الدراسة ١١.٤٦% (١٤.٧٧% للذكور و ٩.٥٨% للإناث)، ومعدل انتشار داء ما قبل السكري ١٨.٧٨% (١٦.٧٧% للذكور و ١٩.٩% للإناث). وقد زادت معدلات انتشار داء السكري من النوع الثاني بنسبة ١.١١% مقارنة بالدراسة السابقة (١٠.٣٥%) المنشورة في عام ٢٠٠٢، مع زيادة كبيرة في معدل داء ما قبل السكري.

الاستنتاج: هناك زيادة في معدلات انتشار داء السكري من النوع الثاني وداء ما قبل السكري في مدينة الموصل، شمال العراق، خلال العقود القليلة الماضية، وخاصة داء ما قبل السكري. ويمكن تفسير هذه الزيادة جزئيًا بالتغيرات في نمط الحياة وتعديلات في معايير التشخيص الصادرة عن رابطة السكري الأمريكية.

الكلمات المفتاحية: معدل الانتشار، داء ما قبل السكري، مدينة الموصل، العراق، داء السكري من النوع الثاني.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is the most common endocrine disorder worldwide and the number of diabetic people is rising. Based on the International Diabetes Federation (IDF), the number of diabetics is estimated to reach 700 million by 2045¹. Such a massive health problem requires innovative tools for screening and early identification of the population at risk².

Prediabetes is another chronic metabolic condition in which the individual's glucose levels are above normal but do not meet the criteria for diabetes³. Apart from random blood glucose, diagnosis of diabetes according to the American Diabetic Association (ADA) relies on both glycated hemoglobin (HbA1c) testing and fasting plasma glucose (FPG), and diabetes is defined as HbA1c values of 6.5% and above and (FPG) values above 125 mg/dl, while prediabetes is diagnosed with any HbA1c reading from 5.7-6.4% and/or FPG from 100 to 125 mg/dl⁴.

In 2021 the global, age-standardized diabetes prevalence rate was 6.1%, the highest prevalence (9.3%) was in the region of Middle East and North Africa (MENA), and by 2050 this figure is expected to be higher than 10% globally and around 16.8 % in MENA region⁵. However, the overall prevalence of prediabetes is not well established due to the differences in the defining criteria for diagnosis. A study published in 2023 revealed the global prevalence of Impaired Glucose Tolerance (IGT) of 9.1% and Impaired Fasting Glucose IFG of 5.8% and expected them to be 10% and 6.5% respectively by the year 2045⁶.

In the last two decades, the number of individuals diagnosed with T2DM worldwide has tripled from 151 million in 2000 to 463 million in 2019, and in the MENA region, the problem was more prominent.^{7,8}

The prevalence of T2DM in Saudi Arabia was 8.5% in 1992 and rose to 14.4% in 2016 according to the WHO country profile⁹, and in another cross-sectional study in the kingdom published in 2022, the overall prevalence of prediabetes was 20%¹⁰.

In Iraq, limited data is available regarding the prevalence of diabetes and prediabetes. T2DM was reported by WHO in 2018 to range between 8.5% and 13.9 %, and prediabetes prevalence in Baghdad was found to be 20.6% by a study in 2019, and 17% in a study published in 2022¹¹⁻¹³.

This study aims to calculate the prevalence of diabetes and prediabetes in Mosul city and to compare the results with previous literature.

MATERIALS AND METHODS

Study Design

This is a cross-sectional study that involved screening of adult subjects (≥25 years) in Mosul city over 4 months, starting from September 1st, 2024. Mosul is a city in northern Iraq situated on both sides of the Tigris River which divides the city into two banks, officially named as the Left (East) and the Right (West) coasts. It represents the center of Nineveh governorate which has an area of about 33,313 Km² and a population of around 3,730,000, and is regarded as the second largest governorate in Iraq. Seven samples were collected for this study. Systematic randomization was used. Random systematic sampling was used, where screening involved people from every other house on the right side of the streets beginning from the first one.

Subjects

The population of the study, a total of 410 individuals, consisted of 7 samples. The first sample was composed of (67) subjects (23 males and 44 females) and was collected from among the

residents of the Al-Qahira quarter on the left side of Mosul city. The second was composed of (63) subjects (25 males and 38 females) and was collected from the Al-Tise'en quarter on the left side of the city.

The third sample was collected from the Tammuz quarter on the right side of the city of Mosul and was composed of (55) subjects (19 males and 36 females). The fourth was collected from the Al-Thawra quarter on the right side of Mosul city also and was composed of (52) subjects (20 males and 32 females).

The fifth sample was collected from Bejwanya village to the south of Mosul and was composed of (46) subjects (18 males and 28 females). The 6th was collected from Al-Hamdannyah town which is about 25 km to the southeast of Mosul. This sample was composed of (66 subjects) subjects (23 males and 43 females). The rest (61) subjects (21 males and 40 females) were collected randomly from people accompanying inpatients in different hospitals in the city upon consenting to participate.

Inclusion and Exclusion Criteria

All those who consented to participate and did not have any exclusion criteria were enrolled in this study. Individuals refusing to consent, patients with Type 1 diabetes mellitus (T1DM), insulin treatment, and renal, hepatic, thyroid, and malignant diseases were all excluded. Pregnant women and those who refused to participate were excluded as well.

Data Collection

Sociodemographic data were recorded using a questionnaire form that included the following data: age, gender, occupation, medical history for diabetes status, chronic illnesses, drug history, and family history of diabetes. Blood pressure was measured in resting state according to 2023 ESH guidelines, and hypertension was defined as SBP \geq 140 and/or DBP \geq 90 mmHg¹⁴.

Calculation of Sample Size

The required sample size was calculated according to the equation¹⁵:

$$n = (Z^2 \times p \times (1 - p)) / d^2$$

Where:

n: sample size

Z: Z-score, which represents the level of precision (1.96 for a 95% confidence level)

p: assumed prevalence (0.139 for diabetes, 0.206 for prediabetes, those values were taken from available literature)

d: margin of error (0.05)

The minimum required sample size according to the above equation was 184 for diabetes and 246 for prediabetes.

Classification of Study Subjects

The subjects were divided into three groups according to ADA criteria for diagnosis of T2DM and prediabetes (4):

1. Normal blood sugar group: subjects with HbA1c value $<$ 5.7% and FSG $<$ 100 mg/dl.
2. Prediabetic group: subjects with HbA1c value of 5.7-6.4 % and/or FSG value of 100-124 mg/dl.
3. Diabetic group: This group includes subjects who were previously diagnosed with T2DM and new cases diagnosed based on the ADA criteria (4). The diagnosis was based on having two abnormal values of the screening tests used. So, those with HbA1c value \geq 6.5% and FSG value \geq 125 mg/dl in the same blood sample were considered to be diabetic. However, for subjects with one test value meeting the criteria and the other one doesn't, the test with a higher value was repeated based on ADA recommendations, and if it is still above the threshold (6.5% for HbA1c and 125 mg/dl for FSG), the subject was classified as diabetic, but if it was lower, the value was implemented for further classification (either normal or pre-diabetes).

Specimens

Venous blood samples were collected from all participants by antecubital venipuncture under aseptic conditions after 12- 16 hours of fasting. People were asked to fast the next day, or when feasible, during the short interview for history taking.

A four-ml blood sample was collected from each subject, and was divided into 2 parts; 2 ml in an EDTA tube for measuring (HbA1c) and another 2 ml in a plain tube for measuring fasting serum glucose (FSG). Serum was obtained through centrifugation of blood samples at 4000 rpm for 5 minutes.

Laboratory Measurements

Biochemical analyses were run at the Clinical Biochemistry Lab, College of Medicine, University of Mosul. While FSG was measured directly after immediate serum separation, HbA1c was measured utilizing either fresh EDTA-mixed blood or refrigerated samples within 48 hr. maximum as feasible. FSG was estimated using FUJI DRI-Chem NX500 chemistry analyzer based on the principle of colorimetry using commercially available kits which are composed of multilayered slides containing dry chemistry ingredients according to

the instructions of the manufacturer¹⁶. However, HbA1c was measured using a Cobas 6000 analyzer based on the principle of colorimetric immunological assay to calculate HbA1c concentration, and its percentage to the total hemoglobin¹⁷.

Calculation of Prevalence Rates

The prevalence rates of T2DM and prediabetes were calculated according to the following equation:¹⁸

$$\text{prevalence} = \frac{\text{number of cases with disease}}{\text{total number of population (sample size)}} \times 100\%$$

Ethical Considerations

This study was already approved by the Medical Research Ethics Committee, College of Medicine, University of Mosul (UOM/COM/MREC/24-25/SEP2) and the Scientific and Research Ethical Committee of Nineveh Health Directorate (approval no.2024131), and it strictly followed the international ethical rules for medical research as stated in Helsinki Declaration II and its updates.

RESULTS

As a result of screening the sample of 410 subjects was categorized into three groups. The mean FSG and HbA1c values for the study groups were as follows.

1. Normal blood sugar group: This group included 286 individuals (102 males and 184 females). The mean (\pm SD) of FSG of this group was (88.97 ± 6.57) mg/dl, and for HbA1c (%), it was 5.06 ± 0.32 .
2. Prediabetic group: Seventy-seven individuals were categorized under this group. Twenty-five were males and (52) were females. The mean of FSG of this group was (101.92 ± 8.69) mg/dl, and for HbA1c it was (5.72 ± 0.32).
3. Diabetic group: This group included 31 (17 males and 14 females) known diabetic subjects, in addition to 16 individuals (5 males and 11 females) who were newly diagnosed with T2DM. Overall, a total of 47 diabetic subjects were encountered (22 males and 25 females). The mean FSG among subjects in this group was 149.81 ± 34.89 mg/dl, and for HbA1c was 7.75 ± 1.4 . The distribution of values of both FSG and HbA1c among the three study groups is shown in Figures (1) and (2) respectively. The basic characteristics of study subjects according to ADA criteria are shown in Table (1)

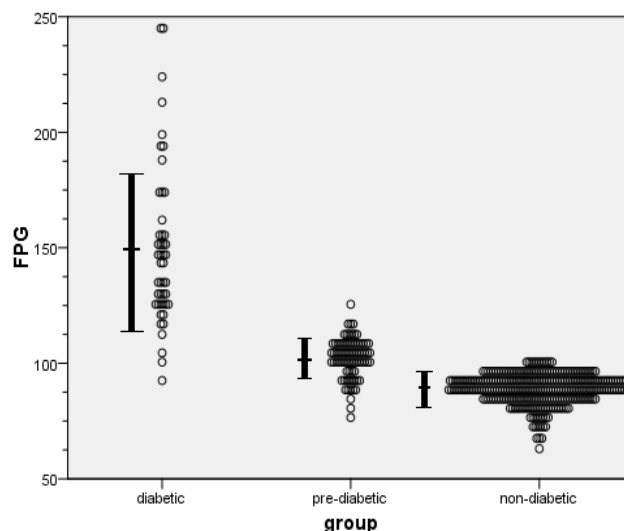


Figure (1). Distribution of FSG values (mg/dl) among the diabetic group, pre-diabetic group, and normal blood sugar group. Bars represent Mean \pm SD

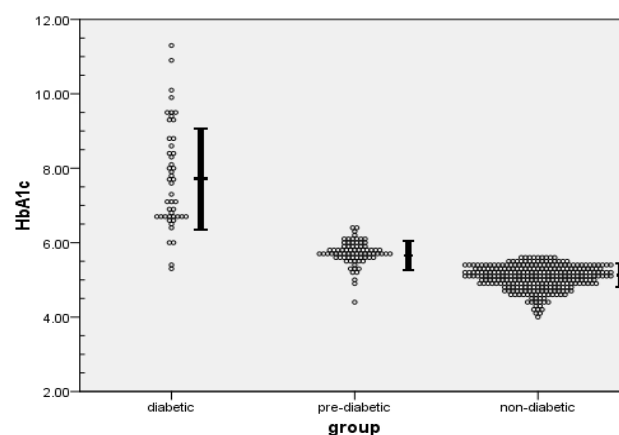


Figure (2). Distribution of HbA1c (%) values among diabetic group, pre-diabetic group, and normal blood sugar group. Bars represent Mean \pm SD

Table (1). Basic characteristics of study subjects classified according to ADA definitions of pre-diabetes and T2DM. Data are expressed as mean \pm SD or N (%) as appropriate.

		Normal blood sugar group (N=286)	Pre-diabetic group (N=77)	T2DM group (N=47)	p-value
Age (years)		42.25 \pm 19.25	49.62 \pm 12.73	57.32 \pm 8.64	0.000*
Sex	Male	102 (35.66%)	25 (32.47%)	22 (46.81%)	0.249†
	Female	184 (64.34%)	52 (67.53%)	25 (53.19%)	
SBP (mmHg)		128.06 \pm 16.36	136.51 \pm 16.51	138.77 \pm 18.15	0.000*
DBP (mmHg)		82.43 \pm 9.89	88.73 \pm 13.98	87.53 \pm 11.25	0.000*
Hypertension		101 (35.31%)	41 (53.25%)	29 (61.7%)	0.000†
FSG (mg/dl)		88.97 \pm 6.57	101.92 \pm 8.69	149.81 \pm 34.89	0.000*
HbA1c		5.06 \pm 0.32	5.72 \pm 0.32	7.75 \pm 1.4	0.000*

SBP: systolic blood pressure, DBP: diastolic blood pressure, FSG: fasting serum glucose. (*) ANOVA was used, and (†): Chi-square test was used.

Prevalence of T2DM and Pre-diabetes

In total, having 47 diabetic subjects out of 410 people screened for diabetes and pre-diabetes in this study, the overall prevalence of T2DM is 11.46 %. The prevalence of diabetes among males was found to be 14.77% compared to 9.58% among females. On the other hand, the overall prevalence of pre-diabetes based on ADA criteria was 18.78%, (16.77% among males, and 19.9% among females), Table (2).

The prevalence of undiagnosed (new cases) of T2DM in our study sample was 3.9%, and the ratio of hidden (new cases) to already diagnosed cases was 0.52:1, with the male-to-female prevalence ratio of 1.54:1. When the study population was subdivided by age groups, no one <35 years was found to be diabetic, however, the prevalence of pre-diabetes in this age group was 9.8%. In subjects \geq 35 years of age, the prevalence rate of diabetes was 15.25%, and of pre-diabetes was 21.75%. The highest prevalence rates of T2DM and pre-diabetes were encountered among those older than 65 years (31.25% and 25% respectively), Table (3).

Table (2). Sex distribution and sex-based prevalence rates of T2DM and pre-diabetes among the study population based on ADA criteria.

Sex distribution	T2DM	Pre-diabetes	p-value
Males (N=149)	14.76% (N=22)	16.77% (N=25)	0.11*
Females (N=261)	9.57% (N=25)	19.9% (N=52)	
Total (N=410)	11.46% (N=47)	18.78% (N=77)	

*Chi-square test was used

Table (3). Prevalence of T2DM and pre-diabetes according to age groups.

Age (years)	Prevalence of T2DM	Prevalence of pre-diabetes	p-value
25-34 (N=102)	0% (N=0)	9.8% (N=10)	<0.00001
35-44 (N=104)	3.8% (N=4)	14.4% (N=15)	
45-54 (N=109)	14.68% (N=16)	22.9% (N=25)	
55-64 (N=63)	26.98% (N=17)	30% (N=19)	
\geq 65 (N=32)	31.25% (N=10)	25% (N=8)	
Total (N=410)	11.46% (N=47)	18.78% (N=77)	

DISCUSSION

For any governmental health system to accommodate major health challenges, it has to be always updated, with epidemiological studies being a major tool. Regarding a common disease like T2DM, there is a need to monitor the changes in the incidence and prevalence rates over time. The current cross-sectional study tried to bridge this gap by comparing its results with those of previous studies in Mosul and Iraq mainly in the last two decades.

In the current study, 410 subjects (\geq 25 years of age; 149 males and 261 females) were screened, with a male-to-female ratio of 1:1.75. In 2001 a similar study was conducted in Mosul, where 1015 adult subjects were screened, 382 of whom were males and 633 females, with a male-to-female ratio of 1: 1.66¹⁹.

In the current study, the overall prevalence rate of T2DM in Mosul was found to be 11.46% which shows a rise in comparison to the figure of 10.35 % in 2001. The prevalence among males in 2024 was 14.77% and among females was 9.58%, compared to 10.21% and 10.43% respectively in the 2001 study. On the other hand, the overall prevalence rate of prediabetes in 2024 was found to be 18.78% compared to impaired fasting glucose (IFG) of 2.86% and impaired glucose tolerance (IGT) of 1.3% in the 2001 study.

The prevalence of undiagnosed (new cases) diabetes in 2024 was 3.9% compared to 4.43% in 2001, with the ratio of hidden (new cases) to diagnosed (known cases) diabetes of 0.52:1 compared to 0.54:1 in 2001. This minor reduction in the rate of undiagnosed diabetes may be due to increased awareness of people towards blood testing to uncover early disturbances of glucose homeostasis.

As in 2001, the current study found that there is an increase in diabetes occurrence with advancing age, where the prevalence of T2DM was 15.25% among those aged ≥ 35 years, with comparable results (15.12%) in the same age group in our previous study.

A cross-sectional study in Basrah, southern Iraq in 2008, revealed a prevalence rate of diabetes of 7.43%, and IFG of 2.14%¹⁹. Another study in Basrah also was conducted in 2014 and screened 5445 individuals from the age of 19-94 and found the prevalence of diabetes to be 19.7% and prediabetes to be 29.1%²⁰.

A study of a population of Iraqi immigrants in Sweden in 2011 found a prevalence of diabetes of 21.9% and prediabetes of 24%. This study had a small sample size (96) and included only adults aged between 45-65, which may explain in part the higher prevalence rates in the Swedish study. In accordance with this study, our study also revealed similar prevalence figures of diabetes and prediabetes for people from 55 to 64 (26.98% and 30% respectively)²¹.

In 2020, the WHO Representative in Iraq stated that the prevalence of diabetes in Iraq is 13.9%²², and around 2 years later a study conducted in Baghdad found the prevalence of prediabetes to be 17%¹². Another Iraqi study was conducted in Al-Rusafa, Baghdad in 2022, involved the screening of 723 individuals, and revealed a prevalence rate of diabetes of 14.7%²³. All these rates are comparable to ours.

A recent study in Duhok, northern Iraq published in 2024 found the prevalence of T2DM to be 18.2%, and prediabetes to be 14.7%²⁴. However, this study used only random blood sugar (RBS) criteria for diagnosis of diabetes (RBS of 140-199 mg/dl as prediabetes, and ≥ 200 mg/dl as

diabetes). Using RBS alone is not recommended by the ADA for the confirmation of T2DM. This might explain the significant difference in our work.

Another study in Zakho City, northern Iraq published in January 2025 found the prevalence of pre-diabetes to be 6.9%²⁵. The study excluded patients with established T2DM, so an accurate overall diabetes prevalence was not obtained, however, the prevalence of newly diagnosed cases of diabetes was 2.6% (compared to 3.9 in our study). This study had a high percentage of the young adult population (28.3% between 18-24 years) which may explain in part the difference to our study.

Diabetes continues to be a global problem. In the United States according to the CDC's national diabetes statistics report, the prevalence rates of diabetes increased from around 10% in 2001 to 13% in 2020²⁶. In 2023 The prevalence of diabetes in US adults increased to 15.8%²⁷. This data indicates a higher prevalence and a higher rise in diabetes levels in the United States compared to our study in Iraq for the approximately same period. This difference could be due to the effect of the sharp rise in the immigrant population in Latin America in the US as they tend to have a higher prevalence of diabetes²⁶.

In general, there is a trend of ever-increasing incidence and prevalence rates of diabetes and pre-diabetes in different areas of the world including Iraq. The significant increases in prediabetes rates are more pronounced and one factor that may explain that is the changes in diagnostic criteria. Before 2003, subjects with FPG < 110 mg/dl were considered normal, after that the prediabetic range was set to be from 100-124 mg/dl. Later on, in 2010, the ADA set a threshold of HbA1c for diagnosis of prediabetes, thus establishing the overall criteria used in our current study³.

In conclusion, the current study revealed an increase in the prevalence rate of diabetes in Mosul city over the last two decades, with a dramatic increase in the prevalence of prediabetes, which may be in part due to the adoption of new diagnostic criteria since our previous study in 2001 was based on the old criteria. In addition, a sedentary lifestyle, consumption of unhealthy fast food, and increased rates of obesity may also stand behind these changes.

Acknowledgment

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Conflict of Interest

Authors declare that they don't have any conflict of interest.

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