



Prediabetes in Syria and Its Associated Factors: A Single-Center Cross-Sectional Study

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ABSTRACT

Introduction: Prediabetes is a major risk factor for diabetes and many chronic complications, particularly cardiovascular disease (CVD). Risk factors vary among races and demographics. This is the first study to assess prediabetes in Syria and its relevant risk factors.

Methods: This cross-sectional study was conducted in a primary health clinic in Al-Mouwasat University Hospital, the major Hospital in Damascus, Syria. Interviews, examinations, and blood investigations were carried out by qualified physicians in the clinic.

Results: This study included 406 participants, of which 363 (89.4%) were females, 43 (10.6%) were males, 91 (22.4%) had prediabetes, 108 (26.6%) were overweight, and 231 (56.9%) were obese. Older age, positive family history of diabetes, obesity, abdominal obesity in females,

high cholesterol, being married, and CVD were statistically significantly associated with prediabetes ($p < 0.05$). However, prediabetes was not associated with gender, living in the city or country, cigarette smoking, hypertension, diet, triglycerides, or polycystic ovary syndrome ($p > 0.05$). However, in the multivariable analysis, only high cholesterol, familial diabetes, and waist diameter had significant association.

Conclusions: Prevalence of prediabetes in our study in Syria was higher than what was estimated by previous studies. While many risk factors were similar to other countries in the regions, other risk factors differed. These results were highly reflective of high burden of prediabetes and diabetes, mainly in relatively young females. Further studies are required to tackle this rising issue as it imposes major complications in the long term, and the high financial burden on the health care system.

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factor; Syria

Key Summary Points

Why carry out this study?

Diabetes is one of the most common medical conditions worldwide and has high disease burden, affecting many people worldwide.

Prediabetes is one of the major risk factors of diabetes and it can itself cause major complications. Prediabetes can be reversible in a third of cases, and this reveals the importance of early detection.

Prediabetes is often neglected, mainly in developing countries due to overburdened healthcare system and poor screening methods.

What was learned from the study?

Prediabetes and obesity in Syria had a high prevalence, mainly among females. However, the majority of cases were unaware.

Syrian demography is unique, indicating that associated factors with prediabetes are different than many studies.

INTRODUCTION

Diabetes is considered one of the major health issues of the 21st century. It is chronic and imposes high financial and medical burden [1]. In 2021, it was estimated that 537 million (10.5%) people worldwide age between 20 and 79 years had diabetes. Unfortunately, almost half of these individuals were unaware of their medical condition. It was also estimated that by 2045, the prevalence will be around 783 million people. This would cause a great financial burden on health care systems globally; thus, effective strategies to counter these issues are essential [2]. Countries in the Middle East in general and Syria in particular have not made significant changes to tackle this issue despite

the Middle East and North Africa having the second highest prevalence in the world. Concerningly, approximately 49% of the cases are undiagnosed and are unaware of this issue in these countries [1].

Prediabetes is when blood glucose is higher than normal, but not high enough for the diagnosis of diabetes mellitus. It is defined by having impaired fasting glucose (IFG), impaired glucose tolerance (IGT), or by having high HbA1C levels above set thresholds [3]. It is a major risk factor for type 2 diabetes mellitus (T2DM) as around 25% of people with prediabetes develop T2DM within 3–5 years [4]. Other complications of prediabetes include cardiovascular disease (CVD), hypertension (HTN), microvascular disease including renal and retinal disease, dental issues, cognitive impairment, and many other metabolic and endocrine complications [3]. Importantly, blood glucose is likely to normalize in approximately 25% of prediabetic patients who adjust their risk factors [5]. This highlights the importance of early detection and intervention as these borderline glucose levels might be neglected for years [3].

Many risk factors of prediabetes remain controversial. However, many of them are modifiable, and they vary depending on the race and population [6]. Therefore, many possible risk factors of prediabetes were included in this study, including: elderly age, CVD, unhealthy diet, living in the countryside, being overweight or obese, high waist circumference (WC), smoking, marital status, high triglycerides (TG), high cholesterol, and family history of T2DM [3, 4, 6–9].

We hypothesized that prediabetes in Syria had higher rates due to neglect, poor lifestyles/diet, and poor screening tools, which would have allowed early interventions. One study that included Syria estimated that prediabetes prevalence was 8.2%. However, they believed that it was underestimated due to poor epidemiological surveys which emphasized even more about the importance of this study [1]. We also hypothesized that the unique demography and being in conflict for several years might have affected other risk factors and made the demography even more unique. Moreover, prediabetes prevalence is increasing worldwide,

which emphasizes the importance of relevant studies. This is the first study to include prediabetes in Syria and its association with various risk factors.

METHODS

Study Design and Sampling

This is a cross-sectional study conducted in the general clinics of Al-Mouwasat University Hospital, the major hospital in Damascus, Syria, covering the period between March 2021 and October 2021.

This study included participants who attended the hospital's general clinics for multiple reasons but were not found to have major comorbidity. Unfortunately, the healthcare system in Syria does not utilize general practitioners. This means that patients can access specialists or can go to general internal doctors directly in either private clinics or healthcare clinics in hospitals or medical centers. Most patients use the latter option, as they are free or relatively cheaper if they are private and provide good-quality care, especially as the majority of the Syrian population is under the poverty line (approximately 90%) [10].

Inclusion and Exclusion Criteria

Inclusion Criteria

Inclusion criteria were any participant who attended the general clinics at Al-Mouwasat University Hospital from March 2021 to October 2021 and aged 18 years or older. Additionally, individuals must be healthy individuals with none of the exclusion criteria.

Exclusion Criteria

- (1) Having abnormal blood tests diagnostic of diabetes or formerly being diagnosed with diabetes
- (2) Having disorders that affect blood glucose level such as endocrinology disorders of cortisol or the thyroid
- (3) Taking medications that affect blood glucose level (BGL) such as steroids

- (4) Being currently pregnant
- (5) Having a poorly controlled co-morbidity

Definitions, Instruments, and Related Measures

Direct interviews and examinations of patients were conducted after written consent for participation in the research, and utilization and publication of the data was obtained. Questions included demographic information, family history of diabetes, cigarette smoking, medical and drug history, and whether their diet regularly contained fruits and vegetables. Women were also questioned about past diagnosis of polycystic ovary syndrome (PCOS) and number of births and miscarriages they had, if any.

Weight, height, WC, and blood tests were taken in the clinic. Blood tests were analyzed in the same clinical lab (hospital clinical lab). Bloods were taken when the patient was fasting for at least 10–12 h. Blood tests included full blood count, BGL, electrolytes, beta human chorionic gonadotropin (BHCG), total cholesterol, low-density lipoprotein (LDL) and TG levels. We questioned whether fruit and vegetables were eaten regularly, and if fully saturated fats were consumed on a regular basis. CVD history was determined to be positive if the patient had any cardiac events, stroke, or peripheral vascular disease. Familial history of diabetes was considered positive when the patient had a first-degree relative diagnosed with T2DM.

Weight was taken after removal of shoes and heavy clothes. Body mass index (BMI) was calculated as body weight (in kilograms) divided by height squared (in meters).

Marital status was divided into married and single, which included other categories such as widowed and divorced. Living places were divided into city and countryside. Cigarette smoking was categorized into never smoked and ex-regular smoker regardless of the duration and amount and current smoker regardless of the duration and amount. No other forms of smoking were included. Blood pressure (BP) was taken 5 min after sitting. High cholesterol was defined as having total cholesterol of ≥ 200 mg/

dl or LDL \geq 130 mg/dl. TG was considered high if TG \geq 150 mg/dl.

Prediabetes diagnosis was made according to the American Diabetes Association (ADA) by having either two abnormal independent tests or one abnormal test in two blood samples. These tests included any of the following [11]:

- Fasting plasma glucose (FPG) between 100 and 125 mg/dl.
- HbA1c level between 5.7 and 6.4%.
- Or BGL between 144 and 199 mg/dl after giving 75 g of glucose.

FPG was repeated in any patient with anemia or congenital blood disorder as HbA1c can be unreliable in these patients [12]. BMI indicated a normal weight when between 18.5 and 24.9 kg/m², overweight when between 25 and 29.9 kg/m² and obese when above 30 kg/m².

HTN is defined as having systolic BP higher than 139 or diastolic BP higher than 89 on several readings on several occasions or needing anti-hypertensive medications [13]. WC was considered normal if < 94 cm for men and < 80 cm for women [14].

Ethical Approval

The ethical approval for conducting this study was obtained from the ethical committee of the Faculty of Medicine at Damascus University in Syria. All methods were carried out following the institutional and national guidelines and conforming to the ethical standards of the Declaration of Helsinki. All participants were informed about the study objectives and written informed consent was obtained as a prerequisite before administering the questionnaire.

This study was approved by the ethical committee to be conducted from March 2021 to October 2021 regardless of the sample size reached at the end. Therefore, sample size calculations were not used.

Statistical Analysis

Statistical Package for Social Sciences version 26.0 (SPSS Inc., Chicago, IL, USA) was used for

statistical analyses. Descriptive statistics were also used; continuous variables were described as mean and standard deviation (SD), while categorical variables were reported as frequency counts and percentages. Pearson's chi-square and analysis of variance (ANOVA) tests were used to detect significant differences for univariate analysis. Additionally, two multivariable binary logistic regression models were used; the first model included all variables which had statistical significance of $p < 0.2$ in the univariate analysis [15]. The second model contained the same variables but included only those that may be complications of prediabetes. Both unadjusted odds ratio (OR) and adjusted odds ratio (AOR) with their 95% confidence intervals (CI) were reported. A p value < 0.05 was used for statistical significance.

RESULTS

This study included 406 participants, of which 363 (89.4%) were females. Mean age was 42.7 (± 13) years. Characteristics of the sample are summarized in Table 1. The prevalence of prediabetes was 91 (22.4%) in our study. The prevalence of overweight patients was 108 (26.6%) while the prevalence of obese patients was 231 (56.9%). Interestingly, there were no significant differences in detecting prediabetes when comparing males and females ($p > 0.05$). Univariate analyses were conducted using chi-square and ANOVA tests as demonstrated in Table 2. Females mean BMI (30.92) kg/m² was higher than male mean BMI (29.27) kg/m² ($p = 0.058$). Males had a mean age of 43 years while females had a mean age of 42.6 years ($p = 0.055$). There was no significant difference in TG number ($p = 0.998$), WC ($p = 0.123$) or high cholesterol (0.812) between genders.

The median number of births in females was 4 (± 2.6) and the median number of miscarriages was 0.8 (± 1.3). There were no significant differences when comparing these two variables with being prediabetic or not ($p = 0.293$, and $p = 0.478$, respectively). Additionally, when comparing smoking cigarettes in general and not smoking with detecting prediabetes, there was no significant difference ($p = 0.322$). WC in

Table 1 Demonstrating characteristics of the sample

Characteristic	Frequency count (<i>n</i> = 406)	Percentage (%)
Age in years (mean, SD) = 42.7 (13.0)		
Gender		
Male	43	10.6
Female	363	89.4
Age		
18–27 years	51	12.6
28–37 years	94	23.2
38–47 years	110	27.1
48–57 years	95	23.4
58 years or older	56	13.8
Marital status		
Single (including divorced and widowed)	83	20.4
Married	323	79.6
Place of residency		
City	277	68.2
Country	129	31.8
Current cigarette smoking		
Never smoked	327	80.5
Previous smoker	15	3.7
Current smoker	64	15.8
BMI		
Normal (BMI between 18.5 and 24.9)	67	16.5
Overweight (BMI between 25 and 29.9)	108	26.6
Obese (BMI above 30)	231	56.9
High cholesterolemia		
No	277	68.2
Yes	129	31.8

Table 1 continued

Characteristic	Frequency count (<i>n</i> = 406)	Percentage (%)
High triglycerides		
No	303	74.6
Yes	103	25.4
Hypertension		
No	333	82
Yes	73	18
Pre-diabetic		
No	315	77.6
Yes	91	22.4

males was not associated with detecting prediabetes ($p = 0.243$). In contrast, prediabetic females had higher WC by over 8.2 cm when compared to non-prediabetic females ($p < 0.001$).

Binary logistic regression on prediabetes was conducted for variables that had $p < 0.2$ from Table 2. Two models were used: the first by regressing all the variables and the second by only regressing potential complications from prediabetes. Results have been summarized in Table 3.

DISCUSSION

This study included 406 participants that attended the primary health clinics in Al-Mouwasat University Hospital, the major hospital in Damascus, Syria, with 91 (22.4%) participants having prediabetes. The average BMI was 30.7 kg/m² and WC was 91 cm; both results were abnormal and reflected obesity in the general population. In using univariate analysis, being married, T2DM in first-degree relatives, older age, higher BMI and WC were all associated with a diagnosis of prediabetes ($p < 0.05$).

The prevalence of prediabetes in our study was lower than that of southwest Iran, where it was (30.29%) in one study [6] and 30.8% in

Table 2 Variables compared with being pre-diabetic or not

Variables	Normal (%) (<i>n</i> = 315)	Pre-diabetes (%) (<i>n</i> = 91)	Chi-square <i>p</i> value
Gender			
Male	36 (11.4%)	9 (9.9%)	0.681
Female	279 (88.6%)	82 (90.1%)	
Marital status			
Single	73 (23.2%)	10 (11.0%)	0.011
Married	242 (76.8%)	81 (89.0%)	
Living place			
Countryside	94 (29.8%)	35 (38.5%)	0.120
City	221 (70.2%)	56 (61.5%)	
Cigarette smoking			
Never smoked	257 (81.6%)	70 (76.9%)	0.072
Ex-smoker	8 (2.5%)	7 (7.7%)	
Current smoker	50 (15.9%)	14 (15.4%)	
Hypertension			
No	261 (82.9%)	72 (79.1%)	0.414
Yes	54 (17.1%)	19 (20.9%)	
High cholesterol			
No	227 (72.1%)	50 (54.9%)	0.002
Yes	88 (27.9%)	41 (45.1%)	
High triglycerides			
No	239 (75.9%)	64 (70.3%)	0.284
Yes	76 (24.1%)	27 (29.7%)	
Cardiovascular disease			
No	273 (86.7%)	71 (78.0%)	0.043
Yes	42 (13.3%)	20 (22.0%)	
Familial diabetes			
No	191 (60.6%)	35 (38.5%)	< 0.001
Yes	124 (39.4%)	56 (61.5%)	

Table 2 continued

Variables	Normal (%) (<i>n</i> = 315)	Pre-diabetes (%) (<i>n</i> = 91)	Chi-square <i>p</i> value
High saturated fat diet			
No	191 (60.6%)	49 (53.8%)	0.246
Yes	124 (39.4%)	42 (46.2%)	
Regular fruits and vegetables consumption			
No	76 (24.1%)	28 (30.8%)	0.201
Yes	239 (75.9%)	63 (69.2%)	
Polycystic ovary syndrome			
No	238 (84.7%)	74 (90.2%)	0.204
Yes	43 (15.3%)	8 (9.8%)	
Age [mean (SD)] ^a			
42.7 in years (13.0)	41.7 (13.2)	46.0 (11.8)	0.005
BMI in kg/m ² [mean (SD)] ^a			
30.7 (6.3)	30.2 (6.2)	32.6 (6.3)	0.001
Waist circumference in cm [mean (SD)] ^a			
91.0 (16.1)	89.2 (15.4)	97.1 (16.9)	< 0.001
Triglycerides number in mg/dl [mean (SD)] ^a			
135.5 (69.6)	131.8 (71.7)	148.0 (60.5)	0.052

Statistically significant *p* values at *p* < 0.05 are marked in bold. Chi-square was used unless stated otherwise

^aANOVA test was used

another [16]. Additionally, prevalence in our study was lower than the prevalence in Ain Shams University in Egypt (36%) [17], Oman (44.2%) [18], and Kuwait (47.9%) [19]. Prevalence of prediabetes in our study was also lower than Qatar (32.6%) [20], Saudi Arabia (27.6%) [21], and Germany, where it was (33%) using IFG, (16%) using IGT, and (26%) using HbA1C [22]. However, prevalence in Syria was higher than that in Ethiopia (15.7%) [23] and UAE where it was between 8 and (17%) depending on ethnicity [24].

Table 3 Binary logistic regression analysis for the association between being pre-diabetic and various predictors

Predictors category	Subcategory	Model 1: pre-diabetes with all variables of $p < 0.2$ from Table 2				Model 2: prediabetes and only complications	
		Crude OR (95% CI) ^b	p value	AOR (95% CI)	p value	AOR (95% CI)	p value
Age ^a	–	1.026 (1.008–1.045)	0.006	1.010 (0.986–1.035)	0.406	–	–
BMI ^a	–	1.061 (1.022–1.106)	0.002	1.007 (0.943–1.076)	0.829	1.000 (0.940–1.063)	0.998
Waist circumference ^a	–	1.032 (1.016–1.047)	< 0.001	1.024 (0.997–1.051)	0.085	1.030 (1.005–1.056)	0.020
Triglycerides level ^a	–	1.003 (1.000–1.006)	0.56	1.000 (0.996–1.004)	0.977	1.001 (0.997–1.004)	0.772
High cholesterolemia	No	Reference					
	Yes	0.473 (0.292–0.765)	0.002	0.509 (0.298–0.868)	0.013	0.507 (0.304–0.845)	0.009
Cardiovascular disease	No	Reference					
	Yes	0.546 (0.302–0.988)	0.046	0.947 (0.481–1.865)	0.875	0.773 (0.413–1.447)	0.421
Familial diabetes	No	Reference				–	–
	Yes	0.406 (0.251–0.655)	< 0.001	0.431 (0.261–0.711)	0.001	–	–
Living place	Country	Reference				–	–
	City	1.469 (0.903–2.390)	0.121	1.352 (0.798–2.291)	0.263	–	–
Marital status	Single	Reference				–	–
	Married	0.409 (0.202–0.830)	0.013	0.750 (0.335–1.675)	0.482	–	–
Cigarette smoking	Never	Reference				–	–
	Ex-smoker	0.973 (0.508–1.861)	0.934	0.944 (0.474–1.879)	0.870	–	–
	Current smoker	3.125 (0.965–10.117)	0.057	2.217 (0.637–7.719)	0.211	–	–

Table 3 continued

Predictors category	Subcategory	Model 1: pre-diabetes with all variables of $p < 0.2$ from Table 2				Model 2: prediabetes and only complications	
		Crude OR (95% CI) ^b	p value	AOR (95% CI)	p value	AOR (95% CI)	p value
Model summary		Nagelkerke's R -square = 0.156; Hosmer–Lemeshow test ($\chi^2 = 10.815$; $p = 0.212$); Predicted overall percentage correct = 77.6%				Nagelkerke's R -square = 0.095; Hosmer–Lemeshow test ($\chi^2 = 5.086$; $p = 0.748$); Predicted overall percentage correct = 78.8%	

Statistically significant values at $p < 0.05$ in the adjusted models are shown in bold

OR odds ratio, AOR adjusted odds ratio, CI confidence interval

^aTreated as continuous variable

^bCrude odds ratio to both models are the same

By reviewing the latest edition of the International Diabetes Federation (IDF), we discovered that the prediabetes prevalence in our study was much higher than estimated values; the estimated prevalence of prediabetes in Syria in 2021 was (14.9%) with age-adjustment, 5.1% (1.7–6.7%) for IFG, and 8.3% (5.4–10.5%) for IGT [25]. Another study estimated prediabetes prevalence to be (8.2%) in Syria [1]. This discrepancy may be due to the lack of data and studies accompanying the spread of prediabetes in Syria, as the IDF relies on data received from neighboring countries with similar ethnicities, languages, and economic status.

Prediabetes was significantly associated with advanced age; this finding was consistent with reports from other studies [23]. This could be due to the increased body fat that accompanies aging, which may contribute to the development of insulin resistance. Additionally, the aging process is associated with a decrease of β -cell proliferative capacity and enhanced sensitivity to apoptosis.

The prevalence of overweight patients in our study was lower than most Arab and Middle Eastern countries. However, more than half of the population in our study had obesity

(56.9%), which was higher than most Arab and Middle Eastern countries.

Prediabetes was significantly associated with higher BMI. Also, there was a statistically significant difference in the weight of prediabetic patients compared to normal individuals, which was similarly observed in other international studies. Obesity causes insulin resistance and decreases insulin-stimulated glucose disposal leading to the development of prediabetes and DM [26].

There was no significant difference in obesity, WC, TG, or cholesterol results when comparing males and females; this differs to many studies that have described prediabetic men having higher TG and prediabetic women having higher HTN prevalence, higher TG, cholesterol, and CVD [6]. This might be not true in our study due to the high number of females included in our study.

Many studies found higher HTN prevalence, high cholesterol, and TG in prediabetes compared to non-prediabetes; additionally, many studies observed these associated factors in higher numbers than our study [6, 16, 27]. CVD was associated with prediabetes, which was similarly observed in other studies [6]. Being married was found to be associated with being

prediabetic, which has similarly been noted in other studies [6, 21, 27].

Being prediabetic was associated with advanced age, being married, positive family history of T2DM, obesity, abdominal obesity in females, high cholesterol, and CVD. High TG association with prediabetes had $p = 0.052$, which might be due to small sample size limiting the ability to show a significant difference. However, being prediabetic was not associated with gender, living in the city or country, waist circumstance in men, cigarette smoking, HTN, having high-fat or regular fruit/vegetable diet, number of births/miscarriages, or PCOS ($p > 0.05$). Not finding significant differences between the gender can be again due to the high number of females in this study compared to males.

In using univariate analysis, being married, diabetes in a first-degree relative, older age, higher BMI and WC were associated with being prediabetic ($p < 0.05$). In the multivariable analysis, only having high cholesterol was found to be significant in both models; familial diabetes in the first model and WC in the second model.

Although this study is the first in Syria, it has limitations that could affect interpretation of the results. Participants were recruited from only one hospital. Thus, results may not be representative of the entire Syrian population. Unfortunately, given the limited resources and infrastructure, collecting data from many centers was unfeasible. Additionally, a larger sample size from a more diverse population would be beneficial. Furthermore, a cohort study would be more useful for identification of complications caused by prediabetes. Physical activity and diets need further variables such as type of activities and regularities and a more detailed diet description. Other factors of prediabetes could not be studied, such as having excessive alcohol due to alcohol being a major stigma in the Syrian society. High levels of glutamic pyruvate transaminase, liver enzymes, insulin level and c-peptide were also not studied despite being a risk factor for prediabetes [28] due to financial limitations.

Selection bias from including one general clinic in one medical center, the relatively

young age of participants, and having high rates of females in our study greatly affect the ability to generalize our finding. Another factor is the sample size. A larger sample size would determine the prevalence more accurately. Not having a clear healthcare structure that utilizes general practitioners affected how participants could be included. However, using the general clinic in the hospital is the closest available means to the general clinic. As the majority of the population was under the poverty line, individuals would frequent these clinics, as they are free, reliable, and the substitute was either similar clinics in other centers or private clinics, which may be expensive.

CONCLUSIONS

The prevalence of pre-diabetes among the Syrian population in this study was remarkably high. Furthermore, a large proportion of people with prediabetes were not aware of their diagnosis. These results indicated that prediabetes was associated with multiple factors, such as increasing age, high BMI, being married, positive family history of diabetes, abdominal obesity in females, high cholesterol, and CVD. These results were particularly significant for female participants.

Many of these factors can be modified to reduce the burden of prediabetes in the coming years. All efforts are required to provide robust screening of those at risk, and strategies for prevention of diabetes are needed to halt the progression of this important health problem.

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Author Contributions. All authors contributed to the study conception and design. Material preparation and data collection were performed by Rama Auad. Data analysis was performed by Rama Auad and Ameer Kakaje. Supervision and facilitation were conducted by Zaynab Alourfi. All authors contributed to the first draft and reviewed and commented on revisions until this manuscript was finalized. All authors read and approved the final manuscript.

Disclosures. Dr Lilianne Haj Hassan has substantially helped with collecting the data and interviewing the patients. Ruby M Kearney has helped with proofreading the paper.

Compliance with Ethics Guidelines. This study fully compliant with ethical guidelines. This was a non-interventional cross-sectional study. Written informed consent was taken before proceeding with the survey for participating in the research, and for using and publishing the data. We ensured that confidentiality was maintained and asked no questions that might reveal any individual's identity. No subjects were under the age of 18. Our study protocol and ethical aspects were reviewed and approved by Damascus University Faculty of Medicine, Damascus, Syria. All methods were carried out following the institutional and national guidelines and conforming to the ethical standards of the Declaration of Helsinki.

Data Availability. The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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