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ARTICLE

Analysis of Factors Influencing Clinical Inertia in the Treatment of Type 2 Diabetes Mellitus Patients With Metformin

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Abstract

Aims/Background Medication therapy is a crucial measure for type 2 diabetes mellitus (T2DM). However, approximately 50% of diabetes patients in China fail to achieve their blood glucose control targets despite receiving hypoglycemic treatment. Studies have indicated that clinical inertia is often a key factor contributing to poor long-term blood glucose control in most patients. This study aims to investigate the factors influencing clinical inertia in the treatment process of patients using metformin.

Methods A retrospective study method was adopted, and 86 T2DM patients treated with metformin who have clinical inertia between June 2021 and June 2023 at Zhejiang Hospital were treated as the inertia group. Additionally, 87 patients who received the same medication treatment and follow-up evaluation without clinical inertia during the same period were selected as the control group. By comparing general data, family and economic situations, lifestyle, and diabetes conditions between the two groups, a logistic multivariate analysis model was used to analyze the factors influencing clinical inertia in the treatment process of T2DM patients using metformin.

Results The proportion of male patients and those with an elementary education or below was significantly higher in the inertia group compared to the control group ($p < 0.05$). Additionally, the proportion of patients without commercial insurance was significantly higher in the inertia group ($p < 0.05$). The proportion of patients practicing dietary control was lower in the inertia group compared to the control group ($p < 0.05$). Furthermore, the inertia group had a lower proportion of patients with initial glycated hemoglobin levels $\geq$8.0%, those conducting home blood glucose monitoring, patients with diabetes-related complications, and those receiving diabetes health education compared to the control group ($p < 0.05$). Male gender (odds ratio (OR) = 3.487, $p = 0.001$), elementary education or below (OR = 2.362, $p = 0.027$), lack of commercial insurance (OR = 3.783, $p = 0.005$), absence of home blood glucose monitoring (OR = 3.127, $p = 0.007$), absence of diabetes-related complications (OR = 2.995, $p = 0.006$), and lack of chronic disease health education (OR = 2.753, $p = 0.017$) were identified as risk factors for clinical inertia in the treatment of T2DM patients using metformin ($p < 0.05$).

Conclusion The risk of clinical inertia during metformin treatment in T2DM patients is relatively high and is associated with various factors. Targeted intervention measures should be implemented for high-risk populations to reduce the risk of clinical inertia.

Key words: type 2 diabetes; metformin; clinical inertia; influencing factors; comorbidities; complications

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Introduction

Diabetes is a metabolic syndrome caused by a combination of genetic and environmental factors. Type 2 diabetes mellitus (T2DM) is the most common type

of diabetes, accounting for over 90% of all diabetes cases (Cloete, 2022; Kim and Kim, 2022; Tinajero and Malik, 2021). According to the International Diabetes Federation (IDF), the global number of adult diabetes patients reached 537 million in 2021, representing 10.5% of the world's adult population. This number is projected to increase to 643 million (11.3%) by 2030 and 783 million (12.2%) by 2045 (Yan et al, 2022). China, as one of the countries with the fastest-growing prevalence of diabetes, is also experiencing a continuous rise in the number of diabetes patients (Wang et al, 2022). Poor long-term blood glucose control can lead to various serious complications, including diabetic retinopathy, cardiovascular and cerebrovascular diseases, diabetic nephropathy, diabetic foot, peripheral neuropathy, and secondary infections. These complications severely impact the quality of life of patients and impose a significant psychological and economic burden on patients and their families (Nauck et al, 2021).

Medication therapy is a crucial measure for controlling blood glucose levels, yet approximately 50% of diabetes patients in China fail to achieve their blood glucose control targets despite hypoglycemic treatment (Costantini et al, 2021). Study has indicated that clinical inertia is often a key reason for poor long-term blood glucose control in most patients (Almigbal et al, 2023). Clinical inertia refers to the recognition of a problem but the failure to take action to address it, such as failing to upgrade drug therapy or apply new drugs according to the latest guidelines, which contradicts the core principles of T2DM treatment. Clinical inertia does not simply refer to the inaction of patients, but encompasses complex phenomena at multiple levels of the healthcare system. From a doctor's perspective, it may be due to insufficient sensitivity to changes in the patient's condition, concerns about increased drug side effects, or overly complicated adjustments to the treatment plan, resulting in failure to adjust the treatment plan in a timely manner based on the patient's blood sugar changes. From the patients' perspective, they may not actively cooperate with treatment or provide feedback on changes in their condition due to factors such as insufficient understanding of the disease, poor compliance with medication treatment, concerns about increased medical costs, or difficulties in changing their lifestyle. This clinical inertia phenomenon is common in the treatment of diabetes and may become more prominent with the extension of the disease duration and increasing complexity of the disease (Isajev et al, 2022). According to a multicenter observational study in China, the incidence of clinical inertia in T2DM patients is 52.2% (Maegawa et al, 2021). Therefore, overcoming clinical inertia has become a crucial breakthrough for improving diabetes control levels. Based on this, the present study aims to investigate the factors associated with clinical inertia during metformin treatment in T2DM patients, providing theoretical and practical foundations for developing more effective personalized treatment strategies.

Methods

General Data

From June 2021 to June 2023, 86 T2DM patients treated with metformin who have clinical inertia at Zhejiang Hospital were selected as the inertia group. Ad-

ditionally, 87 patients who received the same medication treatment and follow-up evaluation without clinical inertia during the same period were selected as the control group. The inclusion and exclusion criteria for patients are as follows.

Inclusion criteria: (1) The diagnostic criteria for T2DM patients selected for this study were based on the standards from the "Chinese Guidelines for the Prevention and Treatment of Type 2 Diabetes (2017 Edition)" (Chinese Diabetes Society, 2018). (2) The selected subjects were aged between 19 and 79 years. (3) Patients were treated with metformin, with an initial glycated hemoglobin (HbA1c) level of $\geq$7.0%. They were continuously treated and followed up for 6 months, during which their treatment regimen was not adjusted, and insulin or glucagon-like peptide-1 (GLP-1) receptor agonists were not initiated without valid reasons. Such patients were considered to have clinical inertia.

Exclusion criteria: (1) Patients with a history of drug allergies. (2) Patients with severe infectious diseases. (3) Patients with malignant tumors. (4) Patients who experienced acute myocardial infarction, cerebrovascular diseases, or major traumatic diseases within the past 6 months.

This study was approved by the Ethics Review Committee of Zhejiang Hospital (KY-2020-040). This study was conducted in accordance with the Declaration of Helsinki, and informed consent was obtained from each participant.

Index Detection and Data Collection Methods

General information: The basic data of patients were collected through questionnaires and consultation of medical records. The data collected included age, body mass index (BMI) (body mass/height^2), gender, partner status, education level, monthly income, family history of diabetes, medical insurance, commercial insurance, smoking, drinking, diet control, physical exercise, hypertension, dyslipidemia, initial HbA1c, family blood glucose monitoring, diabetes-related complications, and diabetes health education.

Initial HbA1c: Fasting venous blood was collected from the patient, and the HbA1c level was detected using high-performance liquid chromatography. The BD Diabetes HbA1c Reagent Kit was selected from Becton, Dickinson and Company (Franklin Lakes, NJ, USA). The study flowchart is shown in Fig. 1.

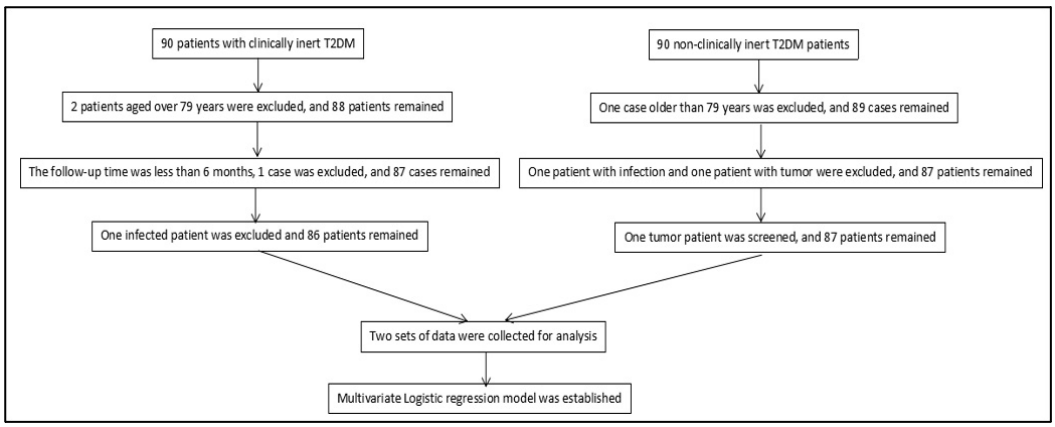

Fig. 1. The flowchart of the study. T2DM, type 2 diabetes mellitus.

Table 1. Comparison of general data between two groups [n (%)].

General data	Inertia group (n = 86)	Control group (n = 87)	χ^2	p
Age (years)			1.700	0.192
≥65	51 (59.30)	43 (49.43)		
<65	35 (40.70)	44 (50.57)		
BMI (kg/m^2)			1.307	0.253
≥25.0	38 (44.19)	46 (52.87)		
<25.0	48 (55.81)	41 (47.13)		
Gender			4.856	0.028*
Male	49 (56.98)	35 (40.23)		
Female	37 (43.02)	52 (59.77)		
Partner situation			1.618	0.203
Married or cohabitation	69 (80.23)	76 (87.36)		
Live by oneself	17 (19.77)	11 (12.64)		
Standard of culture			5.271	0.022*
Primary education level and below	61 (70.93)	47 (54.02)		
Middle school education level and above	25 (29.07)	40 (45.98)		

Note: *, $p < 0.05$. BMI, body mass index.

Statistical Analysis

The data were analyzed using statistical software SPSS 21.0 (International Business Machines Corporation, Armonk, NY, USA). The general data, family and economic conditions, lifestyle, and diabetes status of the patients collected in the study were expressed in a two-category manner. The rate (%) was used for statistical description, and the χ^2 test was employed for statistical analysis. A logistic multivariate analysis model was used to identify the risk factors affecting clinical inertia during metformin treatment for T2DM. A p-value of <0.05 was considered statistically significant.

Results

Comparison of General Data Between Two Groups

The proportion of male patients and those with elementary education or below was significantly higher in the inertia group compared to the control group ($p < 0.05$). The proportions of age, BMI, and partner status were not significantly different between the two groups ($p > 0.05$) (Table 1).

Comparison of Family Economic and Family History Between the Two Groups

The proportion of patients without commercial insurance was significantly higher in the inertia group compared to the control group ($p < 0.05$). The proportions of monthly income, family history of diabetes, and having or not having health insurance were not significantly different between the two groups ($p > 0.05$) (Table 2).

Table 2. Comparison of family economic and family history between the two groups [n (%)].

Family and economic situation	Inertia group (n = 86)	Control group (n = 87)	χ^2	p
Monthly income (USD)			3.264	0.071
≥412	58 (67.44)	47 (54.02)		
<412	28 (32.56)	40 (45.98)		
Family history of diabetes			1.828	0.176
Yes	12 (13.95)	19 (21.84)		
No	74 (86.05)	68 (78.16)		
Having or not having health insurance			2.489	0.115
Yes	78 (90.70)	84 (96.55)		
No	8 (9.30)	3 (3.45)		
Having or not having commercial insurance			5.866	0.015*
Yes	11 (12.79)	24 (27.59)		
No	75 (87.21)	63 (72.41)		

Note: *, $p < 0.05$.

Comparison of Lifestyle Between Two Groups

The proportion of patients practicing dietary control was lower in the inertia group compared to the control group ($p < 0.05$). The proportions of smoking, drinking, and physical exercise were not significantly different between the two groups ($p > 0.05$) (Table 3).

Comparison of Health History Between the Two Groups

The inertia group demonstrated a significantly lower proportion of patients across key clinical and management metrics compared to the control group, including initial HbA1c ≥8.0%, home blood glucose monitoring, diabetes-related complications, and participation in diabetes health education ($p < 0.05$). The proportions of hypertension and lipid abnormalities were not significantly different between the two groups ($p > 0.05$) (Table 4).

Study on Factors Influencing Clinical Inertia During Metformin Treatment in T2DM Patients

A logistic multivariate analysis model was established to assess predictors of clinical inertia, incorporating eight statistically significant independent variables identified through preliminary univariate screening: gender, education level, presence of commercial insurance, dietary control, initial HbA1c, home blood glucose monitoring, presence of diabetes-related complications, and participation in diabetes health education; and using whether the patient experienced clinical inertia as the dependent variable. The results showed that male (odds ratio (OR) = 3.487, p = 0.001), primary school education and below (OR = 2.362, p = 0.027), no commercial insurance (OR = 3.783, p = 0.005), no family blood glucose monitoring (OR = 3.127, p = 0.007), no diabetes-related complications (OR = 2.995, p = 0.006), and no participation in diabetes health education (OR = 2.753, p = 0.017) increase the risk of clinical inertia in the treatment of T2DM patients with metformin (Tables 5,6).

Table 3. Comparison of lifestyle between two groups [n (%)].

Life style	Inertia group (n = 86)	Control group (n = 87)	χ^2	p
Smoking			0.734	0.392
Yes	32 (37.21)	27 (31.03)		
No	54 (62.79)	60 (68.97)		
Drinking			0.712	0.399
Yes	35 (40.7)	30 (34.48)		
No	51 (59.3)	57 (65.52)		
Alimentary control			4.893	0.027*
Yes	41 (47.67)	56 (64.37)		
No	45 (52.33)	31 (35.63)		
Physical training exercise			2.744	0.098
≥1 times/week	28 (32.56)	39 (44.83)		
No	58 (67.44)	48 (55.17)		

Note: *, $p < 0.05$.

Discussion

T2DM, as a chronic metabolic disease, has become a significant public health issue worldwide. Metformin, as a first-line oral hypoglycemic agent, is widely used in the treatment of T2DM (Foretz et al, 2023). However, clinical practice has found that some T2DM patients exhibit clinical inertia during metformin treatment, posing challenges to diabetes management and patient health (Alvis-Guzman et al, 2024). In 2001, Phillips et al (2001) first introduced the concept of "clinical inertia", initially referring to the failure of physicians to take immediate action after recognizing a disease problem. Subsequently, the concept of clinical inertia evolved to mean "an inappropriate delay in identifying, initiating, or appropriately modifying preventive or therapeutic care for a specific disease based on existing clinical evidence, resulting in inadequate disease control or adverse clinical outcomes" (Ampudia-Blasco et al, 2021). Furthermore, clinical inertia can occur at various stages of disease management, including diagnosis, prevention, and treatment (An et al, 2021; Kaewbut et al, 2021). Understanding the mechanisms and influencing factors of clinical inertia is crucial for improving healthcare quality and enhancing patients' quality of life. This study aims to comprehensively explore the manifestations of clinical inertia in T2DM management, its influencing factors, and coping strategies, with the goal of providing more effective treatment plans for both doctors and patients.

In terms of general information, this study observed that the proportion of male patients was higher in the inertia group, and their overall educational level was generally lower. This may be related to the fact that male patients and those with lower educational levels are less likely to adopt proactive health management measures. Specifically, men often exhibit relatively lower health awareness and behaviors when facing health issues, including lower rates of seeking medical care, reluctance to undergo preventive health check-ups, and less active participation in health promotion activities (Bekele et al, 2021; Kang et al, 2022). Patients with lower ed-

Table 4. Comparison of health history between the two groups [n (%)].

Health history	Inertia group (n = 86)	Control group (n = 87)	χ^2	p
Hypertension			1.285	0.257
Yes	21 (24.42)	28 (32.18)		
No	65 (75.58)	59 (67.82)		
Lipid abnormality			0.990	0.320
Yes	49 (56.98)	56 (64.37)		
No	37 (43.02)	31 (35.63)		
Initial HbA1c (%)			4.856	0.028*
≥8.0	37 (43.02)	52 (59.77)		
<8.0	49 (56.98)	35 (40.23)		
Home blood glucose monitoring			9.314	0.002*
Yes	14 (16.28)	32 (36.78)		
No	72 (83.72)	55 (63.22)		
Diabetes related complications			7.419	0.006*
Yes	19 (22.09)	36 (41.38)		
No	67 (77.91)	51 (58.62)		
Participation in diabetes health education			7.957	0.005*
Yes	16 (18.6)	33 (37.93)		
No	70 (81.4)	54 (62.07)		

Note: *, $p < 0.05$. HbA1c, glycated hemoglobin.

ucational levels find it more challenging to understand medical information, follow medical advice, and adopt health management behaviors, making them more prone to clinical inertia (Powell et al, 2021). Lack of educational background can also lead to insufficient understanding of the disease and a lack of clear recognition of the importance of treatment, thus affecting treatment adherence and motivation (Kumar et al, 2022).

Additionally, the proportion of patients without commercial insurance was higher in the inertia group. Purchasing commercial insurance is often a way for individuals to make preventive arrangements for their health and potential future medical expenses. Therefore, the lack of commercial insurance may reflect that these patients undervalue health issues or fail to recognize the potential risk of future medical expenses, or may be older (Alvis-Guzman et al, 2024; Lindvig et al, 2021; McDaniel et al, 2024). Patients without commercial insurance usually do not have sufficient funds to manage their illnesses. The lack of commercial insurance means that they must directly bear greater economic pressure when facing medical expenses, which may lead to lower motivation in seeking medical services, receiving treatment, and following medical advice. They may be more inclined to delay seeking medical treatment or choose non-standard treatment methods to reduce the economic burden, which also increases the risk of clinical inertia.

Based on the aforementioned observations, targeted interventions could be considered. These include enhancing health education and awareness campaigns for male patients to improve their understanding of the disease and health management. For patients with lower educational levels, simpler and more comprehensible health

Table 5. The assignment of each independent variable.

Variable	Assignment situation
Gender	Female = 0 Male = 1
Standard of culture	Junior high school culture and above = 0 Primary school culture and below = 1
Having or not having commercial insurance	With = 0 Without = 1
Alimentary control	Yes = 0 No = 1
Initial HbA1c	$<$8.0 = 0 $\geq$8.0% = 1
Home blood glucose monitoring	Yes = 0 No = 1
Diabetes related complications	Yes = 0 No = 1
Participation in diabetes health education	Yes = 0 No = 1

education methods can be employed, along with providing more personalized treatment plans and management advice. For patients lacking commercial insurance, offering financial assistance or establishing a medical aid system could help alleviate their financial burden. Strengthening health education to increase patients' awareness of disease prevention and treatment, and offering personalized medical advice that aligns more with their actual situation, are essential.

In terms of lifestyle, this study also found that fewer patients in the inertia group adopted dietary control measures. This primarily reflects a lack of understanding of the relationship between diet and health within this group. The analysis suggests that patients in the inertia group may lack awareness of the impact of diet on health or the importance of dietary control. They may not realize the close connection between dietary habits and disease progression, thus not taking proactive dietary control measures (Jing et al, 2023; Zhou et al, 2022). Additionally, the cultural background and family habits of patients may influence their dietary choices and control behaviors. For example, in some regions or cultures, high-sugar and high-fat foods may be considered rather a normal part of the diet than sources of health risks (Hariharan et al, 2022; Rein et al, 2022). Therefore, even with an understanding of the impact of diet on health, cultural factors may prevent habits from changing. Lastly, some patients may have psychological factors such as stress, emotional fluctuations, or a negative attitude towards disease management, leading them to hold a more negative attitude towards dietary control measures (Gardner et al, 2022; Naude et al, 2022). To address these reasons, improving health education, disseminating knowledge about the relationship between diet and health,

Table 6. The results of model analysis on the influencing factors of clinical inertia in patients with T2DM during metformin treatment.

Factor	β	SE	Wald	p	OR	95% CI	
Gender	1.249	0.378	10.932	0.001*	3.487	1.662	7.315
Standard of culture	0.860	0.389	4.879	0.027*	2.362	1.102	5.065
Having or not having commercial insurance	1.330	0.479	7.721	0.005*	3.783	1.479	9.668
Alimentary control	0.717	0.374	3.674	0.055	2.049	0.984	4.263
Initial HbA1c	0.589	0.362	2.651	0.103	1.802	0.886	3.664
Home blood glucose monitoring	1.140	0.420	7.369	0.007*	3.127	1.373	7.122
Diabetes related complications	1.097	0.402	7.430	0.006*	2.995	1.362	6.586
Participation in diabetes health education	1.013	0.423	5.731	0.017*	2.753	1.202	6.310
Constant term	–2.869	0.531	29.187	0.000*	0.057	0.020	0.161

Note: *, $p < 0.05$.

promoting healthy eating guidelines, and providing psychological health services can help patients improve their dietary habits. Additionally, interventions within the community and family can create a conducive dietary environment, promoting the adoption and practice of healthy eating habits.

Further assessment of health history revealed that the proportion of patients in the inertia group with higher initial HbA1c levels was lower, indicating that patients in the inertia group had relatively lower blood glucose levels in the early stages of the disease. This may suggest that these patients did not pay sufficient attention to their condition, leading to a lack of timely and effective treatment or control measures, resulting in faster disease progression or poor blood glucose control (Orozco-Beltrán et al, 2022). Additionally, fewer patients in the inertia group conducted home blood glucose monitoring, indicating a lack of awareness or self-management skills regarding their blood glucose levels (Mdala et al, 2024). Furthermore, the lower proportion of diabetes-related complications in the inertia group also reflects the relatively milder condition of patients in this group, suggesting insufficient awareness among patients (Chudasama et al, 2021). Lastly, the lower proportion of patients in the inertia group receiving diabetes health education indicates a lower level of diabetes awareness among these patients or lack of effective management the disease (Martens and Parkin, 2022; von Arx et al, 2023).

To address these issues, targeted interventions can be implemented. For the lower proportion of patients receiving diabetes health education, diverse health education activities can be conducted, including classroom education, community outreach, and other forms, educating patients about the characteristics of disease progression, the necessity of early control, and methods for exercise, dietary control, and regular medication. Additionally, for patients who conduct less home blood glucose monitoring, targeted health education can be provided to enhance their awareness of self-monitoring, aiding them in better mastering key aspects of blood glucose control.

The logistic regression model established in this study revealed that male patients, those with lower education levels, those not practicing dietary control, those

not conducting home blood glucose monitoring, those without diabetes-related complications, and those who have not received diabetes health education were more likely to experience clinical inertia. The identification of these factors provides valuable guidance for clinicians, helping them take more effective interventions for high-risk patients.

The limitation of this study is that it did not consider the impact of external factors such as medical policies and resource allocation on clinical inertia. Medical policies and resource conditions in different regions may affect patients' treatment decisions and compliance, thereby influencing the occurrence of clinical inertia. Additionally, the study has a relatively short time span, which may introduce confounding bias between various factors. In future studies, the sample size will be expanded, prospective research methods will be adopted, and factors will be controlled. Furthermore, external factors will be considered to comprehensively understand the mechanisms and influencing factors of clinical inertia in T2DM patients undergoing metformin treatment.

Conclusion

This study reveals the relationship between various factors and the occurrence of clinical inertia in patients with T2DM during metformin treatment, providing an important reference for the development of personalized treatment strategies. In future clinical practice, attention should be given to the influence of these factors, with targeted measures implemented to improve patient treatment compliance, reduce the occurrence of clinical inertia, and enhance blood glucose control and quality of life of patients.

Key Points

- Medication therapy plays a critical role in controlling blood glucose levels; however, approximately 50% of diabetes patients in China fail to achieve their blood glucose control targets despite hypoglycemic treatment.
- Clinical inertia is often a key factor contributing to poor long-term blood glucose control in many patients.
- The occurrence of clinical inertia in T2DM patients treated with metformin is associated with factors such as gender, education level, diet control, initial HbA1c level, family blood glucose monitoring, diabetes-related complications, and participation in disease health education.
- Targeted intervention measures should be implemented for high-risk populations to reduce the risk of clinical inertia.

Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

Author Contributions

XL conducted the research and wrote the manuscript. FBJ designed the research and analyzed the data. Both authors contributed to important editorial changes in the manuscript. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Review Committee of Zhejiang Hospital (KY-2020-040). This study was conducted in accordance with the Declaration of Helsinki, and informed consent was obtained from each participant.

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Conflict of Interest

The authors declare no conflict of interest.

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