Original Article

Effect of an Educational Intervention on Knowledge and Metabolic Control in Patients with Type 2 Diabetes

Efecto de una intervención educativa en el conocimiento y control metabólico en pacientes con diabetes tipo 2

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Summary

Objective: To evaluate the impact of an educational intervention through a website on knowledge and glycemic control in patients with type 2 diabetes. **Methods:** A 12-month clinical trial was conducted in patients diagnosed with type 2 diabetes, who were randomly assigned to either a medical and nutritional therapy group (n= 50) or an experimental group receiving medical and nutritional therapy plus access to a diabetes educational website (n= 58). Baseline and follow-up measurements over 12 months included weight, body mass index, waist circumference, glucose, cholesterol, and triglycerides. Diabetes knowledge was assessed using the Diabetes Knowledge Questionnaire (DKQ-24). **Results:** At the end of the intervention, a significantly higher proportion of participants in the experimental group (62%) demonstrated adequate diabetes knowledge compared with the control group (38%, p= 0.004). Significant improvements were also observed in glucose, cholesterol, triglycerides, and body mass index within the experimental group ($p<0.05$). **Conclusion:** An educational website improves knowledge, glycemic control, and lipid profiles in patients with type 2 diabetes attending a primary care clinic.

Keywords: Type 2 Diabetes Mellitus; Health Education; Glycemic Control; Telemedicine.

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Resumen

Objetivo: evaluar el efecto de la intervención educativa a través de un sitio web sobre el nivel de conocimientos y control glucémico en pacientes con diabetes tipo 2. **Métodos:** ensayo clínico de doce meses en pacientes con diabetes tipo 2. Los participantes fueron asignados de forma aleatoria al grupo de intervención con terapia médica y nutricional, así como al grupo experimental con terapia médica y nutricional más sitio web educativo en diabetes. Se midió de forma basal por doce meses el peso, el índice de masa corporal, circunferencia de cintura, glucosa, colesterol y triglicéridos. El nivel de conocimientos en diabetes se evaluó a través del instrumento *Diabetes Knowledge Questionnaire* (DKQ-24). **Resultados:** el porcentaje de participantes (grupo control n= 50, grupo experimental n= 58) con un nivel suficiente de conocimientos en diabetes al final de la intervención fue mayor en el grupo experimental (62%) en comparación con el grupo control (38%, p= 0.004). Asimismo, se observó una mejoría significativa en los niveles de glucosa, colesterol, triglicéridos e índice de masa corporal en el grupo experimental (p<0.05). **Conclusión:** el uso de un sitio web educativo mejora el nivel de conocimientos, el control glucémico y el perfil lipídico en pacientes con diabetes tipo 2 que asisten a una clínica de primer nivel de atención.

Palabras clave: diabetes mellitus tipo 2, educación para la salud, control glucémico, telemedicina.

Introduction

Diabetes is a chronic noncommunicable disease that occurs when the pancreas produces insufficient insulin or when the body fails to use it effectively.[1,2] It represents a major public health concern due to its increasing prevalence and the impact of its complications, which significantly contribute to global morbidity.[3,4]

According to the 2021 report by the International Diabetes Federation (IDF), the prevalence of diabetes continues to rise, with one in two adults unaware of having the disease. An estimated 536.6 million people are currently living with diabetes worldwide, a figure projected to rise to 783.2 million by 2045.[5] In Mexico, data from the 2022 National Health and Nutrition Survey (Ensanut 2022) reported a prediabetes prevalence of 22.1%, and a diabetes prevalence of 18.3%.[6]

Diabetes treatment must be comprehensive. In addition to pharmacological therapy, it is essential to promote the adoption of a healthy lifestyle and effective self-care.[7] Evidence shows that these measures improve glycemic control, reduce complications, and enhance quality of life.[8,9]

Diabetes education is critical for encouraging healthy lifestyle practices—based on diet and physical activity—, fostering self-care, achieving and maintaining glycemic control, and preventing complications.[10-12] In healthcare, Information and Communication Technologies (ICTs) encompass resources and tools designed to optimize care and promote individual well-being. The use of ICTs has proven to be an effective strategy to increase disease-related knowledge, promote self-care, and improve glycemic control among patients with diabetes.[13,14] ICT-supported diabetes education has shown benefits in self-monitoring, glycemic control, and disease-related knowledge. It is also associated with improvements in lifestyle and self-care practices among people living with diabetes.[15,16]

In Mexico, evidence regarding ICT-based diabetes education remains limited, particularly in educational programs developed by clinical experts and tailored to the target population. Therefore, the aim of the present study was to evaluate the effect of an educational intervention delivered through a website on knowledge levels and glycemic control in patients with type 2 diabetes attending a primary care clinic.

Methods

A clinical trial with follow-up over a period of twelve months was conducted at Family Medicine Unit No. 7 of the Mexican Institute of Social Security (IMSS) in Mexico City, from August 2021 to November 2022. The study was approved by the IMSS Research and Ethics Committee, under the registration number R-2021-2703-084.

The sample size calculation was based on a previous study by the Family Medicine Unit. A glycemic control rate of 25% was estimated in the group with the web-based educational strategy, compared to 7% in the control group, as previously reported.[16] A statistical power of 80%, a confidence level of 95%, and an estimated loss rate of 20% were considered. The resulting sample size was 112 patients per group. Patients received detailed information about the study, including the risks and benefits. Once their questions had been answered, they agreed to participate by signing the informed consent form.

Patients, able to read and write, diagnosed with type 2 diabetes for less than ten years, between 20 to 65 years, were included. Exclusion criteria were advanced diabetic retinopathy or blind-

ness, diabetic neuropathy, amputation, and/or chronic kidney disease requiring renal replacement therapy. Participants were randomly assigned using statistical software to the intervention group—which received standard medical therapy plus access to an educational website—or to the control group, which received standard medical and nutritional therapy only.

Sociodemographic, clinical, and pathological data were collected through interviews conducted by the study physicians. Blood pressure was measured twice using a mercury sphygmomanometer, with a five-minute interval between readings. The final measurement was calculated as the average of both readings.

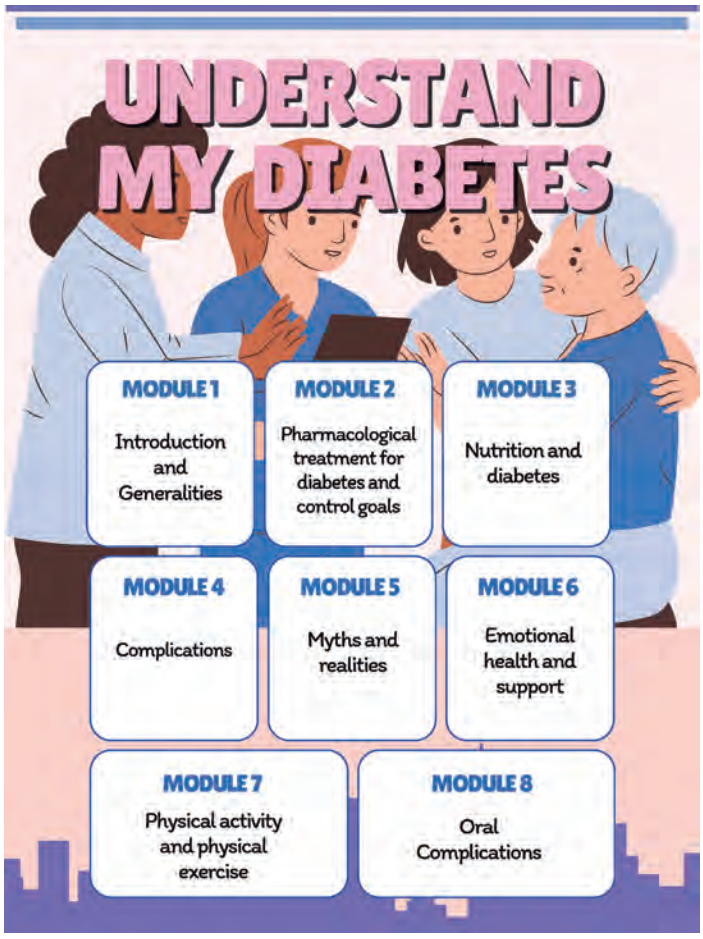
Glucose, cholesterol, and triglyceride levels were measured in venous blood after a 10–12 hour fast using the turbidimetric transmission method. Anthropometric measurements were performed by a nutrition professional, following the method proposed by Habicht and adjusted according to the specifications recommended by Lohman et al.[17,18]

Body mass index (BMI) was calculated from weight (in kilograms) and height using the formula: weight/height^2. Waist circumference was measured at the midpoint between the last rib and the superior border of the iliac crest on the patient's right side. Two measurements were obtained, and the average of both was used for analysis.

Diabetes knowledge was assessed using the Diabetes Knowledge Questionnaire (DKQ-24), which consists of 24 items addressing the etiology, signs and symptoms, diagnosis, treatment, and complications of the disease. Each item has three response options: "Yes," "No," and "I don't know." For scoring, the total sum of the questionnaire was classified as acceptable knowledge (>14 points) or not acceptable (<13 points).[19]

The experimental group received standard medical therapy plus access to the educational website *"Entiendo mi diabetes"* (Understanding My Diabetes), developed and validated by expert consensus to evaluate its usability and comprehension among Mexican patients with diabetes.[20,21] The intervention involved providing patients with a username and password to access the educational website (*https://entiendomidiabetes.org/curso.html*), which includes modules on topics such as general aspects of diabetes, pharmacological treatment, nutrition, and complications, among others (Figure 1). Upon completing the course, patients received a diploma for participation. Each module lasted approximately fifteen minutes, and the platform tracked completion to ensure all patients finished the course within the first six months. In addition to access to the educational website, patients received personalized nutritional therapy from a nutrition professional, who provided an individualized meal plan in accordance with the guidelines of the Mexican Official Standard for Diabetes and the American Diabetes Association.[22,23]

Figure 1.
Topics Included in the Course "Entiendo mi diabetes"



The control group received personalized medical and nutritional therapy, as described for the experimental group, along with a written meal plan and general recommendations for disease management. Both groups were scheduled for follow-up biochemical, anthropometric, and clinical evaluations after six and twelve months. During follow-up, a telephone call was made to participants in both groups, at three and nine months, to reinforce the assigned intervention and address any questions.

Descriptive statistics were used, reporting mean and standard deviation for normally distributed variables, and media with interquartile range for non-normally distributed variables, determined using the Kolmogorov-Smirnov test. Qualitative variables are presented as frequencies and percentages.

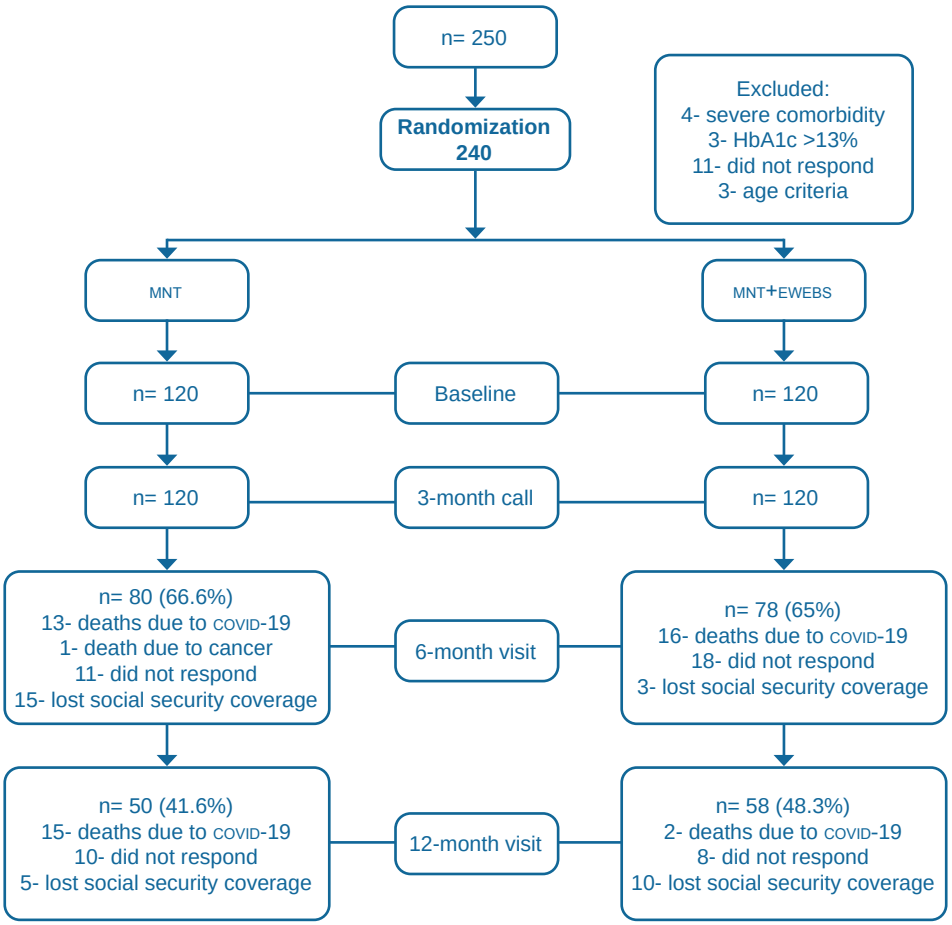
To compare differences between groups over the follow-up period in biochemical, clinical, and anthropometric parameters, as well as achievement of metabolic control goals, the χ^2 test and Mann-Whitney U test were used for between-group comparisons at baseline and at the end of the intervention. The Wilcoxon signed-rank test was used for within-group comparisons.

A p-value <0.05 was considered statistically significant for all analyses. Statistical analyses were performed using SPSS version 25.

Results

Initially, 250 patients with type 2 diabetes were considered; ten were excluded for not meeting the inclusion criteria. During follow-up, losses occurred due to death, lack of response, or loss of social security coverage. The patient flow is presented in Figure 2, which illustrates the follow-up and retention of participants.

Figure 2. Follow-up Diagram



MNT: Medical Nutrition Therapy
MNT+EWEBS: Medical Nutrition Therapy + Diabetes Educational Website

Table 1. Sociodemographic and Clinical Characteristics of Patients with Diabetes

	MNT n= 50 (%)	MNT+EWEBS n= 58 (%)	P Value
Sex			0.405
Female	39 (48)	43 (52)	
Male	11 (42)	15 (58)	
Education level			0.780
Basic	29 (49)	30 (51)	
Middle	15 (44)	19 (56)	
High	6 (40)	9 (60)	
Socioeconomic status			
Low	7 (70)	3 (30)	0.265
Middle	39 (43)	51 (57)	
High	4 (50)	4 (50)	
Weekly exercise (150 min. of moderate PA/week)	15 (52)	14 (48)	0.544
Nutritional therapy	17 (44)	22 (56)	0.412
Diabetes education	6 (43)	8 (57)	0.782
Visits educational diabetes websites	18 (49)	19 (51)	0.440
Smoker	6 (33)	12 (67)	0.172
Alcohol consumption	10 (34)	19 (66)	0.101
Hypertension	25 (57)	19 (43)	0.069
Dyslipidemia	27 (54)	31 (53)	0.549
	Midian and interquartile range age		
Age (years)	53 (47-59)	52 (46-58)	0.499
Duration of diabetes (years)	4 (2-8)	5 (3-6)	0.569
Weight (kg)	79 (67-92)	69 (60-85)	0.006
BMI (kg/m²)	32 (29-36)	28 (25-34)	0.006
Waist circumference (cm)	101 (95-108)	95 (89-108)	0.095
Fasting glucose (mg/dL)	140 (118-206)	121 (105-187)	0.117
Cholesterol (mg/dL)	193 (167-215)	177 (157-211)	0.145
Triglycerides mg/dL	180 (135-245)	166 (128-229)	0.278
SBP mmHg	120 (128-110)	115 (110-127)	0.510
DBP mmHg	77 (70-80)	70 (70-80)	0.346

MNT: Medical Nutrition Therapy. MNT+EWEBS: Medical Nutrition Therapy + "*Entiendo mi diabetes*" Website. SBP: Systolic Blood Pressure. DBP: Diastolic Blood Pressure. χ^2 and U de Mann Whitney tests

Table 2. Baseline and Post-intervention Diabetes Knowledge Levels of Patients

	MNT n= 50 (%)	MNT+EWEBS n= 58 (%)	P Value
Baseline			
Insufficient	26 (43)	35 (57)	0.249
Sufficient	24 (51)	23 (49)	
Post-Intervention			
Insufficient	20 (69)	9 (31)	0.004
Sufficient	30 (38)	49 (62)	

MNT: Medical Nutrition Therapy. MNT+EWEBS: Medical Nutrition Therapy + "*Entiendo mi diabetes*" Website. χ^2 Test

At the beginning, no significant differences were observed between the study groups. A higher proportion of women was noted. The median age was 53 years in the group receiving medical and nutritional therapy (MNT), and 52 years in the group receiving MNT plus access to the *"Entiendo mi diabetes"* website. The median duration of diabetes diagnosis was four years in the MNT group and five years in the MNT plus website group. Key patient characteristics are presented in Table 1.

Similarly, the proportion of participants with an adequate level of diabetes knowledge was 51% in the MNT group, and 49% in the experimental group (p= 0.249). At the end of the intervention, this proportion increased to 62% in the experimental group compared with 38% in the control group (p= 0.004). Complete data Table 2.

At the end of the intervention, the experimental group showed a statistically significant reduction in weight, BMI, as well as glucose, cholesterol, and triglyceride levels (p<0.05), whereas the control group demonstrated improvement in cholesterol and triglyceride levels (p<0.05). These results are shown in Table 3.

At the end of the intervention, the group receiving MNT+EWEB exhibited a higher proportion of patients achieving glycemic control (p= 0.007), triglycerides within the normal range (p= 0.026), and BMI≤24.9 kg/m² (p= 0.012) compared with the control group. These results are presented in Table 4.

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Table 3: Baseline and Final Anthropometric and Biochemical Variables of the Studied Groups

	MNT n= 50			MNT+EWEB n= 58		
	Baseline	Final	P Value	Baseline	Final	P Value
Weight (kg)	79 (67-92)	81 (65-92)	0.838	69 (60-85)	6 (58-83)	0.015
BMI (kg/m^2)	3 (35-29)	31 (27-35)	0.363	28 (26-34)	27 (25-33)	0.032
Waist circumference (cm)	101 (95-108)	102 (92-109)	0.980	101 (96-108)	95 (87-106)	0.071
Hip circumference (cm)	108 (101-117)	110 (102-120)	0.288	95 (89-108)	101 (93-112)	0.134
Glucose (mg/dL)	140 (118-206)	142 (111-199)	0.160	121 (105-187)	117 (97-156)	0.001
Cholesterol (mg/dL)	193 (167-215)	175 (140-201)	0.001	177 (157-211)	157 (120-197)	0.001
Triglycerides (mg/dL)	180 (135-245)	178 (115-253)	0.001	166 (128-229)	132 (99-183)	0.001
SBP (mm Hg)	120 (128-110)	120 (115-130)	0.086	115 (110-127)	120 (110-120)	0.901
DBP (mm Hg)	77 (70-80)	80 (70-80)	0.131	70 (70-80)	78 (70-80)	0.114

MNT: Medical Nutrition Therapy. MNT+EWEBS: Medical Nutrition Therapy + "*Entiendo mi diabetes*" Website. Wilcoxon Test

Table 4. Achievement of Metabolic Control Goals at the End of the Intervention

	MNT n= 50 (%)	MNT+EWEB n= 58 (%)	P Value
Glucose mg/dL (≤130)	20 (34)	38 (66)	0.007
Cholesterol mg/dL (≤199)	33 (43)	43 (57)	0.238
Triglycerides mg/dL (≤149)	19 (36)	34 (64)	0.026
Waist circumference (cm) (≤89 men and ≤79 women)	4 (40)	6 (60)	0.469
SBP mm Hg (≤129)	36 (42)	50 (58)	0.052
DBP mm Hg (≤79)	17 (46)	20 (54)	0.560
Obesity classification (BMI)			
BMI ≤24.9 kg/m^2	5 (26)	14 (74)	0.012
BMI 25-29.9 kg/m^2	13 (39)	20 (61)	
BMI >30 kg/m^2	31 (57)	23 (43)	

MNT: Medical Nutrition Therapy. MNT+EWEBS: Medical Nutrition Therapy + "*Entiendo mi diabetes*" Website. χ^2 Test

Discussion

Type 2 diabetes is a multifactorial condition in which lifestyle plays a key role in its development and management. Diabetes education is essential for achieving metabolic control and improving risk indicators such as obesity, hypertension, and dyslipidemia, which are common comorbidities in this population. The use of information and communication technologies (ICTs) in disease management has become an established set of tools for follow-up, monitoring, education, and influencing the lifestyle of patients with diabetes in primary care.[24]

The results of the present study show a significant improvement in disease-related knowledge after twelve months of an educational intervention delivered through a website, compared with standard medical and nutritional therapy. These findings are consistent with previous reports in populations attending primary care, where improvements in disease knowledge were observed.[16] Other studies have reported increased knowledge following the use of a mobile application for three months, along with greater confidence in using technology for self-care.[25]

Following the intervention, the experimental group accessing the website showed a notable improvement in median glucose levels compared with the control group. Similar results have been reported in other studies evaluating the effects of educational interventions, with additional benefits in lifestyle behaviors.[15] Furthermore, technology has been documented as a supportive tool for glycemic control in primary care patients with diabetes.[26] Importantly, this web-based strategy was developed and validated through expert consensus, incorporating feedback not only from

healthcare professionals but also from patients with diabetes, who assessed its usability and relevance prior to implementation.[27,28]

Obesity contributes to poor glycemic control in patients with diabetes and significantly increases the likelihood of developing cardiovascular disease.[29,30] Therefore, diabetes education should focus on lifestyle modification and improving this risk indicator. In the present study, the website group showed a significant reduction in body weight and waist circumference, as well as a higher proportion of patients with BMI≤24.9 kg/m^2 compared with the control group. The use of technology has been shown to support weight loss, improve quality of life, increase knowledge, and reduce stress symptoms in individuals with obesity and diabetes.[31]

Metabolic control goals were established, and the educational website group achieved a higher proportion of patients with glucose within target range, normal triglycerides, and BMI within recommended goals compared with the control group. Improvement in these cardiometabolic risk factors following a web-based educational intervention supports the utility of such strategies for patients with diabetes in primary care. Evidence indicates that health education contributes to achieving glycemic targets, strengthening self-care, and reducing cardiovascular risk in this population.[32] Similarly, telehealth or online strategies have been shown to promote greater reductions in HbA1c and encourage active participation from healthcare professionals and diabetes educators.[33]

Study limitations include the proportion of losses during follow-up, partly attributable to the COVID-19 pandemic (August 2021 to November 2022), which limited healthcare personnel participation in follow-up visits. A higher proportion of female participants was also observed, highlighting the need to promote greater inclusion of men. It is important that patients complete the educational course within the first three months and complement it with practical activities applicable to daily life. These strategies should be supported by a multidisciplinary healthcare team, including a physician, diabetes educator, and/or nutritionist.

Although the control group initially had a higher proportion of patients with obesity, this indicator showed a more pronounced reduction in the group receiving web-based education during follow-up. The study was conducted in a single clinic; future research should include multiple primary care units to compare variables such as socioeconomic status, education level, and other factors that may influence website usage. In developing countries such as Mexico, digital tools remain understudied, particularly regarding their impact on cardiovascular risk indicators, knowledge, lifestyle, and glucose monitoring in patients with diabetes. Such strategies can help meet the high demand for primary care services and, when integrated into public health prevention programs, can contribute not only to glycemic control but also to enhancing self-care, and promoting a lifestyle that reduces the risk of disease-related complications.

Conclusion

The results demonstrate the benefit of providing diabetes education through a website to improve knowledge, glycemic control, and lipid profile. The study highlights the need to develop tools created by healthcare professionals and tailored to the diabetic population. Delivering remote education with the support of a family physician and other healthcare professionals, such as nutritionists or nursing staff, can be an effective, low-cost, and accessible strategy to enhance both knowledge and metabolic control in patients with diabetes.

Author Contributions

S V-G: conceptualization and development, writing; E R-G: intervention, development, and data analysis; MG V-A: intervention, development, and discussion of results; C I-S: intervention and development; GA O-O: intervention, analysis, and discussion of results; L V-L: conceptualization, data analysis, writing. All authors approve the publication of this manuscript.

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Conflict of Interest

The authors declare having no conflicts of interest.

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