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Research: Educational and Psychological Aspects

Diabetes distress is linked with worsening diabetes management over time in adults with Type 1 diabetes

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Abstract

Aim To determine the cross-sectional and longitudinal associations between diabetes distress and diabetes management.

Methods In a non-interventional study, 224 adults with Type 1 diabetes were assessed for diabetes distress, missed insulin boluses, hypoglycaemic episodes, and HbA_{1c} at baseline and 9 months.

Results At baseline, greater distress was associated with higher HbA_{1c} and a greater percentage of missed insulin boluses. Longitudinally, elevated baseline distress was related to increased missed insulin boluses, and decreases in distress were associated with decreases in HbA_{1c}. In supplementary analyses, neither depression symptoms nor a diagnosis of major depressive disorder was associated with missed insulin boluses, HbA_{1c} or hypoglycaemic episodes in cross-sectional or longitudinal analyses.

Conclusions Significant cross-sectional and longitudinal associations were found between diabetes distress and management; in contrast, no parallel associations were found for major depressive disorder or depression symptoms. Findings suggest that elevated distress may lead to more missed insulin boluses over time, suggesting a potential intervention target. The covarying association between distress and HbA_{1c} points to the complex and likely interactive associations between these constructs. Findings highlight the need to address distress as an integral part of diabetes management in routine care.

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Introduction

Among adults with diabetes, there is accumulating support for significant cross-sectional associations between diabetes distress and diabetes management, including poorer glycaemic control and a range of self-management behaviours (e.g. physical activity, missed medication doses) [1–3]. Most of this work has focused on Type 2 diabetes, but findings of studies in adults with Type 1 diabetes typically mirror those for Type 2 diabetes, with higher levels of distress associated with poorer outcomes. These include higher HbA_{1c}, greater frequency of hypoglycaemia, more missed insulin doses, more episodes of diabetic ketoacidosis and less physical activity [4–8].

Relatively little work has examined the association between diabetes distress and diabetes management over time. Where examined longitudinally, two primary patterns of findings have emerged. First, studies in both Type 1 and Type 2 diabetes have noted that baseline levels of distress are significantly associated with diabetes management at follow-up [9,10]. For example, in an observational study of adults with Type 2 diabetes, Aikens noted that initially elevated diabetes distress was associated with poorer glycaemic control and medication taking 6 months later [10]. Similarly, in a non-intervention study of adults with Type 1 diabetes, Strandberg and colleagues reported baseline distress was associated with glycaemic control 1–3 years later [11]. However, neither of these studies found prospective associations where baseline distress predicted changes in management outcomes over time, or predicted management at follow-up after controlling for baseline levels. In a second pattern of findings, several studies have pointed to significant bidirectional associations among diabetes distress and glycaemic control over time. In both observational and intervention contexts with adults with Type 2 diabetes, we found that decreases in distress were bidirectionally associated with decreases in HbA_{1c}, without support for one construct exclusively influencing the other [2,12]. Analogous longitudinal

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What's new?

- The current study builds on a small body of work focused on diabetes distress for persons living with Type 1 diabetes.
- The longitudinal finding that elevated baseline diabetes distress predicts a worsening in missed insulin boluses suggests that diabetes distress may play a causative role in its impact on management; identifying an additional target for intervention.
- Significant covarying longitudinal associations between increases in diabetes distress and HbA_{1c} over time mirror findings from the Type 2 diabetes literature and indicate an interactive relationship between these key constructs.

linkages have not been well-documented for adults with Type 1 diabetes, but a notable exception is a study by Weinger and Jacobson [13], who found that baseline distress did not predict change in HbA_{1c}, but that change in distress was associated with change in HbA_{1c} over the 5-month study. Thus, support has been found for longitudinal bidirectional associations between diabetes distress and management, deepening our understanding of mechanisms underlying these critical constructs [2,14]. None of these studies, however, has reported significant prospective findings to suggest that distress directly affects or influences management over time.

The lack of significant prospective findings severely restricts identification of the causal and interactive mechanisms to explain these associations. Clarifying the nature of these associations has theoretical as well as practical implications for intervention and treatment. For example, if their relation to one another is only associative, and changes in distress are not causatively linked to changes in diabetes management, effective interventions may need to target each separately. On the other hand, to the extent that distress 'causes' a change in diabetes management over time, a mechanism of influence can be identified such that distress may serve as a major target of prevention and remediation.

This study builds on previous work to explore direct linkages between diabetes distress and disease management in a sample of adults with Type 1 diabetes. Within the context of a 9-month non-intervention study diabetes distress, we asked:

- What are the cross-sectional relationships between distress and disease self-management (including glycaemic control)?
- Using prospective analyses, do baseline levels of distress predict disease self-management at follow-up controlling for baseline levels?
- Using longitudinal analyses, what is the relation between change in distress and change in disease management?

Because of the sometimes confusing linkages between distress and depression [1,2], in supplementary analyses we explored the same cross-sectional, prospective, and time-varying relationships among depression symptoms, a diagnosis of major depressive disorder (MDD), and disease management.

Methods

Participants

Adults with Type 1 diabetes were recruited from diabetes clinics in northern California and in Ontario, Canada, to assure a diverse sample. Inclusion criteria were: Type 1 diabetes for at least 12 months, age ≥ 19 years, ability to read and speak English, absence of severe complications or comorbidities (on dialysis, blindness), and absence of psychosis or dementia.

Materials and methods

Individuals who met inclusion criteria were identified during clinic visits or letters from each clinic informing them that they would receive a telephone call from a project representative if they did not opt out by calling or returning an enclosed postcard. All participants were screened for eligibility by telephone, and, if interested, emailed a personal link to a HIPAA-protected online survey and informed consent form. Participants also provided permission for their healthcare provider to release their most recent HbA_{1c} results (within 3 months). Following survey completion, participants were administered the mood disorders module of a structured psychiatric interview via telephone within 3 weeks of survey completion. The online survey was repeated 9 months after the initial survey, including permission for the release of their most recent HbA_{1c} results. Participants were sent electronic gift cards ($15 for baseline survey, $20 for baseline phone interview and $20 for 9-month survey). The study received approval from the UCSF Committee on Human Research, and data were collected in 2013–2014 and analysed in 2015–2017.

Measures

Demographic measures included age, gender, ethnicity (White/non-White), education (years), living with a partner (yes/no) and age at diagnosis. Diabetes status included: number of diabetes complications (from a list of 14), pump vs. non-pump status and current continuous glucose monitor use.

Diabetes distress

Diabetes distress was assessed by the T1-Diabetes Distress Scale [15], a 28-item survey that yields a total score (alpha = 0.91). Items are rated on a six-point scale from 'not a problem' to 'a very serious problem.' Mean item scores of ≥ 2

are considered clinically meaningful (moderate distress = 2.0–2.9; high distress ≥ 3).

Diabetes management

Clinic-reported HbA_{1c} was obtained from clinic records for laboratory tests within 3 months of survey completion. Numbers of hypoglycaemic episodes (defined as blood glucose < 70 mg/dl) in the past 7 days were self-reported. The per cent of missed insulin boluses was calculated from self-reported total number of boluses and boluses skipped during the past 2 weeks.

Depression

The eight-item Patient Health Questionnaire-8 (PHQ8) [16] assesses depression symptoms linked to Diagnostic and Statistical Manual of Mental Disorders (DSM)-V criteria for MDD (alpha = 0.89). The suicide item was omitted, which does not affect the validity of scoring thresholds or score distributions [16]. The PHQ8 asks how many days during the past 2 weeks the respondent experienced each of the eight symptoms of depression, with a severity score from 0 to 3 for each item (range 0–24). The PHQ8 was scored in three ways: continuously, dichotomized at < 10 = 0 and ≥ 10 = 1, and dichotomized at < 15 = 0 and ≥ 15 = 1. We used the Mood Disorders Module that diagnoses current and past year MDD from the Structured Clinic Interview for the DSM (SCID). The interview was delivered via telephone, which has shown good concordance with face-to-face interviews [17]. Three interviewers were trained by a master SCID trainer until acceptable inter-rater reliability was reached. All three interviewers then rated every tenth interview to monitor ongoing reliability and to prevent inter-rater drift over time (all Kappa values ≥ 0.90).

Data analysis

Chi-square and *t* tests, as appropriate, were conducted to test for differences in participant characteristics and outcome variables across the U.S. and Canadian samples, and to test for differences based on attrition at 9 months.

Multiple regression analyses were conducted to examine relationships between diabetes distress with each diabetes management variable (HbA_{1c}, number of times blood glucose < 70 mg/dl and % of missed insulin boluses) in three ways: (1) cross-sectional analyses to test associations at baseline; (2) prospective analyses between baseline distress and 9-month diabetes management variables, controlling for baseline values of the diabetes management variables; and (3) longitudinal analyses between change in distress (the difference score of baseline values minus 9-month values) and 9-month diabetes management variables, controlling for baseline values of the diabetes management variables. Regression models were conducted both with and without covariates known to be related to these variables: age, gender, and years of education. Because findings from these two regression models were similar, only non-covariate-adjusted results are presented here. Given the large number of analyses, we adjusted for multiple comparisons using the Benjamini–Hochberg procedure [18] utilizing a false discovery rate of 0.05; adjusted significance values are reported in addition to unadjusted values. These analyses were also repeated using a measure of depression symptoms and interview-based MDD diagnoses. The sample size was determined by the aims of the larger study [15] and allowed for detecting moderate effects (e.g. $d = 0.35$) at 0.80 or greater power (two-sided $\alpha = 0.05$). Missing data were not imputed, and cases were excluded list wise.

Results

Preliminary analyses

Of 348 eligible participants identified, 305 completed the baseline survey (88%); 73% ($n = 224$) of whom completed the 9-month assessment. Among these participants, 272 (89%) completed the SCID. Most participants who did not complete the SCID said that they were too busy. There were no significant differences between participants who completed the SCID or 9-month assessment and those who did not on any demographic or diabetes-related variable tested. Data from participants having both baseline and 9-month data were analysed in the present investigation. Descriptive statistics for this sample are presented in Table 1. Average age was 43 (15) years, 56% were female, mean (SD) HbA_{1c} was 56 (13.1) mmol/mol [7.3 (1.2)%] and mean diabetes duration was 22 (14) years. Follow-up descriptive statistics for outcome variables also are presented in Table 1.

Baseline cross-sectional analyses

In cross-sectional analyses using continuous scores or cut-points, diabetes distress was associated with baseline HbA_{1c} ($\beta = 0.28$, $P = 0.03$) and percent of missed insulin boluses ($\beta = 0.04$, $P = 0.02$): greater overall distress was associated with poorer glycaemic control and behavioural self-management (Table 2).

Prospective analyses

In prospective analyses, baseline diabetes distress significantly predicted change in percent of missed boluses ($\beta = 0.05$, $P = 0.006$) over time: those with higher initial diabetes distress displayed more missed insulin boluses over 9 months than those with lower initial diabetes distress. Baseline distress was not predictive of change in HbA_{1c} or number of hypoglycaemic episodes over time. Reversing the independent and dependent variables, models that tested baseline levels of management variables (i.e. missed insulin boluses, HbA_{1c} and number of hypoglycaemic episodes) as predictors of change in distress failed to reach significance. Thus, diabetes distress at baseline significantly predicted

Table 1 Baseline characteristics of participants, with baseline and follow-up outcome values

Characteristic or variable	Baseline	9 Months
Age (years)	43.0 (15.2)	
Age at type 1 diagnosis	20.9 (13.3)	
Sex (% female)	56.3	
Education (%)		
≤ 12 years	1.4	
13–16 years	50.0	
> 16 years	48.6	
Ethnicity (% non-Hispanic White)	84.0	
Living with a partner (%)	66.1	
Duration of diabetes (years)	22.2 (14.3)	
BMI (kg/m^2)	25.4 (4.1)	
No. of complications	2.0 (2.3)	
Insulin pump use (%)	68.8	
Continuous glucose monitor use (%)	38.4	
HbA_{1c} laboratory value mmol/mol	56 (13.1)	56 (12.0)
HbA_{1c} laboratory value (%) (n=213 complete cases)	7.3 (1.2)	7.3 (1.1)
Diabetes distress total continuous score	2.0 (0.6)	1.8 (0.6)
Diabetes distress total score ≥ 2 (%)	43.8	
PHQ8 total continuous score	4.4 (4.2)	3.6 (3.6)
PHQ8 total score ≥ 10 (%)	10.4	
PHQ8 total score ≥ 15 (%)	3.8	
SCID current Major Depression Disorder (%)	2.8	
SCID past year Major Depression Disorder (%)	6.6	
% of missed insulin boluses past 2 weeks	13 (16)	12 (17)
No. of times past week blood glucose < 70 mg/dl	2.9 (2.5)	2.8 (2.2)

Values are given as mean (SD) unless stated otherwise.
N = 224 for all measures except SCID (n = 212).

percent of missed insulin boluses at 9 months, after controlling for baseline levels, whereas management at baseline did not significantly predict change in distress.

Time-varying analyses

Reductions in diabetes distress over the 9 months were significantly related to improvement in HbA_{1c} ($\beta = 0.34$, $P < 0.01$). Reductions in distress, however, was unrelated to change in hypoglycaemic episodes or behavioural self-management, and the association between change in distress and HbA_{1c} remained significant even after controlling for change in self-management behaviour ($\beta = 0.36$, $P < 0.01$).

Supplementary analyses

In like manner, cross-sectional, prospective, and time-varying analyses were undertaken among PHQ8, SCID-based diagnoses of MDD, and the disease management variables (Table 3). In cross-sectional analyses, no PHQ8 measure of depressive symptoms, nor current or past year measures of MDD, was significantly associated with any measure of diabetes self-management. Likewise, models that tested baseline levels of PHQ8 and MDD were nonsignificant. Using cut-off points for the PHQ yielded the same nonsignificant results. In time-varying analyses, change in PHQ was not significantly related to change in diabetes management or glycaemic control. Thus, unlike the diabetes distress results, no measure of depression symptoms or diagnosis of MDD was significantly linked with any diabetes management variable in any cross-sectional, prospective or time-varying analysis.

Conclusion

This study examined cross-sectional, prospective, and time-varying associations between diabetes distress and key diabetes management outcomes. Similar to previous reports [2,8], significant cross-sectional associations between distress and diabetes management are present, with elevated distress associated with higher HbA_{1c} and a greater percentage of missed insulin boluses. Furthermore, distress is significantly related to both an increase in missed insulin boluses and a worsening of HbA_{1c} over time. The effect of high baseline distress on subsequent reductions in missed boluses is prospective and unidirectional, offering cautionary support for a possible causative linkage. In the current study, individuals with elevated baseline distress are more likely to miss more insulin boluses at 9-month follow-up, even after controlling for baseline levels of missed insulin boluses. Interestingly, the converse directional effect does not hold: baseline percent of missed boluses is not a predictor of distress at follow-up, controlling for baseline distress. Considering the cross-sectional and prospective effects together, results suggest that individuals who experience elevated diabetes distress are not only more likely to experience problems with their diabetes management at a given point in time, but also may be more likely to continue to experience difficulties in diabetes self-management, such as missing insulin boluses, over time. On the other hand, the longitudinal effect between diabetes distress and HbA_{1c} is a significant covarying association, in which increases in distress are significantly associated with increases in HbA_{1c} and vice versa.

To our knowledge, this is the first prospective longitudinal finding of its kind and has important implications for intervention. Understanding that high diabetes distress is associated with an increase in missed insulin boluses identifies a potential target for intervention. A critical next step will be to examine this association in a longitudinal research design with more than two time points, which would permit more sophisticated modelling of change and more confidence in causative conclusions. As well, future studies should examine the extent to which intervening with or preventing elevated diabetes distress can proactively protect against subsequent missed boluses.

The presence of a covarying relationship between diabetes distress and HbA_{1c} is in line with our previous findings

Table 2 Cross-sectional and longitudinal associations between diabetes distress with diabetes management

	HbA_{1c}			No. of times blood glucose < 70 mg/dl			% insulin boluses missed		
	B (SE)	*P*	Adjusted *P**	*B* (SE)	*P*	Adjusted *P**	*B* (SE)	*P*	Adjusted *P**
Baseline Concurrent									
BL Diabetes distress	0.28 (0.13)	0.03	0.06	0.11 (0.27)	0.69	0.86	0.04 (0.02)	0.02	0.05
BL Diabetes distress groups (≥ 2)	0.37 (0.16)	0.02	0.05	–0.29 (0.33)	0.37	0.62	0.05 (0.02)	0.02	0.05
9 Months									
Prospective 9M outcome									
BL Diabetes distress	0.09 (0.09)	0.31	0.58	0.003 (0.19)	0.99	0.99	0.05 (0.02)	0.006	0.05
BL Diabetes distress groups (≥ 2)	0.03 (0.11)	0.77	0.89	–0.002 (0.23)	0.99	0.99	0.07 (0.02)	0.005	0.05
9M outcome with time-varying (Δ) predictor									
Δ Diabetes distress (BL–9M)	0.34 (0.13)	0.009	0.05	0.19 (0.27)	0.48	0.72	–0.02 (0.03)	0.54	0.74

BL, baseline; 9M, 9 month.
*Significance values were adjusted using the Benjamini–Hochberg procedure to control for multiple tests (no. of tests = 15; study-wide alpha = 0.05).

Table 3 Cross-sectional and longitudinal associations between depression symptoms and major depressive disorder with diabetes management

	HbA_{1c}			No. of times blood glucose < 70 mg/dl			% insulin boluses missed		
	B (SE)	*P*	Adjusted *P**	*B* (SE)	*P*	Adjusted *P**	*B* (SE)	*P*	Adjusted *P**
Baseline Concurrent									
BL PHQ8	0.02 (0.02)	0.21	0.96	–0.01 (0.04)	0.71	0.96	0.01 (0.003)	0.07	0.96
BL MDD current	–0.29 (0.49)	0.55	0.96	0.06 (10.03)	0.96	0.96	–0.03 (0.07)	0.63	0.96
BL MDD past year	0.22 (0.33)	0.51	0.96	0.67 (0.69)	0.33	0.96	–0.02 (0.05)	0.61	0.96
BL PHQ8 groups (≥ 10)	0.17 (0.27)	0.52	0.96	–0.30 (0.54)	0.58	0.96	0.04 (0.04)	0.25	0.96
BL PHQ8 groups (≥ 15)	–0.03 (0.42)	0.94	0.96	0.13 (0.88)	0.89	0.96	0.01 (0.06)	0.86	0.96
9 Months									
Prospective 9M outcome									
BL PHQ8	–0.01 (0.01)	0.71	0.96	0.01 (0.03)	0.82	0.96	0.002 (0.003)	0.45	0.96
BL MDD current	0.03 (0.30)	0.92	0.96	10.09 (0.72)	0.13	0.96	0.10 (0.07)	0.15	0.96
BL MDD past year	0.20 (0.23)	0.37	0.96	–0.06 (0.48)	0.90	0.96	0.02 (0.05)	0.60	0.96
BL PHQ8 groups (≥ 10)	–0.09 (0.20)	0.64	0.96	0.35 (0.38)	0.35	0.96	0.02 (0.04)	0.62	0.96
BL PHQ8 groups (≥ 15)	0.33 (0.29)	0.27	0.96	0.61 (0.62)	0.33	0.96	0.01 (0.06)	0.89	0.96
9M outcome with time-varying (Δ) predictor									
Δ PHQ8 (BL-9M)	0.01 (0.02)	0.74	0.96	0.03 (0.04)	0.45	0.96	–0.002 (0.004)	0.62	0.96

BL, baseline; 9M, 9 month.
*Significance values were adjusted using the Benjamini–Hochberg procedure to control for multiple tests (no. of tests = 15; study-wide alpha = 0.05).

[2,13]. It suggests that change in distress occurs with change in HbA_{1c}, and that each construct likely influences the other cyclically over time. These short-term bidirectional influences may operate through multiple short-term mechanisms or pathways, including both direct biological linkages and indirect associations though behavioural disease management [19]. Furthermore, in the current study, changes in missed insulin boluses did not explain the association between diabetes distress and HbA_{1c}, supporting the view that there are likely multiple mechanisms at work that may differ for subgroups of participants [2]. The absence of a significant prospective association between distress and HbA_{1c} is intriguing. It may be the case that the 9-month time interval we employed between baseline and follow-up was too short to demonstrate a significant prospective relationship between these two variables. The study might not have provided a sufficient time interval for high distress to have an impact on missed boluses, which, in turn, would affect glycaemic control. Studies of longer duration to explore this mechanism of action are called for.

It is noteworthy that none of the psychological measures was associated with frequency of hypoglycaemia. It may be that the contributing factors and correlates of hypoglycaemia are too varied, and the frequency of hypoglycaemia is too low to yield a systematic association with global psychological assessments. Study designs that allow for more precision in timing, such as daily diary studies, or alternative assessments of hypoglycaemia (e.g. mild, moderate, severe), may yield more consistent linkages.

In supplementary analyses, we find no significant cross-sectional, prospective or time-varying associations between depressive symptoms (PHQ8), current or past year diagnosis of MDD, and any self-management variable. Within the Type 2 diabetes literature, there have been inconsistent associations between depression symptoms or MDD and diabetes self-management. Our findings are in line with previous studies in which most of the emotional impact of diabetes on management and well-being operates through the distress associated with the disease and not necessarily with clinical psychopathology [10,12], in contrast to other studies of Type 2 diabetes that have found depression symptoms to explain the effects of disease-related distress on management [1] or that have shown that both distress and depression symptoms are independently associated with diabetes management [9]. Accumulated, these results highlight importance of distinguishing among the constructs of diabetes distress, depression symptoms, and MDD within the context of diabetes [20,21].

The current findings suggest that diabetes distress may have important consequences for Type 1 diabetes management and highlight the need to address distress in programmes of care. Without intervention, diabetes distress appears to be relatively stable over time [2,12,15], but distress is malleable if addressed directly. Several behavioural programmes have reported successful reductions in diabetes distress, and even relatively modest interventions have yielded improvements when distress was regularly addressed with continuity of care over time [22–24]. In our own behavioural intervention programmes with adults with Type 2 diabetes, decreases in diabetes distress have been associated with increases in self-management behaviours and glycaemic control over time, providing additional support for diabetes distress as a critical point of intervention [2,22]. Thus, addressing distress in diabetes education or in routine clinical encounters can serve as a critical opportunity to help individuals anticipate and recognize the distress that they may feel in response to living with a chronic disease, and address its impact on their disease management.

This study has several strengths, including the use of validated measures, a relatively large community sample, and 9-month longitudinal data with modest attrition. However, results should be considered with several limitations in mind. First, the study could have been strengthened by a comprehensive and less-subjective measurement of missed insulin boluses and low blood sugars. Second, the study sample was relatively well-educated individuals having a high rate of healthcare accessibility and computer access. Third, the study design only allowed for SCID diagnostic interview assessment at baseline, thus not allowing for time-varying models to assess MDD. Fourth, the study was limited to two assessments over 9 months, which did not permit a more comprehensive analysis of long-term change.

In both cross-sectional and longitudinal analyses, high diabetes distress is associated with more missed insulin boluses and poorer glycaemic control. Findings also suggest that high baseline distress is significantly associated with more missed insulin boluses over time. In contrast, we find no support for cross-sectional or longitudinal associations between MDD or depression symptoms with diabetes self-management. Findings underscore the importance of broadening routine clinical care to address diabetes distress as an integral part of diabetes management.

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Competing interests

None declared. Lawrence Fisher: consultant or advisory board with Roche Diagnostics, Elli Lilly Abbott Diabetes Care; William Polonsky: consultant or advisory board with Sanofi, Novo Nordisk, Eli Lilly, Dexcom, Abbott, Johnson & Johnson, Boehringer Ingelheim, Takeda, Roche; Anne Peters: consultant or advisory board with Amgen, Abbott Diabetes Care, Becton Dickinson, Biodel, Bristol Myers Squibb/AstraZeneca, Janssen, Lexicon, Eli Lilly, Medtronic Minimed, Novo Nordisk, OptumRx, Sanofi, Takeda, Thermalin. Speakers Bureau – Bristol Myers Squibb/AstraZeneca, Novo Nordisk, Janssen; Ian Blumer: consultant to or advisory board with Animas, Bayer, BD Diabetes, BMS/AZ, Eli Lilly, Janssen, Medtronic, Merck, Novo Nordisk, Roche, Sanofi.

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