



Does staff-assessed care quality predict early failure of dental fillings? A prospective study

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Abstract

Objectives: The aim of this study was to evaluate staff-assessed care quality as an indicator of register-based measures of care quality at dental clinics, more specifically register-based measures of survival of dental fillings and initiation of preventive treatments for caries patients.

Methods: This prospective study includes data from cross-sectional workplace psychosocial risk assessment surveys at dental clinics and register data on survival of dental fillings, and initiation of preventive treatment for caries patients obtained from the Swedish Quality Registry for Caries and Periodontal Disease (SKaPa). Demographic background data on the age, gender, income level and place of birth of patients was obtained from Statistics Sweden (SCB). The data were analysed using discrete-time multilevel survival analysis and multiple linear regression analysis.

Results: The results showed that staff-assessed care quality rated by the total staff or by dental nurses at the clinic predicted the risk of replacement of dental fillings made due to a caries diagnosis during the 3-year follow-up period, controlling for potential confounding due to patient demographic characteristics (age, sex, income and country of birth). In contrast, the better the staff-assessed care quality at the clinic, the smaller the proportion of the patients received preventive care in addition to operative caries therapy when controlling for potential confounding due to patient demographics. Care quality assessed by dentists at the clinic did not predict either of these outcome measures.

Conclusions: Premature failure of dental fillings is costly for both patients and society, which leads to a need for relevant measures for following dental care quality. Our findings indicate that staff-assessed care quality – a cheap and easy measure to collect and follow continuously in dental practice – can be used to monitor aspects of quality in real time in order to facilitate continuous improvement and quickly amend quality problems. Also, it can be used for integrating quality improvement in systematic work environment risk management.

KEYWORDS

care quality, caries, dentistry, prevention, survival of dental fillings, workplace

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1 | INTRODUCTION

Improving quality of health care while reducing costs is crucial for achieving the Sustainable Development Goals of universal health coverage in 2030. Therefore, the World Health Organization, the Organisation for Economic Co-operation and Development, and the World Bank jointly call for action to improve the quality of health services by ensuring the quality of care.¹

According to Donabedian, quality of care is a multifaceted concept,² where assessments ideally should be based on hypotheses concerning the interrelationship among structure, process and outcome.³ In accordance with this, WHO and partners define quality of care as 'the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge'.¹

Dentistry is lagging behind other parts of the healthcare sector when it comes to establishing relevant measures of care quality.⁴⁻⁷ A systematic literature review on dental care quality from 2019 finds the majority of measures refer to treatment and preventive services.⁷ Another systematic literature review from the same year reveals a gap in valid measurement across domains (structure, process and outcome) and dimensions (eg safety, effectiveness, timeliness, patient-centeredness, efficiency and equity) of dental care quality.⁶ Adding further to this complexity, the relevance of a measure for quality improvement purposes differs depending on stakeholder perspective and level for follow-up (eg society, dental organization, clinic, dental team, care provider, patient, tooth or surface). Finally, data on care quality can be collected from various sources such as register data, patient records, care provider assessment, patient satisfaction surveys or even workplace surveys.

General medical practitioners report lack of data, and lack of skills to manage and analyse data, as hinderances for quality improvement.⁸ This is understandable as register data are difficult to handle and auditing patient records are time-consuming. It is easier to use questionnaires, and most validated outcome measures for dentistry thus deal with patient satisfaction.⁶ However, research has shown that neither patients' assessment of the quality of their dental treatment nor their general satisfaction with dental care were associated with dentists' assessment of the quality of dental restorations provided.⁹ This indicates that care providers and patients base their evaluation of quality on different aspects. General medical practitioners believe that staff can assess quality at the practice,⁸ and in other parts of health care, staff assessments is a novel but promising research field.^{10,11} To our best knowledge, the present study is the first to take up this challenge within the context of dentistry.

The management and staff have a key role in quality improvement.^{8,12} Utilization of register-based indicators of quality, such as survival of fillings, is rather complicated to implement in continuous quality improvement at dental clinics. Therefore, a valid measure of staff-assessed care quality for inclusion in regular work environment risk assessment surveys would be of high relevance. In a previous multilevel study, we introduced such a measure based on three items.¹³ The findings corroborated the validity and reliability of

aggregating individual staff scores on care quality to report a mean score for each clinic. Also, the organizational justice climate at the clinic contributed to explain a substantial part of variation in staff assessment of care quality among clinics, thus linking the measure to the work environment.¹³ It remains to test the predictive validity of the measure in relation to other established measures of dental care quality.

In 1967, Schonfeld wrote¹⁴:

Probably all will agree that the greater the proportion of satisfactorily inserted restorations, the better the quality of care rendered.

Thus, quality of dental fillings has been in focus at least since the sixties. Around one in five dental fillings made in Sweden are replaced within a 5-year period,¹⁵ which implies a substantial potential for improvement. While a high-quality restoration may stop the caries process locally in relation to the specific surfaces, it does not change the overall caries risk profile of the patient.¹⁶ Preventive care is thus another important indicator of care quality.

In this study, we aim to evaluate staff-assessed care quality as an indicator of register-based measures of care quality at dental clinics (eg survival of dental fillings and initiation of preventive treatments for caries patients). Specifically, we are assessing the impact of staff-assessed care quality as rated by different members of the clinic (eg dentists, dental nurses and all staff together), onto early filling failure and initiation of prevention, while controlling for patient characteristics (eg age, gender, country of birth, education and income).

2 | METHODS

This study has a prospective design including data from cross-sectional risk assessment surveys at dental clinics and register-based follow-up measures of dental care quality.

2.1 | Data

Questionnaire data were collected in 2014-2015 among staff at all public dental practices in four regions of Sweden. Each employee received a personal link to an online questionnaire. Inclusion criteria for the present study are dental nurses, dental hygienists and dentists including heads of clinic from general dental practices with a minimum of three respondents. Data from 74 clinics, based on 908 individual ratings, are thus included in the analyses and with a response rate of 73% after two reminders (range 40%-100%; three workplaces had lower than 50% response rate).

Staff-assessed care quality was measured by three items with five response options (Table 1). Cognitive interviews were used for development and evaluation of content validity; construct validity has further been supported by findings from previous studies.^{13,17-19}

TABLE 1 Item and scale characteristics for staff-assessed care quality

Group	All staff (N = 908)	Dentists (N = 244)	Nurses (N = 463)
	Corrected item-total correlation	Corrected item-total correlation	Corrected item-total correlation
Items ^a			
QW1	0.56	0.60	0.57
QW2a	0.66	0.64	0.68
QW2b	0.74	0.74	0.74
Scale			
Cronbach's α	.81	.81	.81
Mean (SD)	4.20 (0.55)	4.09 (0.57)	4.24 (0.56)
ICC(1)	0.12	0.18	0.16

^aQW1: Are you satisfied with the quality of the work done at your workplace? QW2: To what extent do you think that the following issues characterize your ward/department? QW2a: Is the quality of communication with patients good? QW2b: Is the quality of the actual treatment of patients good? Response options: To a very small extent, to a small extent, to some extent, to a large extent and to a very large extent.

An additive index scale in the range 1-5 was constructed, setting the scale score as missing if respondents had not replied to all items. The individual scores for respondents working at the same clinic were aggregated to calculate an average score for staff-assessed care quality for each clinic. The aggregated scores were calculated for all staff, for dentists and for dental nurses, as different professions potentially add different meaning to the questions on care quality.

Register data on dental care quality were obtained from SKaPa that automatically extracts data from the electronic patient records at public clinics. Class 2 and class 3 composite fillings in premolars and molars, which were made at the included clinics during a 3-month period surrounding the work environment survey, were included in the study and followed during a period of 3 years. Time to event was measured as the difference in days between the date the filling was made and the date for a diagnosed failure. For fillings made due to a caries diagnosis, additional information was obtained about whether the patient had received preventive care during a 5-month period surrounding the work environment survey. Preventive care included information, instruction, applied behavioural medicine and application of fluoride. For each clinic, the proportion of caries patients who had received preventive care was calculated.

Data on the age, gender, income level and place of birth of patients were obtained from Statistics Sweden.

2.2 | Analyses

Using multilevel discrete-time survival analysis with proportional effects, the model from staff-assessed care quality to early filling failure, controlling for covariates, was analysed using maximum likelihood restricted (MLR) estimation in Mplus v8, across three time points. Our three event indicators – year 1, year 2 and year 3 – were binary and corresponded to the three time periods. If our event of interest – filling failure – occurred within the first-year scores were

coded as 1, and 0 if no event occurred within the year period. Once filling failure occurred at the tooth level or the tooth information was lost in the following data collections, and the remaining event indicators were coded as missing. At the clinic level (level 2), we tested the distinct effects of staff-assessed care quality on the probability of experiencing early filling failure, for nurses, doctors and all staff separately. In these three separate multilevel discrete-time survival models, we controlled for patient characteristics at the tooth level (level 1); patient age, gender, education, country of birth and income. In the post hoc analysis, the proposed models were subsequently tested only including teeth that received a filling due to a caries diagnosis to minimize confounding from local factors. The proportionality assumption of our predictors was assessed and found to be time-invariant. As such, our level 1 covariates and level 2 predictors were entered into the proposed model with proportional effects across the three time points.

Multiple linear regression analyses were performed with the proportion of caries patients receiving preventive care alongside operative caries therapy as the dependent variable and with staff-assessed care quality (as perceived by all staff, dentists and dental nurses, respectively) as independent variable in SPSS v26. Patient demographics for the clinic (percentage of caries patients born outside the Nordic countries, average income level of caries patients, average age of caries patients and percentage of male caries patients at the clinic) were included as covariates. Inter-correlations between independent variables, variance inflation factors (VIF) and Durbin Watson statistics were checked for; and residual plots and Cook's distances were inspected.

2.3 | Ethics

The study was approved by the Regional Ethical Review Board in Southern Sweden (dnr: 2017 323).

3 | RESULTS

The average size of the clinics included in the study was 16 staff members (range 3-43). Respondents were older than nonrespondents (46.8 vs 44.3 years, $P = .003$) and more likely women (92.1% vs 88.3%, $P = .053$). Compared to the target population, the proportion of dentists was lower (24% vs 28%) and the proportion of dental nurses higher (53% vs 50%) in the study sample while no significant difference was found for dental hygienists. Item and scale characteristics are presented in Table 1. Cronbach's α was .81, and the corrected item-total correlations were at the same level for all staff, dentists and dental nurses. On average, dental nurses assessed care quality as better than dentists did ($P < .001$). The amount of variance in the employees' responses explained by workplace (ICC(1)) was larger when aggregating responses from occupational groups separately than from all staff at clinics.

In total, 8505 patients received 9997 dental fillings fulfilling our inclusion criteria. Of these, 63.7% ($n = 6364$) were made due to a caries diagnosis. Most patients had only received one (86.0%) or two fillings (11.4%). Similarly, for patients with caries, most only received one (85.8%) or two fillings (11.8%). Among the 5398 caries patients, 9.8% received preventive care alongside operative caries therapy. Of the included patients, 50.1% were women, 90.5% were born in a Scandinavian country, the average age of patients was 50.2 years, SD 15.7, and the average total yearly income was SEK 296 161, SD 161 276 (100 SEK was equivalent to 9.1 USD on 2 January 2017). Among patients, 28.9% had primary, 37.9% secondary and 27.1% higher education; for 6.1%, the educational level was unknown.

As can be seen in Table 2, staff-assessed care quality did not predict filling failure (including all fillings) in any of the three groups tested.

When restricting the analyses to fillings made due to a caries diagnosis, higher staff-assessed care quality as rated by all staff,

as well as by the nurses, predicted fewer early filling failures (OR = 0.927 (0.856-0.999) and OR = 0.925 (0.854-0.996), respectively, per scale unit [1-5], Table 3). The dentists' ratings, however, did not predict failures. The only covariate significantly linked with early filling failure was patient age. As the age of the patient increases, the odds of the tooth experiencing filling failure increase. Patient gender, education, country of birth, and income had not significant impact on the probability of early filling failure.

The cumulative survival probability for care quality as rated by dental nurses exclusively can be seen in Figure 1. The higher the assessments of care quality, the slower the cumulative survival rate drops.

The regression models for the analysis of hypothesis 2 are presented in Table 4. One extreme outlier was identified and excluded from the analyses. Controlling for demographic factors, staff-assessed care quality was significantly associated with the percentage of caries patients that received preventive care at the clinic when assessed by the total staff (Model 1) or by the dental nurses (Model 3), but not by the dentists (Model 2). However, the direction of the association was the opposite of what was hypothesized; the better the staff-assessed care quality at the clinic, the smaller the proportion of patients received preventive care in addition to operative caries therapy. Among covariates, the income level among patients was positively correlated with the provision of preventive care at the clinics, while the proportion of men among caries patients was negatively correlated with the provision of preventive care. The overall pattern of associations for covariates was consistent across models.

4 | DISCUSSION

We found that better staff-assessed care quality rated by the total staff or by dental nurses at the clinic predicted (a) lower risk of early

TABLE 2 The findings from the proposed model of experiencing early filling failure as predicted by clinic level perceived care quality by all staff, dentists and nurses separately, while controlling for patient characteristics at the tooth level

	All staff			Dentists			Nurses		
	OR	SE	95% CI	OR	SE	95% CI	OR	SE	95% CI
Tooth level (L1)									
Sex (male)	1.055	0.077	0.904, 1.205	1.008	0.077	0.858, 1.160	1.039	0.076	0.890, 1.188
Age (y)	1.013***	0.002	1.009, 1.018	1.014***	0.003	1.009, 1.019	1.013***	0.002	1.008, 1.018
Education (1-3)	0.992	0.043	0.908, 1.076	0.980	0.046	0.891, 1.069	0.991	0.043	0.907, 1.075
Country (born outside Scandinavia)	0.858	0.092	0.677, 1.039	0.880	0.095	0.695, 1.065	0.856	0.093	0.674, 1.038
Income (100 SEK)	1.034	0.021	0.994, 1.074	1.042	0.022	0.999, 1.085	1.036	0.021	0.995, 1.076
Clinic level (L2)									
Care quality (1-5)	0.960	0.037	0.888, 1.032	1.002	0.046	0.911, 1.092	0.956	0.036	0.885, 1.026
Model fit indices									
-2LL	-4663.916			-4097.535			-4585.049		
Correction factor	1.242			1.318			1.235		
Free parameters	9			9			9		

*** $P < .001$.

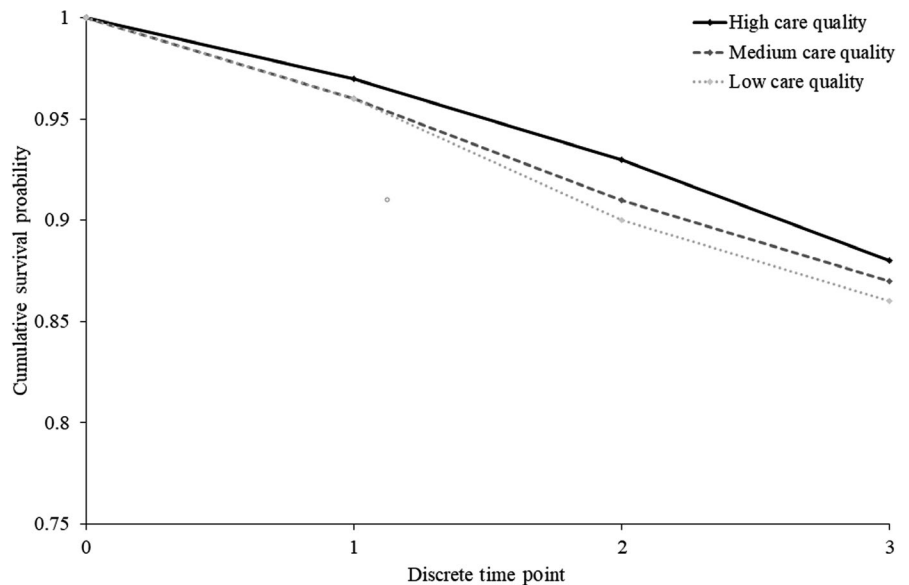
TABLE 3 The findings from the proposed model of experiencing early filling failure as predicted by clinic level perceived care quality by all staff, dentists and nurses separately, while controlling for patient characteristics at the tooth level, for caries disease fillings only

	All staff			Dentists			Nurses		
	OR	SE	95% CI	OR	SE	95% CI	OR	SE	95% CI
Tooth level (L1)									
Sex (male)	1.080	0.098	0.889, 1.272	1.044	0.097	0.854, 1.234	1.056	0.095	0.869, 1.242
Age (y)	1.012***	0.003	1.007, 1.017	1.012***	0.003	1.006, 1.018	1.011***	0.003	1.006, 1.017
Education (1-3)	1.033	0.062	0.912, 1.155	1.032	0.069	0.897, 1.167	1.028	0.062	0.906, 1.149
Country (born outside Scandinavia)	0.801	0.105	0.595, 1.008	0.837	0.111	0.621, 1.054	0.798	0.105	0.592, 1.005
Income (100 SEK)	0.994	0.030	0.934, 1.044	1.001	0.033	0.937, 1.066	0.997	0.030	0.938, 1.057
Clinic level (L2)									
Care quality (1-5)	0.927	0.036	0.856, 0.999	1.003	0.048	0.91, 1.096	0.925*	0.036	0.854, 0.996
Model fit									
-2LL	4975.456			4310.326			4903.262		
Correction factor	0.996			1.047			0.988		
Free Parameters	9			9			9		

***P < .001.

*P < .05

FIGURE 1 Cumulative survival probabilities of failure for fillings made due to caries, based on clinic-level assessment of care quality for dental nurses



failures of dental fillings made due to a caries diagnosis and (b) less initiation of preventive care for caries patients.

In accordance with our expectations, we found that staff-reported assessment of dental care quality predicted the survival of posterior composite fillings made due to a caries diagnosis. This is in line with the findings from hospital sector studies investigating corresponding aggregated staff-reported quality assessments in relation to organizational performance measures.^{10,11} For example, staff-reported care quality has been shown to predict patient mortality, failure to rescue, patient satisfaction and care process measures,¹¹ and correlates with publicly reported screening indicators of delirium, malnutrition and pain.¹⁰ Contrary to our expectations, however, we found that the better the staff assessed the quality at

the clinic, the lower the proportion of caries patients received preventive care. The two studies from the hospital sector did not include any preventive measures.^{10,11}

Dentist assessment of care quality was far from significant both in prediction of failure of fillings and initiation of preventive measures in contrast to nurse-assessed care quality. This indicates a potential discrepancy in what auxiliary staff and dentists attribute to good care quality. However, the corrected item-total correlations were quite similar across groups, thus not supporting this interpretation. It might be that auxiliary staff have better overview of what is delivered across different care providers, at the front desk and back-stage, in contrast to dentists, who typically work more isolated with own patients.

Predictor	Model 1	all staff	Model 2	dentists	Model 3	dental nurses
	<i>b</i>	<i>P</i> -value	<i>b</i>	<i>P</i> -value	<i>b</i>	<i>P</i> -value
Constant	25.879	.323	5.995	.848	16.222	.521
Staff-assessed care quality (range 1-5)	-8.174	.019	-2.666	.398	-5.473	.040
Percentage of caries patients at clinic born outside Scandinavia	0.186	.149	0.154	.338	0.189	.153
Average income level of caries patients at clinic (100 000 SEK)	0.111	.001	0.103	.018	0.111	.002
Average age of caries patients at clinic	0.169	.580	0.116	.753	0.151	.629
Percentage of male caries patients at clinic	-0.463	.000	-0.426	.006	-0.477	.000

Note: Model 1. Adj. $R^2 = .259$; $P < .001$; Durbin Watson = 1.967. Model 2. Adj. $R^2 = .244$; $P < .001$; Durbin Watson = 1.966. Model 3. Adj. $R^2 = .187$; $P = .008$; Durbin Watson = 1.805.

To better understand the contrasting main findings across the two main hypotheses, it is relevant to discuss the pattern of covariates. Patient age was a risk factor for failure of dental fillings. However, only gender composition and income level among caries patients treated at the clinic were related to how large a fraction of patients received preventive care. For example, the higher the income among caries patients, the more likely it was that the patients received prevention. This indicates that the provision of prevention is driven by other factors than solely the patients' needs, for example economic factors and patient demands.

Previous research points to the performance of dental health professionals as being influenced by economic incentives,²⁰⁻²² especially for services without firm professional norms.²⁰ No direct personal economic incentives are at play, as staff working at public dental services in Sweden have fixed salaries of which only a small percentage is individually negotiated. On the other hand, dentistry in Sweden is a free market, which implies that even the public dental sector is organized according to business models.²³ Adult patients without specific needs pay the majority of the costs for their dental care with co-financing from the national social insurance. Most patients (four out of five) who use public dental services choose fee-for-service as the payment model, while only a minority take the capitation model, which includes basic prevention.²⁴ In general, those signing up for the capitation model are younger, in a higher socio-economic position and have a better oral health status than those choosing the fee-for-service model.²⁴ In other words, those in greatest need of prevention, but with the lowest income, are enrolled in the fee-for-service model, where prevention has to be explicitly charged for. Thereby, prevention in the fee-for-service model might lead to providing and charging the patients who can afford it rather than those in most need.

Across the European countries, there is a gap between the highest and the lowest income quartiles in abstaining from necessary dental care due to costs or other economic factors.²⁵ While the decision

TABLE 4 Multiple linear regression model with percentage of caries patients at the clinic that receive preventive care in relation to operative caries therapy as dependent variable

about a need for a filling relies on the judgement of the health professional, adult patients are in a more informed position to voice rejection of preventive care. An interpretation of the controversial finding that the better the staff assessed the quality led to less prevention might be that the understanding of what constitutes good quality in a business model can be expressed by 'the customer is always right'.

For the individual patient, quality in the form of longevity of fillings and reduced future caries risk has implications for his/her oral and general health, quality of life and personal finances. Dental care quality is also central to intrinsic motivation of dental staff.^{26,27} Addressing dental care quality is thus important from a public health perspective in relation both to patient and to staff well-being. The three-item measure can easily be included in systematic work environment risk assessment surveys. The studied measure of self-assessed care quality could be relevant for the clinical setting to facilitate team discussions for a joint understanding of care quality and for identification of structures and processes that could be addressed for improvement of the care quality at the clinic. Such an approach would facilitate organizational integration of processes for quality management with processes aiming at improvement of the work environment for staff.

The findings of the present study should be seen in the light of some strengths and limitations. The main advantage is the prospective study design that combines questionnaire and register data. Another strength is related to the measure of staff-assessed care quality. First, the questions on care quality are formulated in a way that aims to avoid social desirability bias due to a potential bad conscience over the individual's own performance. Next, the individual replies are aggregated to the clinical level, indicating the shared perceptions of the level of care quality. Using register data and the opportunity to control for several demographic factors are a strength, although the reliability relies on the accuracy of the registrations. In general, we regard the included register data as highly reliable as

the regions hold responsibility for ensuring that patient records and registrations are in accordance with legislation. However, what is registered might differ slightly to what has been provided, for example, a delay from the true event to the patient is diagnosed. Finally, the use of multilevel analyses taking clustering at clinics into account is a strength. It was technically impossible to also include potential effects of clustering at patient level, but sensitivity analyses with inclusion of only one, randomly selected filling from each of the relatively few patients who had received two or more fillings did not change the overall findings.

This study is the first to investigate the potential of staff-reported care quality as an indicator of the quality of the actual care delivered regarding two important aspects of dental care quality. It is therefore important to replicate the study in different settings and in relation to various working conditions and other indicators of quality. In addition, there is a need to achieve a deeper understanding of underlying factors that drive the provision of preventive care and what forms the staff perceptions of quality of care.

5 | CONCLUSION

Premature failure of dental fillings is costly for both patients and society leading to a need for relevant measures for following dental care quality. Our findings indicate that staff-assessed care quality – a cheap and easy measure to collect and follow continuously in dental practice – can be used to monitor quality in real time in order to facilitate continuous improvement and quickly amend quality problems. Also, it can be used for integrating quality improvement in systematic work environment risk management.

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CONFLICT OF INTEREST

The authors state no conflict of interest.

AUTHOR CONTRIBUTIONS

All authors meet the ICMJE criteria for authorship. HB, KW and HW substantially contributed to conception and design, HB acquired the data and HB, MO and HW analysed and interpreted the data. HB and MO drafted the article and KW and HW revised it critically for important intellectual content. HB, MO, KW and HW finally approved the version to be published.

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