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Original article

Social inequalities and outcomes in type 2 diabetes in the German region of Augsburg. A cross-sectional survey.

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Summary

Objectives: To assess the association of socioeconomic position with health (care) outcomes in type 2 diabetes with a particular focus on glycaemic control.

Methods: A cross-sectional survey in the region of Augsburg (Germany) on 373 men and women with type 2 diabetes, drawn from representative MONICA surveys and the myocardial infarct register. Analysis of association of socioeconomic position with HbA1c levels, cardiovascular risk factors and long-term macro- and microvascular diabetes complications using logistic regression models.

Results: Glycaemic control, measured by HbA1c levels, is strongly associated with indicators of socioeconomic position favouring the better off. Comparison of the lowest with the highest socioeconomic group showed an odds ratio of 2.49 (95 % CI: 1.22–5.07) for the MI register subgroup and 1.80 (95 % CI: 0.80–4.06) for the survey subgroup for failure to achieve the recommended HbA1c target. This association could not be accounted for by differences across social groups in age, sex, diabetes duration, obesity, or physical activity.

Conclusions: Social inequalities in glycaemic control do exist. This finding may indicate a level of diabetes care that is inappropriate to the need of socially disadvantaged groups.

Keywords: Type 2 diabetes – Glycaemic Control – Social inequalities.

An inverse association of socioeconomic status (SES) with the prevalence of diabetes (type 2) as well as with morbidity and mortality in diabetic persons has been demonstrated in a variety of countries (Chaturvedi et al. 1998; Connolly et al. 2000; Robbins et al. 2001; Roper et al. 2001). In particular, cardiovascular disease and many of its risk factors, mortality from all causes, cardiovascular and ischaemic heart disease are more prevalent in diabetic persons of lower versus higher SES (Kelly et al. 1993; Unwin et al. 1996; Chaturvedi et al. 1998; Roper et al. 2001). The same has been shown for the prevalence of microvascular diabetes complications, especially nephropathy and retinopathy (Charurvedi et al. 1996; Chaturvedi et al. 1998; West et al. 2002).

Despite clear evidence of the central importance of good glycaemic control for the prevention of macro- and microvascular complications in diabetes (American Diabetes Association 2002), few studies on social inequalities in diabetes have reflected the crucial role of glycaemic control. In these former investigations, HbA1c tends to be one of many examined variables, the statistical approach does not control for confounders, and findings are hidden amongst others and inconsistent between studies.

Most British studies on type 1 and/or type 2 diabetes published in the 1990s find no evidence of a link between HbA1c levels and individual or area-based SES indicators (Connolly et al. 1993; Pringle et al. 1993; Connolly & Kesson 1996; Baumer et al. 1998; Chaturvedi et al. 1998). Some report an inverse association for the subgroup of type 2 diabetic patients on insulin (Kelly et al. 1994; Unwin et al. 1996). With few exceptions (Baumer et al. 1998; Chaturvedi et al. 1998), however, all of these investigations are limited by their use of unadjusted mean or median HbA1c levels for their comparisons across social groups.

In contrast to the British findings, research elsewhere in Europe and the USA demonstrates an inverse association between HbA1c levels and SES indicators (Chaturvedi et al. 1996; Hjelm et al. 1996; Overstreet et al. 1997; Mühlhauser et al. 1998; Saaddine et al. 2002). Nearly all of these studies (Chaturvedi et al. 1996; Hjelm et al. 1996; Mühlhauser et al. 1998; Saaddine et al. 2002) base their analyses on regression models and adjust as a minimum for age, sex and diabetes du-

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ration. Two, more recent, UK studies, which in contrast to the previous British work, follow a more sophisticated analytical approach, also report a socioeconomic gradient in glycaemic control and agree with the findings elsewhere (Bachmann et al. 2003; Edwards et al. 2003).

Few German studies have investigated SES inequalities regarding diabetes. The findings so far indicate inverse social gradients in the prevalence of type 2 diabetes (Helmert & Shea 1994; Mielck 2000; Rathmann et al. 2005), some aspects of diabetes care, and for some health (care) outcomes in type 1 diabetes (Mühlhauser et al. 1998; Icks et al. 2003). Up to now there has been no systematic assessment of an association of SES with health (care) outcomes in type 2 diabetes in Germany.

The aim of this study was, to investigate for the first time the existence of a socioeconomic gradient in health (care) outcomes in persons with type 2 diabetes in Germany, with a particular focus on HbA1c levels. Beyond that we hoped to make a valid contribution to the still muddled picture in this area on an international level.

Patients and methods

Design and participants

Our analyses refer to all persons with type 2 diabetes (n = 373) examined in the 1997/98 KORA-A study (Co-operative Health Research in the Region of Augsburg) "Medical and non-medical outcomes of type 2 diabetes" in the region of Augsburg/Germany which comprises the city of Augsburg and two surrounding counties. The KORA-A study builds on two previous WHO MONICA surveys and the MONICA myocardial infarct (MI) register in the same study region. The two independent MONICA surveys from 1989/90 and 1994/95, respectively, were conducted on age-sex stratified random samples drawn from residents age 25–74 years (about 5000 persons per survey) (Filipiak et al. 1997). The population-based MI register covers all hospital cases with MI in the study region since 1984. In 1997/98 all persons with self-reported physician-diagnosed diabetes who had been identified by either the MONICA surveys or the MI register, and were still alive and living in the study region were contacted for the KORA-A study.

From the MONICA surveys, 413 diabetic patients were identified, 363 (87.9%) of whom were still living in the study region. Of those, 20 were not contactable, 82 refused and 37 were unable to participate, leaving 224 diabetic persons who could be included in the KORA-A study (response rate 61.7%). From the MI register, 463 diabetic subjects were identified with 384 (82.9%) still living in the study region. Of those, 16 were not contactable, 73 refused and 21 were unable to participate, leaving 274 diabetic persons who could be included in the KORA-A study (response rate 71.4%) and making a combined total of 498 diabetic participants from both sources. In all of the 498 KORA-A participants presence of diabetes was ascertained via repeated self-report of physician-diagnosed diabetes and validated by measurement of HbA1c. We restricted our analysis to those 373 persons who had confirmed their type of diabetes as type 2 (197 from the MONICA MI register and 176 from the previous MONICA surveys).

The KORA-A study was granted full ethical approval by the ethics commission of the Bavarian Medical Association in February 1997. Between March 1997 and July 1998, all KORA-A survey participants underwent a personal interview and extensive physical and laboratory examination and completed a questionnaire.

Measurements and assessed outcomes

Full details of the study protocol, survey instruments and measurements are described elsewhere (Mielck et al. 1999; Rathmann et al. 2002; Mielck et al. 2006). Non-fasting venous samples were drawn from the sitting participant with minimal tourniquet use and analysed by one laboratory the same day or the following work day. Total cholesterol analyses were done on the autoanalyzer Hitachi 917 using the CHOD-PAP method (Boehringer Mannheim, Germany); HDL cholesterol was measured enzymatically after precipitation of the apoprotein B-containing lipoproteins with phosphotungstate/Mg2+ (Boehringer Mannheim, Germany). LDL cholesterol was determined by precipitation method based on dextran sulfate (Quantolip, Immuno). Glycosylated hemoglobin (HbA1c) was measured quantitatively with an immunologic test kit (Tina-quant, Boehringer Mannheim, Germany). Albumin was assessed quantitatively in spot urine samples with an immunoturbidimetric test (Tina-quant, Boehringer Mannheim, Germany) and creatinine was measured quantitatively with an enzymatic colorimetric test (Hitachi 717, Boehringer Mannheim, Germany). Internal and external quality controls were carried out. Systolic and diastolic blood pressure were measured in sitting subjects with the Hawksley random zero sphygmomanometer three times under standardised conditions in accordance with the MONICA manual. All blood pressure values are based on the first and fifth phase of the Korotkoff sounds and on the calculation of the mean of the second and third blood pressure measurements.

Details of variables related to participants' diabetes and socioeconomic position were collected at the interview. Education was classified based on the highest level obtained into lower (less than secondary school) and higher. Occupational status

Table 1 Categorisation of the outcome measures

Outcome	Target level/classification
HbA1c, DCCT standardised[a]	<6.5 %
Serum total cholesterol[a]	<5.2 mmol/l
Serum HDL cholesterol[a]	men: >1.1 mmol/l; women: >1.4 mmol/l
Serum LDL cholesterol	<3.0 mmol/l
Blood pressure[a]	≤140/90 mmHg
Urinary albumin-creatinine ratio	<30 mg/g
Neuropathy	"present" versus "absent" according to score in study protocol[24]
Diabetic Retinopathy	"present" versus "absent" based on self-report of physician-diagnosed diabetic retinopathy
Myocardial infarct (MI) (analysed in MONICA survey sourced participants only)	"present" versus "absent" based on self-report of physician-diagnosed MI
Stroke	"present" versus "absent" based on self-report of physician-diagnosed stroke
Pain in legs at rest (as indicator of peripheral vascular disease)	"present" versus "absent" based on self-report
Smoking	"current" (regular and occasional smoking) versus "non-smoker" (never and ex-smokers)
Physical activity	"low" (less than one hour of physical activity per week in summer and winter) versus "high"
Obesity	"present" (BMI ≥30 kg/m^2) versus "absent"

[a] target level derived from European NIDDM Policy Group 1994 guidance (Alberti et al. 1994)

was grouped into three categories (Helmert & Shea 1994). For unemployed persons the occupation of the spouse, and for retired persons their latest occupation was used. Finally, using a composite index of socioeconomic position based on education, occupation and equivalent household income (Helmert & Shea 1994), three SES categories, representing tertiles of the total study population, were formed and assigned to the participants.

The investigated outcome measures were categorised as shown in Tab. 1. Where applicable we used the treatment targets for type 2 diabetes proposed by the European NIDDM Policy Group in 1994 (Alberti et al. 1994), which were endorsed in Germany at the time of the study.

Statistical analysis

The outcomes under investigation were analysed as binary response variables using logistic regression models. As exposure variables, education, occupational status and SES were examined. Associations were adjusted for age, sex, diabetes duration and for the outcomes MI, stroke and pain in legs at rest, also for smoking status. For HbA1c we repeated the analyses adding physical activity, obesity and diabetes medication into the models, using different cut off levels (HbA1c <7.0 % and <7.5 %, as suggested by the American Diabetes Association, 2003, and the UK National Institute for Clinical Excellence, 2002, respectively) and analysing HbA1c as a continuous outcome variable. The analyses were all carried out separately for the MI register and survey subgroup.

Based on these regression models, odds ratios, adjusted prevalences and corresponding 95 % confidence intervals were derived. A test for linear trend was based on the corresponding contrast. Statistical significance was accepted for $p < 0.05$ unless stated otherwise. All statistical analyses were performed using the SAS®/STAT software (*SAS Institute: SAS/STAT User's Guide, Version 8, Cary NC, 1999*).

Results

Table 2 gives an overview of the demographic, treatment and health related variables in the study population. There are no significant differences between the MI register and survey subgroups regarding age, socioeconomic variables, diabetes duration and medication. Neither in the MI register nor in the survey subgroup there was a significant difference in the distribution of diabetes medication over the different socioeconomic groups (Chi-square test, data not shown). Striking is the relatively high mean age in both subgroups (68 years) and the smaller percentage of women than men, particularly in the predominantly male MI register subgroup. Remarkable is also the relatively low percentage of current smokers (8.9 % for both subgroups), which can be explained at least in part by the relatively high age of the study group. For most outcomes

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Table 2 Distribution of demographic and health related variables (unadjusted)

	Persons with Type 2 Diabetes (n = 373)		
	MI register n = 197	Surveys n = 176	Total n = 373
Mean age (years)	69.0	67.1	68.1
Sex (% female)	20.8	44.3	31.9
Mean diabetes duration (years)	13.4	13.7	13.5
Diabetes medication (%)			
Diet only	13.8	12.9	13.4
Tablets ± diet	53.2	50.3	51.8
Insulin ± tablets/diet	33.0	36.8	34.8
SES (%)			
Lower	34.2	37.7	35.9
Middle	26.9	35.4	31.0
Upper	38.9	26.9	33.2
Education (%)			
Lower	70.6	80.0	75.0
Higher	29.4	20.0	25.0
Occupational status (%)			
Lower	14.9	13.6	14.3
Medium	63.1	71.0	66.9
Upper	22.0	15.3	18.9
Low physical activity (%)	72.1	78.9	75.3
Obesity (%)	36.3	48.3	42.1
Current smokers (%)	7.6	10.3	8.9
HbA1c target not achieved (%)	47.7	62.5	54.7
BP target not achieved (%)	47.2	63.1	54.7
Total cholesterol target not achieved (%)	68.0	71.6	69.7
HDL cholesterol target not achieved (%)	48.5	45.5	47.0
LDL cholesterol target not achieved (%)	59.7	76.6	67.7
Microalbuminuria[a] (%)	47.7	47.4	47.6
Neuropathy (%)	25.6	14.9	20.5
Diabetic Retinopathy	16.1	24.8	20.2
MI (%)	–	9.7	–
Stroke	12.2	8.6	10.5
Pain in legs at rest	26.9	24.0	25.5

[a] Urinary albumin-creatinine ratio ≥30 mg/g

(life style as well as clinical parameters) the majority of participants does not achieve the treatment targets recommended at the time of study with the survey subgroup tending to fare slightly worse than the MI register subgroup. These differences, however, reach statistical significance only for the outcomes HbA1c, BP and LDL cholesterol target (Chi-square test, $p < 0.05$).

Table 3 shows for all three social indicators the age-, sex- and diabetes duration-adjusted prevalence of persons with type 2 diabetes failing to achieve the recommended HbA1c target of less than 6.5 %, and the adjusted odds ratios when compared to the respective upper social group. Clear social gradients emerge for all diabetic persons irrespective of their source, although they are more pronounced in the MI register subgroup. Belonging to a lower socioeconomic group is linearly associated with a higher likelihood of failing the recommended HbA1c target. This inverse social gradient persists across all socioeconomic indicators with little change in the magnitude of the association when additionally adjusting for obesity, physical activity and type of diabetes medication. Increasing the HbA1c cut off level from 6.5 % to 7.0 % or analysing HbA1c as a continuous outcome variable did also not change the character of the association, whereas the association becomes less clear for a HbA1c cut off level of 7.5 % (data not shown).

Regarding the other assessed outcomes a much less striking picture emerged as Tab. 4 exemplifies. Physical activity

Table 3 Failure to achieve the recommended HbA1c target (HbA1c <6.5 %)

	Persons with Type 2 Diabetes (n = 373) MI register (n = 197)		Surveys (n = 176)	
	OR[a] (95 % CI	Prevalence %[b] (95 % CI)	OR[a] (95 % CI)	Prevalence %[b] (95 % CI)
SES				
Upper	1.00	40.2 (27.9–53.9)	1.00	58.3 (43.4–71.9)
Middle	1.38 (0.66–2.91)	48.2 (33.5–63.2)	0.96 (0.43–2.14)	57.4 (44.4–69.4)
Lower	2.49** (1.22–5.07)	62.6 (49.3–74.2)	1.80 (0.80–4.06)	71.6 (59.4–81.3)
Education				
Higher	1.00	41.2 (27.9–56.0)	1.00	60.9 (43.6–75.9)
Lower	1.80* (0.95–3.43)	55.8 (45.8–65.4)	1.13 (0.51–2.47)	63.7 (55.3–71.4)
Occupational status				
Upper	1.00	39.2 (24.0–56.8)	1.00	58.3 (39.1–75.2)
Medium	1.75 (0.83–3.68)	52.9 (42.5–63.2)	1.14 (0.48–2.69)	61.3 (52.3–69.7)
Lower	2.40* (0.88–6.60)	60.8 (41.1–77.5)	2.71 (0.77–9.52)	79.1 (58.4–91.1)

[a] Odds ratio for failure to achieve the recommended HbA1c target (reference group: respective upper status group; adjusted for age, sex and diabetes duration)
[b] Prevalence of failure to achieve the recommended HbA1c target (adjusted for age, sex and diabetes duration)
** significant at 0.05 significance level;
* significant at 0.10 significance level

showed a statistically significant inverse association to all analysed socioeconomic indicators in the survey subgroup. The prevalence of diabetic retinopathy showed a statistically significant inverse association to socioeconomic status in the MI register subgroup only. Concerning the targets for blood pressure, total, HDL and LDL cholesterol, and the prevalence of obesity, smoking, microalbuminuria, neuropathy, MI, stroke and pain in legs at rest no statistically significant socioeconomic differences were found in either the MI register or the survey subgroup.

Analysing the health outcomes as continuous instead of binary variables did not alter this picture. However, further analyses with additional stratification by sex indicated an inverse social gradient for the achievement of total cholesterol and blood pressure targets in women of the survey subgroup. Due to small numbers, however, these sex differences need to be interpreted with great caution.

Discussion

This study shows an inverse association of glycaemic control, as indicated by HbA1c levels, with socioeconomic position in type 2 diabetes. This association could not be accounted for by differences in age, sex, diabetes duration, obesity, physical activity or diabetes medication and was consistent, albeit not statistically significant, across all investigated indicators of socioeconomic status. Overall, our findings indicate that Germany may well need to be added to the list of countries with evidenced social inequalities in a major outcome of care in persons with type 2 diabetes. Although the cross-sectional study design of the study does not allow conclusions on the causality of the described association, one potential explanation could be that in comparison to the better off, socioeconomically disadvantaged persons with type 2 diabetes receive a level of diabetes care that is inappropriate to their need. Due to the cross-sectional data reverse causality, i.e. the possibility that diabetes or its complications may have led to a worse socioeconomic position, should also to be considered as an explanation. Two arguments can, however, be raised against that: firstly, the absence of an inverse association of most of the investigated long term diabetes outcomes (MI, neuropathy, stroke and peripheral vascular disease as indicated by pain in the legs at rest) with socioeconomic indicators; and secondly, the inverse association of HbA1c with all applied

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Table 4 Association with socioeconomic indicators for selected outcomes

		Persons with Type 2 Diabetes (n=373) MI register (n = 197) OR[a]	95 % CI	Surveys (n = 176) OR[a]	95 % CI
Low physical activity	SES	1.32	0.54–3.24	3.43**	1.23–9.55
	Education	1.05	0.49–2.22	2.98**	1.28–6.97
	Occ. Status[b]	2.21	0.64–7.64	6.65**	1.26–35.25
Micro-albuminuria present	SES	1.06	0.52–2.14	1.81	0.83–3.95
	Education	0.65	0.34–1.24	1.59	0.73–3.44
	Occ. Status[b]	1.05	0.39–2.83	2.09	0.68–6.45
Neuropathy present	SES	1.41	0.38–5.22	2.03	0.38–11.01
	Education	0.74	0.25–2.21	1.06	0.26–4.42
	Occ. Status[b]	2.52	0.40–15.84	1.93	0.15–24.90
Diabetic Retinopathy present	SES	3.43**	1.24–9.50	1.80	0.66–4.95
	Education	1.39	0.53–3.69	2.36	0.77–7.17
	Occ. Status[b]	4.11	0.99–17.07	1.67	0.36–7.82
MI present	SES	–	–	0.50	0.13–1.97
	Education	–	–	0.88	0.26–3.03
	Occ. Status[b]	–	–	0.87	0.13–5.92
Stroke present	SES	0.98	0.31–3.12	1.22	0.32–4.59
	Education	1.27	0.46–3.51	1.71	0.36–8.13
	Occ. Status[b]	0.90	0.12–6.50	1.16	0.15–9.10
Pain in legs at rest present	SES	0.71	0.32–1.61	2.46	0.91–6.61
	Education	1.09	0.53–2.25	2.79	0.91–8.57
	Occ. Status[b]	1.67	0.56–4.97	1.16	0.21–6.43

[a] Odds ratio for lowest versus highest status group; adjusted for age, sex and diabetes duration (and smoking for MI, stroke and pain in legs as outcome)

[b] Occupational status

** significant at 0.05 significance level

socioeconomic indicators, including educational level which cannot be altered by disease in later life. Interestingly enough, another set of analyses on the same group of diabetic patients showed the prevalence of "pain in the legs on walking" to be inversely associated with educational level (Mielck et al. 2005). This demonstrates that inequalities do occur at least in some long term health outcomes in this group of persons. However, they are associated with inequalities in educational level, which cannot be affected by these health conditions in later life, making reverse causality unlikely. Although it can be assumed that reverse causality is not the cause for the demonstrated social inequalities in HbA1c levels in our study population, our results cannot further elucidate as to why these inequalities may have arisen. As our analyses show, there does not appear to be an association between type of diabetes medication and socioeconomic status or type of diabetes medication and achieved HbA1c level. Adding the available data on diabetes medication into the model did not alter the strength or direction of the association of socioeconomic status and HbA1c level. However, there is much more to diabetes care than the prescription of medication; other therapy related issues such as compliance should also be considered in future studies. Another study on the same group of diabetic patients has demonstrated a social gradient in the knowledge on diabetes and the participation in diabetes training courses (Mielck et al. 2006). These aspects could belong to the potential set of factors that mediate the association of social status and treatment outcomes such as HbA1c levels.

Our findings also lend support to our assumption that the internationally inconsistent picture with regard to social inequalities in glycaemic control may rather be due to limited analytical methods – in particular a lack of controlling for confounding – of the studies that fail to report such an association than to a true absence of a link.

The strengths of our work lie in the use of a well-tested infrastructure for data collection and validation going back to the first WHO MONICA surveys in the mid-eighties, and in our comprehensive analytical approach, which included the use of several distinct social indicators and adjustment for relevant confounders. A drawback of the study is the sampling of participants from two sources: the population-representative MONICA surveys and the highly selected group on the MI register. This necessitated a separate analysis of the two groups leading to subgroups with smaller numbers and thereby reducing the statistical power of the study. Whilst this compromises the statistical significance of the found inverse association of SES indicators with glycaemic control it does, however, not impinge on the character of the association.

In our further analyses we found little evidence of social inequalities in our study population: only physical activity

convincingly showed a significant inverse association with social position in type 2 diabetic persons. Population-based surveys in Germany confirm this link for the general population (Helmert & Shea 1994; Mielck 2000), but they have also repeatedly demonstrated inverse social associations for smoking and obesity, which we failed to do. Regarding hypertension and dyslipidaemia there was no unequivocally recognisable social trend in our data, nor do the aforementioned German population surveys present a consistent picture for these outcomes. Another seeming discrepancy lies in the finding of a statistically significant association of social status variables with HbA1c in the MI register subgroup but not the survey subgroup and vice versa of a statistically significant association of social status variables with physical activity for the survey, but not for the MI register subgroup. The main difference in the two subgroups lies in the very uneven sex distribution with a strong male predominance in the MI register subgroup compared to the survey subgroup – this may play a role in this issue.

Beyond the problem of small numbers and a limited statistical power, the high average age of the study participants may have contributed to the absence of social inequalities in our findings, in particular concerning smoking and obesity. Most German surveys on social inequalities focus on younger age groups. The available evidence from other industrialised countries suggests that health inequalities decrease in the elderly (Huisman et al. 2003; Knesebeck et al. 2003). This potential levelling off of inequalities in older age, however, makes our findings of significantly worse glycaemic control in socioeconomically disadvantaged groups at that age ever more outstanding.

What, however, is the significance of inequalities in HbA1c levels, given our inability to demonstrate inequalities in long-term diabetes outcomes in our study group? Firstly, for the reasons given above, absence of evidence of inequalities in our study does not imply evidence of absence. Further work with larger samples and a particular focus on the age dependency of inequalities in intermediary and long-term diabetes outcomes is needed. Secondly, although glycaemic control is of high importance, it is not the only factor affecting the incidence of long-term diabetes complications. Several studies on type 1 diabetes failed to explain social differentials in diabetes complications through social gradients in HbA1c levels alone (Chaturvedi et al. 1996; Mühlhauser et al. 1998).

The most immediate conclusion of our findings is therefore, that in today's Germany, which prides itself of an allegedly equitable health care system, socioeconomically disadvantaged persons with type 2 diabetes achieve worse outcomes in a central aspect of diabetes care in comparison to their better off counterparts. This should give German health policy makers plenty of food for thought – particularly at a time when the German government has pledged to dramatically improve diabetes care. Regarding the international picture, our findings support those studies from elsewhere, which show clear socioeconomic inequalities in glycaemic control in type 2 diabetes.

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