

1 **Maternal characteristics associated with the obesogenic quality of the home environment**
2 **in early childhood**

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16 **Abbreviations**

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18 DEBQ = Dutch Eating Behaviour Questionnaire

19 HEI = Home Environment Interview

20 SES = socioeconomic status

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34 **Abstract**

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36 The home environment is likely to influence children's diet and activity patterns and
37 ultimately, their weight trajectories. Identifying family characteristics associated with a
38 more 'obesogenic' home can provide insight into the determinants, and has implications for
39 targeting and tailoring strategies to promote healthier lifestyles. The present study
40 examined maternal characteristics associated with a more obesogenic home environment in
41 1113 families with preschool children. Primary caregivers (99% mothers) from the Gemini
42 cohort completed the Home Environment Interview (HEI) when their children were 4 years
43 old. Maternal demographics and BMI were assessed in the Gemini baseline questionnaire
44 when the children were on average 8 months old. Maternal eating style was assessed when
45 the children were on average 2 years old, using the Dutch Eating Behaviour Questionnaire
46 (DEBQ). Responses to the HEI were standardized and summed to create a composite score
47 of the obesogenic quality of the home; this was categorized into tertiles. Multivariate
48 ordinal logistic regression showed that mothers who were younger (adjusted OR; 95%
49 CI=0.96; 0.94–0.98), less educated (1.97; 1.40–2.77), and had lower incomes (1.89; 1.43–
50 2.49) at baseline were more likely to live in an obesogenic home environment at 4 years, as
51 were mothers who scored higher on the DEBQ External Eating scale (1.40; 1.16–1.70) at 2
52 years, and had a higher baseline BMI (1.05; 1.02–1.08). Using a novel, composite measure
53 of the home environment, this study finds that families who are more socio-economically
54 deprived, and where the mothers are themselves heavier and have a more food responsive
55 eating style, tend to provide a home environment with the hallmarks of a higher risk of
56 weight gain.

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58 **Keywords:** home environment, obesity, childhood, parents

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68 Introduction

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70 Overweight and obesity are notoriously difficult to treat^{1,2}, and therefore identifying
71 opportunities for early prevention is vital. The home environment is thought to be a key
72 influence on childhood weight trajectories³⁻⁵. Parents create the child's home environment,
73 and are often involved in weight management interventions^{5,6}. Knowledge of parental
74 characteristics that are associated with a more 'obesogenic' home environment may
75 therefore help to understand the origins of the environmental effects and to target or tailor
76 obesity prevention strategies.

77

78 The concept of an 'obesogenic' home environment incorporates influences from three
79 domains: food, physical activity, and media^{7,8}. This includes availability and accessibility of
80 healthy and unhealthy foods, opportunities for physical activity, and availability of screen-
81 based media, as well as social aspects such as modelling of eating and physical activity
82 behaviours.

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84 Several parental demographic characteristics have been associated with individual aspects
85 of the home environment. Less educated parents are more likely to have energy-dense
86 foods at home⁹, have a TV in their child's bedroom¹⁰, use inappropriate feeding practices
87 such as permissiveness¹¹, and are less likely to model physical activity behaviour¹². Family
88 income is also potentially relevant^{13,14}; although whether education and income contribute
89 independently has not been studied. Maternal age has also been identified as relevant to
90 parenting; with older mothers being able to draw on more established cognitive and
91 emotional skills to create a supportive home environment¹⁵. In the context of risk for
92 weight gain in early childhood, younger mothers tend to breastfeed for less time¹⁶ and
93 introduce solid foods earlier¹⁷, including foods that are not recommended for young
94 children^{18,19}. These factors could be markers of a risky profile for a more obesogenic food
95 environment as the children get older.

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97 Other parental characteristics have been implicated in the quality of the home environment;
98 though not in relation to obesity. Mothers living with a partner and with fewer children are
99 more likely to provide environments that are supportive of their child's cognitive, emotional,
100 and social development^{20,21}. Smaller family size has also been associated with lower levels of

101 disorganisation within the home²². It is possible that these characteristics extend to aspects
102 of the food and activity environment.

103

104 Obese parents are more likely to have obese children²³, although part of the explanation for
105 familial resemblance is genetic²⁴. However, parents whose eating and activity behaviours
106 are characteristic of the obese population may also create a home environment that
107 supports habits of overeating and being under-active. In line with this, parental energy-
108 balance knowledge, and investment in weight-related issues, have been associated with
109 having more fruit and vegetables in the home^{25,26}, using more restrictive feeding practices²⁷,
110 and limiting access to media equipment²⁵. No previous studies have directly examined the
111 association between parental appetitive traits, in the form of external and emotional
112 eating²⁸, and the obesogenic quality of the home environment.

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114 To date, there have been no large-scale studies examining predictors of the home
115 environment in early childhood, which is likely to be an important period for long-term
116 overweight and obesity prevention²⁹. Furthermore, none of the studies described above
117 used a comprehensive indicator of the obesogenic home environment (incorporating food,
118 activity, and media-related influences), although this should capture the overall level of risk
119 for weight gain more effectively than any one aspect of the home environment; and most
120 focused on a limited range of potential predictor variables. Recent findings from 1096
121 families participating in the Gemini birth cohort highlight the relevance of the obesogenic
122 quality of the home environment in early weight trajectories, and the importance of obesity
123 prevention strategies³⁰. Preschool children living in more 'obesogenic' home environments
124 had poorer diets (less fruit and vegetable consumption, and more energy-dense snack and
125 sweetened drink consumption), lower levels of physical activity, and watched more TV than
126 children living in lower-risk home environments³⁰.

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128 Little is known about potential parental characteristics that may affect/substantiate the
129 home environment. The aim of the present study was therefore to examine whether
130 maternal demographic characteristics and weight-related traits are associated with the
131 obesogenic quality of the home environment in early childhood.

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135 **Method**

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137 *Sample*

138 Data were from families taking part in the Gemini UK twin birth cohort (described in detail
139 elsewhere³¹), who had completed the home environment interview when the children were
140 aged 4 years (n = 1113). Because information was provided for both twins at the time of the
141 interview (n = 2226), one twin was selected at random to avoid clustering effects.

142

143 *The home environment*

144 The Home Environment Interview (HEI) is a comprehensive measure of the food, activity,
145 and media environment, developed for the study (and available on request), which was
146 administered as a telephone interview with the primary caregiver (mothers in 99% of cases)
147 when the children were 4 years old. The HEI was based on the Healthy Home Survey³²,
148 which was the most comprehensive measure available at the time, had been
149 psychometrically tested, and had been used with families with young children.

150 A composite score was created based on feedback from an international panel of 30 experts
151 in pediatric obesity (see **Table 1**). Constructs identified as being associated with lower risk of
152 weight gain were reverse-scored so that a higher composite score would reflect higher
153 obesogenic risk. Each variable was standardized using z-scores and they were summed.
154 Missing values were recoded to 0 (the mean value for each standardized variable). There
155 were few missing cases on home environment variables (15 for garden play equipment; 39
156 for emotional feeding, instrumental feeding, encouragement, and modelling of healthy
157 eating; 40 for monitoring and covert restriction; 42 for restriction; 73 for partner TV
158 viewing). Test-retest reliability over 7-19 days (mean = 9.6 days, SD = 3.4) of the home
159 environment composite was high (ICC = 0.92; 95% CI = 0.86 – 0.96). Previously-reported
160 associations between the home environment composite and child diet, physical activity, and
161 TV viewing at 4 years were as expected; although associations with BMI were not apparent
162 at this age³⁰.

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170 **Table 1:** Constructs included in the home environment composite score
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Food-related constructs
<i>Availability</i>
Number of fruit types ¹
Number of vegetable types ¹
Number of energy-dense snack types
Presence of sugar-sweetened drinks
<i>Accessibility (visibility)</i>
Fruit on display ¹
Vegetables ready-to-eat ¹
Energy-dense snacks on display
Sugar-sweetened drinks on display
<i>Accessibility (child can help him/herself)</i>
Fruit ¹
Vegetables ¹
Energy-dense snacks
Sugar-sweetened drinks
<i>Parental feeding practices</i>
Emotional feeding
Instrumental feeding
Encouragement ¹
Modelling ¹
Monitoring ¹
Covert restriction ¹
Restriction ¹
Family meal frequency
Frequency child eats while watching TV
Physical activity-related constructs
Garden/outdoor space ¹
Garden play equipment ¹
Allowed to play indoors ¹
Allowed to play outdoors ¹
Parental modelling of physical activity ¹
Parental support of physical activity ¹
Media-related constructs
Number of media equipment
TV in the child's bedroom
Household rules around media use ¹
Maternal TV viewing
Partner TV viewing

¹ Variable was identified as being associated with decreased risk for weight gain.

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177 *Maternal characteristics*

178 The measured characteristics fell into two main categories: (i) maternal demographics and
179 living circumstances (age, education, household income, number of other children living in
180 the home, marital status); and (ii) maternal weight-related traits (BMI, eating style).

181

182 Maternal demographics were assessed in the Gemini baseline questionnaire (when the
183 children were on average 8 months old), but information on the number of other children in
184 the home and marital status was updated at the time of the HEI. Maternal BMI was
185 calculated from self-reported weight and height at baseline. Eating style was assessed when
186 the children were on average 2 years old, using the Dutch Eating Behaviour Questionnaire
187 (DEBQ)²⁸. The three subscales measure restraint (e.g. 'how often do you refuse food or
188 drink because you are concerned about your weight?'), emotional eating (e.g. 'do you have a
189 desire to eat when you are feeling lonely?'), and external eating (e.g. 'if food smells and
190 looks good, do you eat more than usual?'). There are five items per subscale, each scored
191 on a 5-point scale (1 = never; 5 = very often). A mean score was calculated for each
192 subscale, with higher scores indicating higher levels of the particular eating trait. Internal
193 consistency (using Cronbach's alpha) for each scale was high in the study sample (all alpha's
194 > 0.80).

195

196 *Statistical analyses*

197 There were some missing data among the predictors (2 for maternal age; 17 for maternal
198 BMI; 34 for income; 143 for DEBQ restraint and DEBQ emotional eating; 144 for DEBQ
199 external eating); these were assigned the mean score. This approach is said to provide a
200 more accurate estimate of association than other methods of handling missing data³³.
201 However we also did a sensitivity analysis including only families with complete data (n =
202 925) and the results were the same.

203

204 For ease of interpretation, the home environment composite was categorised into tertiles,
205 creating lower-, medium-, and higher-'risk' environment groups. Education level was
206 categorised as high (university-level education), intermediate (vocational or advanced high-
207 school education), or low (no qualifications or basic high-school education). Household
208 gross annual income was categorised as lower (\leq £30,000) or higher ($>$ £30,000) as this
209 categorisation was close to the UK average for 2008 (the baseline assessment period)³⁴.

210 Marital status was categorised as married or cohabiting, or single. The number of other

211 children in the home was treated as a continuous variable. Maternal ethnicity was not
212 included in the analyses as just 5% of mothers in the sample were from ethnic minority
213 backgrounds with many ethnic sub-groups, which would make it difficult to draw meaningful
214 conclusions.

215

216 Univariate and multivariate ordinal logistic regression analyses were used to examine
217 associations between maternal characteristics and the obesogenic home environment. For
218 the multivariate analyses, maternal demographics were entered simultaneously into a
219 model (also adjusting for maternal BMI) to see which were independently associated with
220 the home environment; as research has shown that these characteristics are interrelated.
221 Maternal eating style scales were entered into separate multivariate models for ease of
222 interpretation as they are conceptually interrelated. Each model adjusted for core
223 demographic characteristics (maternal age, education, and income) plus maternal BMI.

224

225 Multicollinearity and the proportional odds assumption³⁵ were tested by examining
226 correlations between the predictor variables and using the SPSS Test of Parallel Lines,
227 respectively. Statistical analyses were conducted using SPSS version 18.0. A p value of < 0.05
228 was considered statistically significant.

229

230 **Results**

231

232 *Sample characteristics*

233 Characteristics of the study sample are shown in **Table 2**. At baseline, mothers were on
234 average 34 years old, 48% had university-level education, and three-quarters (74%) were
235 living in homes with an average annual income of at least £30,000. At 4 years, half the
236 families (47%) had no children other than the twins, 38% had one other child, 10% had two
237 other children, and 4% had three or more; 93% of mothers were married or cohabiting.
238 Mean maternal BMI at baseline was 24.8 kg/m². Average scores for maternal restraint,
239 emotional eating, and external eating at 2 years were close to the mid-points of the DEBQ
240 scales; comparable to other population-based samples³⁶.

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245 **Table 2.** Descriptive characteristics for the study sample (% (n), unless stated otherwise)
 246

N = 1113	
Maternal demographics and living circumstances	
Age in years, mean (SD)	33.86 (4.74)
Education level	
Low	15.5 (173)
Intermediate	36.2 (403)
High	48.2 (537)
Household annual income	
< £30,000	26.4 (294)
≥ £30,000	73.6 (819)
Marital status	
Married or cohabiting	93.2 (1037)
Single	6.8 (76)
No. of other children living in the home, mean (SD)	0.53 (0.50)
Maternal weight-related traits, mean (SD)	
BMI	24.84 (4.54)
DEBQ ¹ restraint	2.71 (0.89)
DEBQ emotional eating	2.13 (0.89)
DEBQ external eating	3.10 (0.60)

247 BMI = body mass index; DEBQ = Dutch Eating Behaviour Questionnaire. Education level categorised
 248 as: low (no qualifications or basic high-school education, intermediate (vocational or advanced high-
 249 school education), and high (university-level education). ¹ Possible range = 1 – 5. Maternal
 250 demographics and BMI assessed when twins were 8 months old, living circumstances when twins
 251 were 4 years old, and weight-related traits when twins were 2 years old.
 252

253 *Characteristics associated with living in a higher-risk home environment*

254 Results of the regression analyses are shown in **Table 3**. At the univariate level, younger
 255 age, lower education, and lower household annual income at baseline were associated with
 256 living in a higher-risk home environment at 4 years (p 's < 0.001). The number of other
 257 children living in the home at 4 years was also associated with living in a higher-risk home
 258 environment (p = 0.02), but there was no association with marital status. Of the maternal
 259 weight-related traits, higher baseline BMI, and higher emotional and external eating at 2
 260 years were associated with living in a higher-risk home environment at 4 years (p 's ≤ 0.002).
 261 Maternal restraint was not associated with the quality of the home environment.

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267 Multivariate analyses confirmed that all the maternal demographic characteristics (at
268 baseline), except for the number of other children (at 4 years), were independently
269 associated with a higher-risk home environment at 4 years ($p's \leq 0.001$). Maternal baseline
270 BMI and external eating at 2 years, but not emotional eating or restraint, were also
271 independently associated with living in a higher-risk home environment at 4 years ($p's \leq$
272 0.001).

273 **Table 3.** Maternal characteristics associated with living in a higher-risk home environment (N = 1113)

	Univariate results		Multivariate results	
	OR	95% CI (p value)	OR	95% CI (p value)
Demographics & living circumstances¹				
Age (years)	0.95	0.92 – 0.97 (<0.001)	0.96	0.94 – 0.98 (0.001)
Education level				
High	1	–	1	–
Intermediate	2.13	1.67 – 2.71 (<0.001)	1.72	1.34 – 2.21 (<0.001)
Low	2.63	1.91 – 3.63 (<0.001)	1.97	1.40 – 2.77 (<0.001)
Household annual income				
≥ £30,000	1	–	1	–
< £30,000	2.73	2.12 – 3.52 (<0.001)	1.89	1.43 – 2.49 (<0.001)
Marital status				
Married or cohabiting	1	–	1	–
Single	1.48	0.96 – 2.28 (0.074)	1.06	0.67 – 1.65 (0.815)
Number of other children	1.16	1.03 – 1.32 (0.017)	1.08	0.95 – 1.23 (0.235)
Weight-related traits²				
BMI (per unit increase)	1.07	1.04 – 1.10 (<0.001)	1.05	1.02 – 1.08 (<0.001)
DEBQ restraint	0.98	0.87 – 1.10 (0.696)	0.90	0.79 – 1.03 (0.118)
DEBQ emotional eating	1.21	1.08 – 1.37 (0.002)	1.11	0.98 – 1.27 (0.111)
DEBQ external eating	1.39	1.16 – 1.67 (<0.001)	1.40	1.16 – 1.70 (0.001)

274 OR = odds ratio; 95% CI = 95% confidence interval; 1 denotes the reference group; BMI = body mass index; DEBQ = Dutch Eating Behaviour Questionnaire. ¹ Variables
275 entered simultaneously into the multivariate model (along with maternal BMI). ² For each eating style, the multivariate model adjusted for core demographics (maternal
276 age, education level, and household income) and maternal BMI.

277 Discussion

278

279 This study confirmed that markers of lower socioeconomic status (SES) (measured at
280 baseline) were predictors of living in a more 'obesogenic' home environment in terms of
281 food, physical activity, and media-related influences at 4 years. In addition, maternal weight
282 (at baseline) and eating style (at 2 years) independently predicted a more obesogenic home
283 environment at 4 years.

284

285 Previous studies examining individual aspects of the home environment have reported
286 associations with indicators of lower SES⁹⁻¹²; the present study indicated that education and
287 income both contribute. Parents with fewer financial resources may not be able to afford a
288 wide variety of fruit and vegetables, which can cost more and have a higher wastage rate
289 than energy-dense, processed foods¹⁴. They may also have less access to activity facilities³⁷.
290 Less educated parents may lack the health-related knowledge^{38,39} to create a healthier home
291 environment. Another possible explanation is that lower SES families have additional life
292 stresses which demote health behaviours in terms of key day-to-day priorities⁴⁰.

293

294 Previous studies have found family structure (marital status, number of children) to be
295 independently associated with the quality of the home environment²⁰⁻²². However, these
296 studies were concerned with the learning environment in particular or the overall level of
297 organisation within the home rather than the energy-balance environment. In the context
298 of obesity, there has been some evidence that the presence of older children encourages
299 earlier introduction to non-recommended foods¹⁹. We did not find a direct effect of other
300 children in the home, but early feeding practices could be markers of a risky profile for a
301 more obesogenic environment as the children get older.

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303 There is some evidence that parents with more energy-balance knowledge and greater
304 investment in weight-related issues are more likely to have a home environment that
305 supports a balanced diet and physical activity²⁵⁻²⁷. We had expected that maternal dietary
306 restraint would be associated with a lower-risk home environment, in that more restrained
307 mothers would make more of a conscious effort to limit obesogenic exposures for the
308 children, but we did not see any evidence of this. We found that mothers who were
309 external eaters - a trait that may increase risk of weight gain, were more likely to live in
310 higher-risk home environments; and the association was independent of maternal BMI. This

311 finding suggests that young children who inherit 'high-risk' appetitive traits from their
312 parents are also more likely to grow up in a more obesogenic home environment, placing
313 them at greater risk of future overweight irrespective of their mother's actual weight status.
314 In our sample, maternal weight was also an independent predictor of the home
315 environment. Two previous studies had failed to find any such associations^{41,42}, but they
316 were smaller studies and did not use a composite home environment measure. To further
317 test the idea that obesity-prone mothers live in higher-risk home environments, it would be
318 useful to have an independent instrumental variable such as genetic risk score, as an
319 indicator of obesity risk.

320

321 The findings of this study provide some insight into potential mechanisms for the
322 development of overweight and obesity. As several of the characteristics in this study have
323 been identified as risk factors for child overweight and obesity, the obesogenic quality of the
324 home environment may be a mediating factor. For example, the consistent association
325 between maternal and child weight status^{43,44} is largely explained by genetic inheritance, but
326 heavier mothers may also expose their child to an obesogenic home environment. Heavier
327 mothers may create or seek out home environments that are in line with their obesogenic
328 tendencies, also known as active gene-environment correlation (*rGE*)⁴⁵.

329

330 *Limitations*

331 This is a study of associations, as are many of the previous studies, so it is not possible to
332 assume that predictors 'caused' the home environment. However, they are markers that
333 can be used to identify groups for whom guidance on creating a home environment that
334 facilitates healthy child development would be useful.

335

336 This study focused on maternal characteristics as mothers are generally the main caregivers
337 within the home environment. However, the home environment may be influenced by
338 other family members, including partners and children. Research indicates that parenting
339 practices are responsive to child characteristics including temperament^{46,47}, behaviour⁴⁸, and
340 weight status^{49,50}. Future research should further test the child-responsive model within the
341 context of the obesogenic home environment; collecting data from all children living in the
342 home.

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345 It must be acknowledged that the maternal characteristics were measured at different time
346 points prior to the HEI assessment. Whilst there is some evidence that weight-related traits
347 are relatively stable^{51,52}, 100% temporal stability cannot be assumed. The test-retest
348 reliability of the home environment composite was high, but the longitudinal stability is also
349 unknown. However, the associations in this study do concur with those reported in other
350 studies where aspects of the home environment and maternal characteristics were assessed
351 at the same time. Moreover, it is likely that any instability in the predictor variables and
352 home environment would lead to an underestimation of true associations. Nevertheless, to
353 fully understand the nature of the associations in this study, and consider reverse and
354 reciprocal causation, it would be important to assess the home environment and maternal
355 characteristics at each time point.

356

357 It would have been useful to examine other potentially relevant characteristics such as
358 parental health-consciousness and self-efficacy in creating a healthier home environment,
359 but these variables were not available. Maternal ethnicity has been associated with aspects
360 of the home environment^{53,54}, but this factor could not be examined as the study sample was
361 almost exclusively white.

362

363 As in previous studies in this field, the home environment and maternal characteristics were
364 assessed using parent report, which may be prone to bias. However, test-retest reliability of
365 the home environment composite was high and previous research has provided some
366 evidence for criterion validity³². The reliability and validity of the DEBQ^{28,55} has also been
367 demonstrated previously.

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369 Finally, although families with twins may differ in some respects from non-twin families, the
370 findings of this study are generally in line with those from non-twin samples, suggesting that
371 differences are not sufficient to modify the overall conclusions.

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379 **Conclusion**

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381 This study found that maternal demographic characteristics and weight-related traits were
382 independently associated with the obesogenic quality of the home environment in early
383 childhood. Although further research is needed to fully understand the nature of
384 associations, the present findings offer some insight into the development of child
385 overweight and obesity and its prevention.

386

387 **Acknowledgements**

388

389 The Gemini Study was funded by a grant from Cancer Research UK to Professor Wardle
390 (C1418/A7974). Cancer Research UK had no role in the design and conduct of the study;
391 collection, management, analysis and interpretation of data, and preparation, review or
392 approval of the manuscript. We thank Amy Ronaldson and Laura McDonald for helping to
393 collect the data, and the Gemini families for taking part in the study.

394

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