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An assessment of dietary sodium levels among adults (aged 19-64) in the UK general population in 2008, based on analysis of dietary sodium in 24 hour urine samples

Introduction

The FSA has a target to reduce average salt intakes across the population to 6g per day by 2010. This study was designed to collect 24-hour urine samples for sodium analysis to provide a ‘snapshot’ of overall sodium intakes in the UK. This report presents the final results of the study. Similar studies were conducted in England, Wales, Scotland and Northern Ireland in 2005 and 2006.

Epidemiological, clinical and animal-experimental evidence shows a direct relationship between dietary electrolyte consumption and blood pressure (BP). Furthermore, clinical trials show that a reduction in salt (NaCl) intake reduces BP levels in normotensive and hypertensive populations and prevents the development of hypertension.¹

In the UK, the Committee on Medical Aspects of Food Policy (COMA) panel on Dietary Reference Values (DRV)² set the Reference Nutrient Intake (RNI)¹ for men and women at 1.6g of sodium (or 4.0g of salt) per day. Following this, COMA's Cardiovascular Review Group recommended that salt intake should be gradually reduced to a daily average of 6g.³, a recommendation that was endorsed by the Chief Medical Officer of England.⁴ Most recently the Scientific Advisory Committee on Nutrition (SACN) considered the evidence linking salt intakes and high blood pressure.⁵ The report found that the evidence of a link was stronger than when it had been considered by COMA in the early 90s and maintained their recommendation that intakes to should be reduced to a population average of 6g.

In general, diets of western communities contain amounts of sodium which are far in excess of any physiological need and many times the recommended daily sodium requirement. Earlier UK surveys have estimated an intake of 10g of salt/day in men (range 4-18g) and 7.7g of salt/day (range 3-14g) in women.⁶ It is now thought that with increasing consumption of processed food, salt intake may be higher and this is supported by the 2000-01 National Diet and Nutrition Survey where the salt intake estimates were 11 g/day in men and 8.1 g/day in women.⁷

The intakes of sodium (Na) and potassium (K) can be estimated by measuring urinary excretion, given that under normal circumstances this is the pathway for their elimination. As electrolyte excretion rates reflect the diet of an individual, unless the diet is very

¹ The RNI represents the amount of a nutrient likely to meet the needs of 97.5% of the population.

stable over time, variation in Na and K excretion from spot samples taken at different times of day within the same individual can be large, often larger than the variation among a group of individuals in westernised populations. Therefore a 24-hour measurement has been taken for this study.

Methodology

Sample design, recruitment and response

The aim was for the study to collect 24-hour urine samples from 750 respondents, representative of the population aged 19-64 living in the UK. It was expected that this would yield samples sufficiently complete for analysis from around 80%, i.e. around 600 individuals.

A random sample of 45 postcode sectors was selected initially, and within these a random sample of telephone numbers was drawn using random digit dialling. When eligible households were identified, a short telephone interview was conducted and the household was asked to take part in the 24-hour urine collection study. Within each household, up to two adults, aged between 19 and 64, were eligible to take part in the study, and if there were three or more eligible adults two were selected at random. Respondents were offered an incentive of £20 per person on successful completion of the study.

Random digit dialling was used for this study to ensure a random sample of the population including households that were ex-directory as well as those with listed telephone numbers. Random digit dialling is a method where a representative sample of telephone numbers is generated at random from a frame of all possible telephone numbers. Many of the numbers generated are non-working numbers (some of which, at the time of the project, could be identified and removed from the sample). Others are non-residential.

NatCen was provided with a RDD sample of telephone numbers from within the 45 postcode sectors selected to provide some clustering. This sample covered all eligible telephone area codes located in these 45 points. The Ofcom database lists the first seven digits of all telephone numbers that have been allocated to telephone companies for land lines (e.g. 01222 78XXXX). For each selected area code, the last four digits were randomly generated.

8,100 telephone numbers were generated (after removing non-working numbers). A reserve sample 4,500 numbers was also generated in case the required number of completed urine samples was not obtained from the initial sample. In fact numbers of productive outcomes were lower than average, and some reserve sample was released towards the end of fieldwork to ensure adequate coverage across all points. 3,700 numbers from the reserve sample, spread across all areas, were issued, but not all numbers were needed to achieve the final sample size.

Response from sample from Random Digit Dialling

	First issued sample		Reserve sample		Total	
	Number	%	Number	%	Number	%
Total issued	8100	100%	3700	100%	11800	100%
Issued but not attempted (cut-off date reached)	1	0%	69	2%	70	1%
Telephone number unusable: out of service, disconnected, non-residential	3369	42%	1653	45%	5022	43%
Unable to establish eligibility: no contact/incomplete contact	1785	22%	829	22%	2614	22%
Total usable	2945	36%	1149	31%	4094	35%
Not eligible: no-one in household aged 19-64, out of area	1220	15%	463	13%	1683	14%
Eligible	1725	21%	686	19%	2411	20%
Refused, not available	1179	68%	478	70%	1657	69%
Agreed at telephone interview	546	32%	208	30%	754	31%

Data collection took place between January and May 2008. Overall, 780 adults (341 men, 439 women) completed the study and provided a 24-hour sample. Edit checks revealed that one individual outside the eligible age range had been included. The basic characteristics of the eligible recruited sample are presented in the table below.

<i>Basic characteristics of recruited sample (aged 19-64)</i>			
	<i>N</i>	<i>Mean Age</i>	<i>SD</i>
Men	340	46.4	11.8
Women	439	46.7	11.2

During lab analyses it was not possible to provide results for 84 samples because they were assessed as incomplete 24 hour collections. The analysis in this report was therefore based on samples from 692 individuals (3 samples were lost in the post).

Nurse training

Nurses attended a half-day briefing covering the background and purpose of the study, and the methodology. This comprised a teaching and practice session designed to familiarise nurses with the rationale for the study, the methodology and fieldwork procedures. The training included a practical demonstration of the monovette syringe that nurses would use for taking aliquots from the 24 hour collection. A DVD of the briefing was also produced and given to those who were unable attend a face-to-face briefing.

Nurses were also given detailed written instructions covering the aims of the study, methodology and fieldwork procedures.

Fieldwork in Northern Ireland was conducted by two nutritionists from the University of Ulster.

Data collection procedures overview

Ethical approval for the study was granted from the MREC.

At the initial telephone contact, once the interviewer had established that there were people resident in the household in the eligible age range (19-64), they established how many were eligible, and made a selection of two if there were three or more eligible within the household. Once the interviewer was speaking to one of the selected adults, they asked a brief questionnaire about eating habits, verified eligibility to the study and then sought permission for a nurse to contact them. For those who agreed, a confirmatory letter was sent to respondents after the initial telephone contact. A further letter with details of their appointment was sent after the nurse made contact.

The 24-hour urine collection element of the study used the same protocol and procedures that were used in an equivalent study in England during 2005/06 and a study in Wales in 2006/07. As well as providing urine samples, respondents were asked to take three PABA (para-aminobenzoic acid) tablets at specified intervals. Analysis of PABA excretion provides a measure of the completeness of the 24-hour sample.

At the first nurse visit, the nurse first checked eligibility, and respondents were excluded from the study if they were pregnant; if they were allergic to hair dye, sunscreen or vitamins; or if they were taking sulfonamides, since PABA may interfere with the action of these. The nurse then provided information about the purpose of the study, the procedures involved, supplied all necessary equipment, and made arrangements for collection of urine samples and the timing of the second visit.

Protocol

Respondents were asked to collect all urine they passed during a 24-hour period starting from the second morning urine pass of the 24-hour collection day, and ending with the first urine pass the following morning. Respondents were given detailed written instructions (see Appendix A), and were provided with the following equipment:

- 5 litre capacity screw cap container to serve as collection container for urine. This contained a small amount of the preservative boric acid (powder).
- 2.5 litre capacity screw cap container for collections made away from the home.
- 1 litre plastic beaker, kept inside a re-sealable plastic bag when not used.
- Funnel kept inside a re-sealable plastic bag when not used.
- Plastic carrier bags for transporting the equipment away from home.
- An aide-memoire safety pin for the participant to pin the under- and outer-garments together during the period of the collection to remind that the specimen of urine about to be passed should be collected.
- Three PABA tablets to verify completeness of the 24-hr collection.

Respondents were instructed to pass urine into the beaker, and then pour it into the large collection container. Plastic bags were provided to carry the equipment if respondents were not at home for some of the collection period.

Three PABA tablets were provided, with the instruction that these should be taken at approximately even intervals throughout the 24-hour collection period, ideally with or after meals. Nurses wrote the suggested times for taking the tablets on a diary left with respondents, and they were asked to record the time that they actually took them, as well as the start and finish times of their collection, any missed urine passes, and any medication taken during the collection.

Typically the second nurse visit took place within one day of the 24-hour urine collection. The nurse checked the diary to ensure that PABA tablets had been taken, and took 4 aliquots from the 24-hour sample during the second visit. Samples were not accepted if all three PABA tablets had not been taken.

After the second nurse visit, all samples were labelled and despatched to MRC Human Nutrition Research, Cambridge, where the analyses of sodium and were carried out by flame photometry on an Instrumentation Laboratory (IL) 943 Flame Photometer (Milan, Italy) using a caesium internal standard. An aliquot of the 24-hour sample was also sent to the MRC Dunn Human Nutrition Laboratory, Cambridge, for an assessment of the completeness of the 24-hour collection. Completeness was assessed using the para-amino-benzoic acid (PABA) recovery method.⁸ In brief, the method involved administering three 80mg PABA tablets and measuring urinary recovery over 24 hours, with those collections having paba recovery between 85 and 110% considered complete. Some common drugs such as paracetamol cross-react in the colorimetric method to give falsely high recoveries and these urines were further analysed by an hplc method.⁹

Weighting

In 29 of the 45 selected areas the full reserve sample was issued to interviewers. In the remaining 16 only a proportion of the reserve numbers were used, individuals in these areas had a lower chance of being included in the sample and an adjustment was made accordingly. Households in areas where the full sample was issued were given a weight of 0.82 (i.e. the number issued in partial areas / the full main + reserve sample; 230/280). Households in the remaining areas had a weight of 1.

At each responding household the interviewer selected an eligible person at random for inclusion in the study. Eligible persons were aged 19-64. The selection process means individuals in households with more than one eligible person have a lower chance of being selected. As a result large households are under-represented in the sample. To correct for this an individual selection weight is applied. This is equivalent to the eligible number of persons in the responding household. Weights greater than 4 were trimmed to avoid a small number of large weights, such weights would inflate the standard errors around our estimates.

As a final correction the individual selection weights were adjusted raking ratio (or rim) weighting to make the sample distribution match the UK population by age, sex and

country. The population figures were taken from the ONS 2006 mid-year household population estimates for individuals aged 19-64 living in the UK. These figures are given in Tables 1 and 2 below.

Table 1 ONS 2006 mid-year population estimates by age group and sex

	Male	Female
19-29	4,393,467	4,291,282
30-39	4,291,330	4,347,642
40-49	4,360,966	4,452,730
50-59	3,747,873	3,845,144
60-64	1,584,429	1,655,705
Total 19-64	18,378,065	18,592,503

Table 2 ONS 2006 mid-year population estimates by country

All aged 19-64	
England	31,004,881
Wales	1,759,294
Scotland	3,162,275
Northern Ireland	1,044,118
Total	36,970,568

Table 3 shows the age and sex distribution of the sample, weighted by the selection weight and the final weight, compared to that of the population.

Table 3 Distribution of the weighted sample

Age sex	Sample weighted by the selection weight only	Sample weighted by the final weight	Population estimates
Male 19-29	5.4	11.9	11.9
Male 30-39	9.0	11.6	11.6
Male 40-49	10.9	11.8	11.8
Male 50-59	13.0	10.1	10.1
Male 60-64	7.1	4.3	4.3
Female 19-29	4.1	11.6	11.6
Female 30-39	12.2	11.8	11.8
Female 40-49	15.3	12.0	12.0
Female 50-59	16.0	10.4	10.4
Female 60-64	7.0	4.5	4.5
England	81.3	83.8	83.9
Wales	6.3	4.8	4.8
Scotland	9.4	8.6	8.6
Northern Ireland	3.1	2.8	2.8
Base (unweighted)	780	780	36,970,568

Statistical analysis

As in the 2001 National Diet and Nutrition Survey, salt intake was estimated as 1 g salt =17.1 mmol of sodium.

Analysis of para-amino-benzoic acid (PABA)

Twenty-four-hour urine collections containing between 85% and 110% of the PABA marker were considered complete. Additionally, urine samples with 70-84% PABA recovery were included after correction.¹⁰ The correction was made by using the equation:

$$\text{Corrected Sodium} = \text{Sodium} * (93 / \text{Percentage PABA recovery})$$

Urine samples with over 110% of PABA recovery can be artificially high because of concomitant medications. All samples with results over 110% were therefore reanalysed by HPLC where there is no medication interference in the measurement of PABA. Results for HPLC below 75% were excluded, as were results that were still high with this analysis. In the tables below are the sample numbers and numbers excluded in the various categories of the overall PABA analysis and the additional HPLC analysis. In total, 13% of men (n=44) and 9% of women (n=40) were excluded from the analysis. The age profile of the included sample was similar to that of the sample excluded from the analysis.

<i>Sample exclusions</i>			
	<i>Men</i>	<i>Women</i>	<i>Total</i>
Total number sampled	341	439	780
Samples lost in post	2	1	3
Wrong age group	1	0	1
Total providing sample	338	438	776
Excluded:			
Incomplete samples	44	40	84
Complete samples	294	398	692

<i>Summary of PABA analysis</i>			
	<i>Men</i>	<i>Women</i>	<i>Total</i>
Total samples obtained for PABA analysis	338	438	776
Complete colourimetric PABA (85 - 110%)	194	283	477
Adjustable colourimetric PABA (70% - 84%)	44	46	90
HPLC PABA Complete (77-110%) (High colourimetric PABA >110%)	54	62	116
HPLC PABA Borderline (75-77%) (High colourimetric PABA >110%)	2	7	9

Complete samples	294	398	692
Incomplete PABA	26	22	48
HPLC analysis incomplete or high	5	10	15
No PABA results obtained	13	8	21
Total incomplete samples	44	40	84

Results

The table below shows the basic characteristics of the 692 informants that were included in the analysis.

61% of the 24-hour samples collected were found to be complete (85-110% recovery) with the PABA recovery method. After including those which were 70-84% recovery (likely to have taken the 3 PABA tablets but lost a bit of urine) and therefore corrected, this percentage went up to 73% and finally, including 125 samples that were found to have >110% of PABA concentration and were re-analysed using the HPLC method, 89% of the recruited sample was included in the analysis. The age distribution of the sample included and that excluded are shown below:

<i>Characteristics of the included and excluded samples</i>				
	<i>N</i>	<i>Mean Age</i>	<i>SD</i>	<i>Median age</i>
Included sample				
Men	294	46.6	11.6	48
Women	398	46.8	11.0	47
Excluded sample				
Men	44	44.5	13.2	42.5
Women	40	46.1	12.4	45.5

Summary

This brief report presents the results of a 24-hour urine sample study that was designed to provide estimates of salt intake using sodium concentrations in urine. The study was carried out among a representative sample of adults aged 19-64 in the UK. The estimated daily salt intake of a representative sample, based on the 294 men and 398 women analysed in the study was 9.7g and 7.7 g, respectively (8.6 g/day for both men and women together). These estimates are lower than those reported by the most recent NDNS for adults (9.5g/day) but are similar to recent estimates based on urinary sodium from 2005/06 in the UK (9.0g/day).

In most respects the results from this study should be broadly comparable with those from the NDNS survey. However, comparability may be affected by some differences in methodology, including the way in which the samples were recruited, the offer of an incentive and response rates. The NDNS survey covered a full 12 month period, while most of the fieldwork for this study took place over the a period between January and May 2008, and there may be some differences reflecting seasonal patterns in salt

consumption. While PABA analyses were used in this study to exclude incomplete samples, a different methodology was used for most of the NDNS sample.

Table 1 Mean urinary sodium (mmol/24hr), by sex and age

Corrected 24hr Sodium (mmol/24hr)

	Age group				Total
	19-24	25-34	35-49	50-64	
Men					
Mean	182	174	163	159	166
Standard Deviation	58	76	69	51	70
Standard Error	19	12	7	4	4
Lower 2.5 centile	63	42	68	54	55
Top 2.5 centile	247	378	327	283	283
Median	207	156	160	162	163
Women					
Mean	171	138	127	119	131
Standard Deviation	57	66	52	39	50
Standard Error	26	8	4	4	4
Lower 2.5 centile	57	66	52	39	50
Top 2.5 centile	308	253	245	238	253
Median	194	121	119	114	119
All					
Mean	177	154	144	139	148
Standard Deviation	60	74	66	57	75
Standard Error	15	8	4	3	3
Lower 2.5 centile	57	53	57	46	52
Top 2.5 centile	308	267	276	270	271
Median	194	139	137	132	138
<i>Bases (unweighted)</i>					
<i>Men</i>	9	37	111	137	294
<i>Women</i>	7	54	157	180	398

Table 2 Percentage distribution of total urinary sodium (mmol/24hr), by sex and age

<i>mmol/24hr</i>	Age group				
	19-24	25-34	35-49	50-64	Total
	%	%	%	%	%
Men					
Under 60	-	7	1	4	3
Under 90	14	7	10	12	10
Under 120	14	19	28	26	25
Under 150	25	37	43	46	41
Under 180	34	60	65	64	61
Under 210	57	72	78	80	76
Under 270	100	97	96	95	96
Women					
Under 60	7	1	4	10	5
Under 90	7	19	24	31	23
Under 120	39	49	52	55	51
Under 150	49	68	72	78	71
Under 180	49	79	86	88	82
Under 210	72	83	92	95	89
Under 270	91	98	99	99	98
All					
Under 60	4	4	3	7	4
Under 90	10	13	17	22	17
Under 120	26	35	40	41	38
Under 150	37	54	58	62	57
Under 180	42	70	76	76	72
Under 210	65	78	85	88	83
Under 270	95	98	97	97	97
<i>Bases (unweighted)</i>					
<i>Men</i>	9	37	111	137	294
<i>Women</i>	7	54	157	180	398

Table 3 Mean estimated salt (g/day), by sex and age

<i>g/day</i>	Age group				
	19-24	25-34	35-49	50-64	Total
Men					
Mean	10.67	10.16	9.50	9.30	9.68
Standard Deviation	3.39	4.42	4.06	3.00	4.10
Standard Error	1.13	0.73	0.39	0.26	0.24
Lower 2.5 centile	3.66	2.46	3.98	3.16	3.21
Top 2.5 centile	14.43	22.08	19.15	16.55	16.55
Median	12.09	9.14	9.47	9.47	9.52
Women					
Mean	10.01	8.08	7.41	6.97	7.66
Standard Deviation	4.03	3.26	2.86	3.00	4.77
Standard Error	1.52	0.44	0.23	0.22	0.24
Lower 2.5 centile	3.34	3.85	3.04	2.25	2.95
Top 2.5 centile	18.02	14.79	14.34	13.94	14.81
Median	11.37	7.10	6.95	6.69	6.97
All					
Mean	10.33	9.02	8.44	8.12	8.64
Standard Deviation	3.52	4.34	3.87	3.31	4.39
Standard Error	0.88	0.46	0.24	0.19	0.17
Lower 2.5 centile	3.34	3.10	3.31	2.68	3.04
Top 2.5 centile	18.02	15.61	16.15	15.81	15.82
Median	11.37	8.10	8.00	7.72	8.08
<i>Bases (unweighted)</i>					
<i>Men</i>	9	37	111	137	294
<i>Women</i>	7	54	157	180	398

**Table 4 Percentage distribution of estimated salt intake (g/day),
by sex and age**

<i>g/day</i>	Age group				Total
	19-24	25-34	35-49	50-64	
	%	%	%	%	%
Men					
3 or Less	-	5	1	2	2
6 or Less	14	13	19	20	18
9 or Less	25	43	47	48	44
12 or Less	46	70	76	78	73
15 or Less	100	87	95	93	94
18 or Less	100	97	97	99	98
<i>Over 6g</i>	86	87	81	80	82
Women					
3 or Less	-	-	2	6	3
6 or Less	21	28	38	39	35
9 or Less	49	68	76	80	73
12 or Less	72	82	92	95	89
15 or Less	91	98	99	98	98
18 or Less	91	99	99	100	99
<i>Over 6g</i>	79	72	62	61	65
All					
3 or Less	-	2	2	4	2
6 or Less	18	21	29	30	26
9 or Less	37	56	61	64	59
12 or Less	59	76	84	87	81
15 or Less	95	93	97	96	96
18 or Less	95	98	98	100	98
<i>Over 6g</i>	82	79	71	70	74
<i>Bases (unweighted)</i>					
<i>Men</i>	9	37	111	137	294
<i>Women</i>	7	54	157	180	398

APPENDIX A: RESPONDENT INSTRUCTIONS FOR 24-HOUR URINE COLLECTION



The UK Diet and Health Study 2008 THE 24-HOUR URINE COLLECTION



We are interested in measuring certain indicators of dietary intake in the urine. The best way to get this information is from the analyses of the urine sample you provide.

We cannot get this essential information in any other way!

We are not testing for drugs or viruses.

As a token of our appreciation we will send you £20 in high street vouchers for completing this part of the study.

Why 24 hours?

The level of some dietary intake markers in urine fluctuate according to what was eaten at the last meal, and how much fluid we drink. A collection over 24 hours gives much more reliable information than a single collection about the usual levels of these nutrients in a person's diet.

We also ask that you take three tablets of a marker, called **para-aminobenzoic acid** (PABA), which helps to check how complete the urine sample is. PABA is part of the vitamin B folic acid. You will receive a leaflet providing more information about PABA.

Equipment provided

The nurse will give you the following equipment for making your collections. All equipment is disposable and used only once.

- A blister pack of 3 PABA tablets.

- A sheet to record important information about the collection.
- Urine-collecting equipment for the home:
 - (a) 5 litre screw-capped plastic collection bottle (containing the preservative boric acid)
 - (b) a 1 litre plastic jug and funnel
 - (c) a safety pin (to attach to your underclothes or nightwear simply as a reminder for you to make your collection)
- Urine-collecting equipment for outside the home:
 - (a) a 2 litre screw-capped plastic collection bottle (without preservative)
 - (b) two plastic bags for carrying the equipment

Don't forget to take the jug out with you.

Note: the larger (5 litre) plastic bottle contains a boric acid preservative. This could cause skin or eye irritations by contact or could cause stomach upset if swallowed. There is a warning label on the bottle but please be sure to keep it out of the reach of unsupervised young children.

Before making the urine collection

Our nurse will help you choose the day on which you would like to make the 24-hour urine collection. You may prefer to choose a day when you will be mostly at home or only going out for a short time. If you are female, you should not make your collection during your period.

How to make your collection

- Please start your collection from the second time you pass urine in the morning. **DO NOT PUT YOUR FIRST URINE OF THE DAY INTO THE BOTTLE.** But record the time on the Collection Sheet – this is start time.
- From then on please collect all of your urine for the next 24 hours **INCLUDING THE FIRST URINE OF THE NEXT MORNING.**
- This completes the 24-hour collection. Please record the end time on the Collection Sheet.
- You need to take your first PABA tablet after the first morning void urine (that is before you start collecting) and then evenly spaced throughout your waking hours, preferably with meals at midday and in the evening.

You should pass all urine direct into the 1 litre plastic jug. Then pour the urine into the collection container using the funnel. If you need to open your bowels, always remember to pass urine first before you pass a stool.

Each time you add a new urine specimen to the large plastic bottle, screw the lid tight and swirl it around a few times, so as to mix with the preservative.

Please add any urine collected in the small bottle, to the large bottle, as soon as possible after returning home, so as to mix it with the preservative.

If you miss a sample or forgot to take a PABA tablet

If during the collection a sample is missed for any reason, such as because of a bowel motion, please record this on the Urine Collection Sheet. If you forget to take the morning PABA tablet please take it as soon as you remember and no later than mid-day. If you forget the midday tablet please take it as soon as you remember and no later than 4pm. Do not take PABA after 10 o'clock at night because otherwise it won't appear in your urine by the morning (when you stop your collection). Don't forget to make a note for us about missed tablets on the collection sheet.

Once you have completed your collection

As soon as possible after you have completed your 24-hour urine collection, the nurse will arrange a time with you to take four small samples from your 24-hour urine collection which will be sent to our laboratory for analysis.

In the meantime, please store your complete collection in a cool, dark place.

If you have any other questions

We hope this leaflet answers the questions you may have. If you have any other questions, please speak to the nurse. You are free to withdraw from this study at any point.

Your co-operation is very much appreciated.

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