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1 **COMPARISON OF SODIUM CONTENT OF MEALS SERVED BY INDEPENDENT TAKEAWAYS**  
2 **USING STANDARD VERSUS REDUCED HOLED SALT SHAKERS: CROSS-SECTIONAL STUDY**

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**25 ABSTRACT****26 Background**

27 Takeaway food has a relatively poor nutritional profile. Providing takeaway outlets with  
28 reduced-holed salt shakers is one method thought to reduce salt use in takeaways, but  
29 effects have not been formally tested. We aimed to determine if there was a difference in  
30 sodium content of standard fish and chip meals served by Fish & Chip Shops that use  
31 standard (17 holes) versus reduced-holed (5 holes) salt shakers, taking advantage of natural  
32 variations in salt shakers used.

**33 Methods**

34 We conducted a cross-sectional study of all Fish & Chip Shops in two local government areas  
35 (n=65), where servers added salt to meals as standard practice, and salt shaker used could  
36 be identified (n=61). Standard fish and chip meals were purchased from each shop by  
37 incognito researchers and the purchase price and type of salt shaker used noted. Sodium  
38 content of full meals and their component parts (fish, chips, batter) was determined using  
39 flame photometry. Differences in absolute and relative sodium content of meals and  
40 component parts between shops using reduced-holed versus standard salt-shakers were  
41 compared using linear regression before and after adjustment for purchase price and area.

**42 Results**

43 Reduced-holed salt shakers were used in 29 of 61 (47.5%) included shops. There was no  
44 difference in absolute sodium content of meals purchased from shops using standard versus  
45 reduced-holed shakers (mean=1147mg [equivalent to 2.9g salt]; SD=424mg;  $p>0.05$ ).  
46 Relative sodium content was significantly lower in meals from shops using reduced-holed  
47 (mean=142.5mg/100g [equivalent to 0.4g salt/100g]; SD=39.0mg/100g) versus standard  
48 shakers (mean=182.0mg/100g; [equivalent to 0.5g salt/100g]; SD=68.3mg/100g;  $p=0.008$ ).  
49 This was driven by differences in the sodium content of chips and was extinguished by  
50 adjustment for purchase price and area. Price was inversely associated with relative sodium  
51 content ( $p<0.05$ ).

52 **Conclusions**

53 Using reduced-holed salt shakers in Fish & Chip Shops is associated with lower relative  
54 sodium content of fish and chip meals. This is driven by differences in sodium content of  
55 chips, making our results relevant to the wide range of takeaways serving chips. Shops  
56 serving higher priced meals, which may reflect a more affluent customer base, may be more  
57 likely to use reduced-holed shakers.

58 **KEYWORDS**

59 salt; sodium; takeaway; public health; diet; nutrition

**60 BACKGROUND**

61 Takeaway food consumption makes significant contributions to total dietary intake.[1]  
62 Emerging evidence of associations between takeaway food consumption and both total  
63 diet,[1] and body weight,[2] has led to public health action to improve the nutritional quality  
64 of takeaway food.[3, 4] One particular area of focus has been dietary salt (sodium chloride,  
65 or simply 'salt') reduction.[3] Single takeaway meals frequently contain more salt than the  
66 World Health Organization's maximum recommended daily intake for adults of 5g.[5-9] In  
67 systematic reviews, reductions in salt intake have been associated with reduced blood  
68 pressure;[10-12] and higher blood pressure with stroke and ischaemic heart disease events  
69 and mortality.[13, 14]

70 In the UK, traditional Fish & Chip Shops, serving a core offering of battered and deep-fried  
71 white fish with chipped and deep-fried potatoes, account for up to one-third of takeaways.<sup>a</sup>  
72 Traditionally in Fish & Chip Shops, hot food is served into disposable packaging, seasoning  
73 (including salt as a minimum) offered and added by the server, and food wrapped – all in  
74 front of the customer. The addition of server-added 'discretionary' salt is relatively unique  
75 to these settings. In this context we use the term 'discretionary' salt, to mean salt that is  
76 added after food has been prepared but before consumption.

77 Providing outlets with reduced-holed salt shakers is one method that has been used to  
78 reduce salt use in UK takeaways. Building on observational findings that discretionary salt  
79 use is related to the size and number of holes in salt shakers,[15] standard shakers with 17  
80 holes are replaced with equivalent ones with 5 holes.[3] In a number of documented cases,  
81 individuals working for or with local authority environmental and public health departments  
82 have offered takeaway outlets reduced-hole salt shakers free of charge.[16] These shakers  
83 can also be purchased by outlets directly from wholesalers. We do not have good  
84 information on uptake of these shakers across the board (although the current work  
85 documents uptake in the areas studied), or factors influencing uptake, nor have the effects  
86 of these shakers on the salt content of food served been formally tested.

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<sup>a</sup> Personal communication, E Macguire (2015) – bespoke additional analysis of data described in ref<sup>(12)</sup>

87 Five-holed salt shakers (5HSS) are relatively cheap (~£2.50; \$3.54; €3.14) and comparable in  
88 price, look and feel to 17-holed salt shakers (17HSS; see **Figure 1**). The ‘health-by-stealth’  
89 approach of 5HSS is particularly attractive and acceptable to both public health practitioners  
90 and takeaway managers and staff.[17][3] Whilst 5HSS have been particularly associated  
91 with Fish & Chip Shops, their use has been encouraged across the takeaway sector for both  
92 servers and customers.[3] Although we are not aware of 5HSS being used outside of the UK,  
93 they may be appropriate elsewhere.

94 In controlled settings, we found that 5HSS delivered around one-third of the salt of 17-holed  
95 salt shakers (17HSS).[18] This difference may not translate into practice because, for  
96 example, servers might shake for longer with 5HSS than 17HSS,[19] or customers ask for  
97 additional salt when 5HSS are used.[16] We aimed to determine if there were differences in  
98 the sodium content of meals served by Fish & Chip Shops using standard (17HSS) versus  
99 reduced-holed (5HSS) salt shakers, taking advantage of natural variations (i.e. not  
100 researcher-influenced) in salt shakers used.

## 101 **METHODS**

102 We conducted a cross-sectional study in two local government areas in northern England in  
103 May-June 2015. The populations of both areas are concentrated in medium-sized towns  
104 (population sizes 120,000 and 83,000) and rank in the more socio-economically deprived  
105 half of all such areas in England.

### 106 **Data collection**

107 We took a pragmatic approach to sample size determination and aimed to conduct a census  
108 of all Fish & Chip Shops in the two study areas. To identify Fish & Chip Shops, we conducted  
109 text analysis of a national database of food businesses kept to administer statutory food  
110 hygiene inspections ([www.ratings.food.gov.uk](http://www.ratings.food.gov.uk)). We searched business names for those  
111 likely to be Fish & Chip Shops (e.g. those containing ‘fish’, ‘fry’, ‘chips’ and derivatives).  
112 Additional Fish & Chip Shops identified in the study areas during fieldwork were added to  
113 the sample.

114 In each shop, a researcher (LG in area 1 and FHB in area 2) ordered and purchased one  
115 standard fish and chip meal. Researchers remained incognito (i.e. did not identify

116 themselves to servers or customers as researchers). Researchers accepted any salt offered  
117 by the server, but did not indicate how much they wanted. Researchers noted the type of  
118 salt shaker used and meal price and recorded these soon after leaving shops.

119 Meals were stored in their packaging in insulated bags for transport to the laboratory. Here  
120 they were disaggregated into their components parts of fish, chips, and fish batter, weighed  
121 using scales accurate to 0.1g (MyWeigh, i2600) and frozen at -18°C until analysis in  
122 polythene bags. Any 'loose' salt that was contained in packaging but had not 'stuck' to food  
123 was likely to have been transferred with food and included in the chips component.

#### 124 **Sample analysis**

125 Sodium was measured in thawed, homogenised and desiccated samples using flame  
126 photometry (Jenway, PFP7) in October-December 2016.[20] Due to resource constraints,  
127 analyses were completed in singlicate only. Sodium values were converted to salt values by  
128 multiplying by 2.542.[21]

#### 129 **Data analysis**

130 We compared the absolute and relative (per 100g) sodium content of meals served by shops  
131 using 5HSS vs 17HSS using linear regression. Here, sodium content was the outcome and  
132 salt shaker the exposure. Separate analyses were conducted for full meals as well as  
133 component parts (i.e. fish, chips and fish batter). In addition to unadjusted analyses,  
134 analyses adjusted for the potential confounders of local government area and meal price  
135 were conducted. As a male researcher (LG) collected data in area 1 and a female researcher  
136 (FHB) data in area 2, adjustment for area also served to adjust for researcher gender.

#### 137 **RESULTS**

138 Sixty-two shops were identified from the food hygiene database. Five of these were  
139 permanently closed on visiting, whilst eight additional shops were identified during  
140 fieldwork. Thus, sample meals were purchased from 65 shops. Samples from four shops  
141 were excluded due to no server-added salt being offered (n=2) and uncertainty about the  
142 type of salt shaker used (n=2). Of the remaining 61 shops, 29 (47.5%) used 5HSS and 32 used  
143 17HSS.

144 Descriptive information and unadjusted results are summarised in **Table 1**. Mean (standard  
145 deviation; SD) absolute sodium content of all meals was 1147mg (424mg) – equivalent to  
146 2.9g of salt. Mean (SD) total meal weight was 724g (145g). Post-hoc t-tests revealed no  
147 difference in the weight of meals, or their component parts, by type of salt shaker ( $p>0.05$ ).  
148 In unadjusted regression analyses, there were no statistically significant differences in  
149 absolute sodium content of total, or component parts of meals purchased from shops using  
150 5HSS vs 17HSS.

151 Mean (SD) relative sodium content of meals was 163mg (59) per 100g – equivalent to 0.4g  
152 of salt per 100g. In unadjusted analyses, relative sodium content was significantly lower in  
153 meals purchased from shops using 5HSS vs 17HSS. Meals from shops using 5HSS contained  
154 around 40mg per 100g (equivalent to 0.1g per 100g of salt), or 22%, less sodium than meals  
155 from shops using 17HSS. This difference appeared to be attributable to differences in  
156 relative sodium content of chips. Chips from shops using 5HSS contained around 42mg per  
157 100g (equivalent to 0.1g per 100g of salt), or 32%, less sodium than chips from shops using  
158 17HSS.

159 Analyses adjusted for meal price and local government area are shown in **Table 2**. There  
160 remained no difference in total sodium content of meals, or their component parts, after  
161 adjustment. Neither meal price nor area was associated with total sodium content in any  
162 analysis.

163 Adjustment for meal price and area extinguished the relationship between shaker type and  
164 relative sodium content of meals and chip components. Meal price was also significantly  
165 inversely associated with relative sodium content of both meals, and chip components.

## 166 **DISCUSSION**

### 167 **Summary of results**

168 This is the first study we are aware of to determine whether using reduced-holed salt  
169 shakers is associated with lower sodium content of takeaway meals. We found that  
170 standard fish and chip meals purchased from Fish & Chip Shops using 5HSS had significantly  
171 lower relative sodium content than those purchased from shops using 17HSS. This appeared  
172 to be driven by a difference in relative sodium content of the chips component of meals and



173 was extinguished by adjustment for area and meal price – higher cost meals had lower  
174 relative sodium content. There was no difference in absolute salt content of meals, or  
175 component parts of meals, purchased from shops using 5HSS vs 17HSS.

### 176 **Interpretation and implications of findings**

177 The total relative sodium content of meals in the sample was comparable to that in fish and  
178 chip meals reported in a previous survey conducted in a different part of England.[8] In this  
179 previous work, 51 portions of fish and chips were bought in a large urban conurbation in the  
180 North West of England. Mean absolute salt content per meal was 3.00g (equivalent to  
181 1181mg of sodium and comparable to the 1147mg found in the current work – see Table 1)  
182 and mean relative salt content was 0.43g/100g (equivalent to 169mg of sodium and  
183 comparable to the 163mg found in the current work – see Table 1). Whilst the mean relative  
184 salt content we found (0.4g per 100g) would be considered ‘medium’ according to UK front-  
185 of-pack traffic light labelling,[22] the absolute salt content (2.9g) equates to more than half  
186 of the WHO’s maximum recommended daily salt intake for adults.[9]

187 Our findings of unadjusted differences in relative, but not absolute, sodium content by  
188 shaker type suggest there may be a systematic difference in total weight of meals served  
189 between shops using 5HSS vs 17HSS. Whilst meals from shops using 5HSS weighed a mean  
190 of 58g more than those from shops using 17HSS and this was primarily due to larger chip  
191 serving sizes (a mean of 47g more in shops using 5 versus 17HSS), these differences were  
192 not statistically significant. As such, this may also reflect random, rather than systematic,  
193 variation.

194 Our unadjusted results suggest that customers eating full meals would not consume  
195 significantly different amounts of salt in meals from shops using 5HSS vs 17HSS. However,  
196 customers consuming similar absolute quantities of meals would consume less salt in meals  
197 from shops using 5HSS vs 17HSS. Whilst it is clear that people eat more when given larger  
198 portions,[23] it is not clear how meals from Fish & Chip Shops are eaten and how this varies  
199 by overall portion size. Some meals may be eaten in full by a single person, others shared,  
200 and others eaten only in part with leftovers discarded. Further work exploring patterns of  
201 consumption is required to determine the population impact of our findings.

202 Differences in relative sodium content of meals from shops using 5HSS vs 17HSS appeared  
203 to be due to differences in relative sodium content of the chips component of meals. In a  
204 standard fish and chip meal, the chips are likely to have a larger overall surface area than  
205 the battered fish – meaning they are more exposed to discretionary salt. Chips may also  
206 provide a more adherent surface for salt granules than fish batter. High sodium content of  
207 chips may also reflect salting practices – researchers observed that chips were often served  
208 and salted first, before the fish was placed on top.

209 As the chip component of meals had the highest absolute sodium content of meals, salt  
210 reductions here have the largest potential to lead to reductions at the meal level. This also  
211 makes our results of relevance to the wide range of takeaways – beyond Fish & Chip Shops –  
212 in the UK that serve chips with discretionary salt.

213 Our findings that adjustment for meal price and local government area extinguished the  
214 association between salt shaker and relative sodium content, and that meal price was  
215 inversely associated with relative sodium content, hints at one potential determinant of salt  
216 shaker use. It is possible that those Fish & Chip Shops serving higher priced meals have more  
217 affluent customers. As affluence is associated with greater dietary knowledge[24] shops  
218 serving these customers may be more willing to use 5HSS. Alternatively, or in addition, total  
219 sodium intake decreases with increasing affluence in the UK.[25] More affluent customers  
220 may, therefore, have less pronounced taste preferences for salt – driving less salt use by  
221 servers in the takeaways these customers frequent. It should be noted, however, that a  
222 post-hoc t-test revealed no difference in meal cost between shops using 5HSS vs 17HSS  
223 ( $p>0.05$ ).

224 The relative sodium content of fish (removed from batter) we found (228mg/100g – see  
225 Table 1) was much higher than the 100-110mg/100g listed for a range of white fish in  
226 standard food tables.[26] This suggests that salt has been added during preparation –  
227 possibly leaching out of batter. Further work to change the amount of salt added during  
228 preparation may be required to achieve substantial reductions in the salt content of meals  
229 from Fish & Chip Shops.

230 **Strengths and limitations of methods**

231 Incognito researchers purchased meals from shops under natural conditions, maximising the  
232 likelihood that sample meals were representative of all meals produced by included  
233 takeaways. However, there may be unmeasured within-takeaway, between-meal variation  
234 in sodium content, leading to error and potentially bias. Variables at the takeaway level that  
235 may also have influenced salt content but that we were unable to measure include: server  
236 gender and experience, and the length of time shops have been in business and their  
237 popularity. Time of day and day of week may also have confounded our results. However, in  
238 post-hoc tests, we found no evidence that either varied by salt shaker used ( $p < 0.05$ ) or was  
239 associated with total absolute or relative salt content of meals ( $p > 0.05$ ).

240 For resource reasons, we only performed sodium analysis in singlicate. As additional  
241 repetitions are likely to provide more accurate estimates, this may be a further source of  
242 error. Again, there is no reason to believe that this error would vary systematically  
243 according to shaker used. Although we did not specifically compare the use of singlicate  
244 analyses to performing multiple replications on each sample, the flame photometer was  
245 recalibrated using analytical grade sodium chloride diluted in deionised water after every 9-  
246 12 samples.

247 Although there are regional variations in condiments offered in UK Fish & Chip Shops,  
248 server-added salt is almost universally offered (as was the case in 97% of shops in our  
249 sample). Our findings are likely to be generalizable across UK Fish & Chip Shops. However,  
250 they may not be generalizable to other takeaway types, or takeaways in other countries.  
251 Further research is required to confirm the effects of reduce holed salt shakers more widely.

## 252 **CONCLUSIONS**

253 Meals from shops using reduced-holed salt shakers (5HSS) had lower relative sodium  
254 content than those using standard salt shakers (17HSS), but there was no difference in  
255 absolute sodium content. Whilst our findings suggest that 5HSS could be a useful public  
256 health intervention, additional work will be required to model the likely population impact  
257 fraction of 5HSS on total salt intake, blood pressure, and health outcomes such as stroke  
258 and cardiovascular disease and hence quantify the health benefits of 5HSS.

259 The differences in salt content we identified appeared to be particularly driven by  
260 differences in the sodium content of chips. This makes the findings of relevance to a wide  
261 range of independent takeaways in the UK that serve chips. Differences in relative sodium  
262 content were extinguished by adjustment for meal price and area, and there was an inverse  
263 association between meal price and relative sodium content. This may reflect and  
264 contribute to socio-economic inequalities in diet.

265 Whilst reduced-holed salt shakers may help reduce 'discretionary' salt added after food  
266 preparation by servers and consumers, takeaway food appears to be high in salt even  
267 before the addition of this discretionary salt. Additional efforts, focusing on salt added  
268 during cooking, may be required to substantially reduce the salt content of food served by  
269 Fish & Chip Shops and takeaway food more generally.

270

## 271 **ABBREVIATIONS**

272 5HSS: 5-holed salt shaker

273 17HSS: 17-holed salt shaker

274 SD: standard deviation

275

## 276 **DECLARATIONS**

### 277 **Ethics**

278 No human participants were recruited for this study meaning that ethical permission was  
279 not required.

### 280 **Consent for publication**

281 Not applicable

### 282 **Availability of data**

283 Data available from the last author (JA) on request.

**284 Competing interests**

285 MW is Director of NIHR's Public Health Research Programme, for which he is employed one  
286 day per week. None of the other authors have competing interests to declare.

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**304 Authors contributions**

305 LG, FHB, WW, VAS, CS, MW, AJA and JA conceived the idea for the study together. All  
306 authors contributed to methods development. FHB and LG collected the data. AD prepared  
307 and analysed the samples. JA analysed the data and drafted the manuscript. All authors  
308 provided critical comments on drafts of the manuscript and approved the final version for  
309 submission.

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314 Council originally developed and introduced the five holed salt shaker studied in this work.

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**Figure caption**

Figure 1: 17 (left) and five (right) holed salt shakers

Figure 1 foodnote: Image credit: Martin White © 2015

**Table 1 – unadjusted comparison of sodium in standard fish & chip meals from shops using 5 vs 17-holed salt shakers**

	Mean (SD) weight (g)	Mean (SD) Sodium (mg)			Mean Sodium in 5HSS as % of 17HSS	Unadjusted regression analysis of 5HSS compared to 17HSS; $\beta$ (95% CI)
		All (n=61)	17HSS (n=32)	5HSS (n=29)		
<b>Total sodium</b>						
Fish	161.9 (40.3)	357.1 (156.1)	352.2 (162.7)	362.4 (151.1)	102.9	10.2 (-70.5 to 90.9)
Chips	437.7 (101.8)	460.5 (296.7)	526.6 (366.4)	387.5 (171.6)	73.6	-139.1 (-288.2 to 10.1)
Batter	122.2 (37.9)	329.8 (171.5)	355.9 (192.8)	300.9 (142.1)	84.5	-55.0 (-142.6 to 32.5)
Meal	724.4 (145.2)	1147.3 (423.7)	1234.8 (493.9)	1050.9 (310.3)	85.1	-183.9 (-397.8 to 30.1)
<b>Sodium per 100g</b>						
Fish	NA	227.9 (95.4)	231.2 (91.0)	224.1 (101.6)	96.9	4.2 (-45.8 to 54.1)
Chips	NA	107.8 (64.4)	127.5 (77.0)	86.1 (37.2)	67.5	-40.7 (-73.6 to -7.8)*
Batter	NA	270.0 (107.8)	288.3 (125.4)	249.9 (81.8)	86.7	-53.2 (-109.6 to 3.1)
Meal	NA	163.2 (59.3)	182.0 (68.3)	142.5 (39.0)	78.3	-37.0 (-66.0 to -8.1)*

SD: standard deviation; 5HSS: 5-holed salt shaker; 17HSS: 17-holed salt shaker; CI: confidence intervals

\*Statistically significant at  $p < 0.05$

**Table 2 – adjusted comparison of sodium in standard fish & chip meals from shops using 5 vs 17-holed salt shakers**

	Adjusted linear regression analysis of 5HSS compared to 17HSS; $\beta$ (95% CI)			
	Fish	Chips	Batter	Meal
Total sodium				
Sodium (mg); 5HSS compared to 17HSS	8.4 (-77.5 to 94.2)	-126.0 (-280.5 to 28.4)	-76.9 (-168.3 to 14.6)	-194.5 (-421.6 to 32.6)
Meal price (£)	31.3 (-50.6 to 113.2)	-141.6 (-288.9 to 5.8)	33.1 (-54.1 to 120.3)	-77.2 (-293.9 to 139.4)
Area (2 vs 1)	-5.1 (-94.8 to 84.5)	-31.9 (-193.2 to 129.3)	-51.5 (-147.0 to 44.0)	-88.6 (-325.7 to 148.6)
Sodium per 100g				
Sodium per 100g (mg); 5HSS compared to 17HSS	21.0 (-29.7 to 71.7)	-32.0 (-65.0 to 1.0)	-41.2 (-100.3 to 17.9)	-28.0 (-57.2 to 1.2)
Meal price (£)	-20.5 (-68.9 to 27.8)	-41.4 (-72.8 to -9.9)*	-38.8 (-95.1 to 17.6)	-31.2 (-56.1 to -3.4)*
Area (2 vs 1)	40.3 (-12.7 to 93.3)	6.6 (-27.9 to 41.0)	28.6 (-33.1 to 90.3)	12.5 (-18.0 to 42.9)

5HSS: 5-holed salt shaker; 17HSS: 17-holed salt shaker; CI: confidence intervals

\*Statistically significant at  $p < 0.05$