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RESEARCH ARTICLE

REVISED Consumer knowledge of and engagement with traditional takeaway and dark kitchen food outlets

[version 2; peer review: 2 approved]

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Abstract

Background

Dark kitchens – delivery-only food outlets operating through digital technology platforms – are a contemporary addition to the food environment. Some concerns have been raised around the ability for local authorities to identify and regulate these businesses, with growing concern around the nutritional quality of foods, food safety practices and impact on the local food environment. The present work explores consumer understanding of and engagement with dark kitchen and traditional takeaway establishments.

Methods

Healthy adults living in the United Kingdom completed an online survey comprising of questions measuring demographics, engagement with takeaways and dark kitchens, purchasing behaviours and decision making, and knowledge and understanding around dark kitchens. Data were analysed using descriptive statistics.

Results

In total, 2,023 participants (46.3 ± 16.7 years) completed the survey. Forty percent purchased a takeaway at least weekly, often through aggregator applications (e.g., Just Eat, Deliveroo). Food was mainly purchased as a treat (79.3%), for enjoyment of the food or taste (60.8%) and for convenience (58.2%). When ordering, consumers considered the taste (88.1%), quality (83.5%), value for money (77.8%),

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Approval Status ✓ ✓

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version 2 (revision) 10 Mar 2025	✓ view	
version 1 18 Oct 2024	? view	✓ view

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and familiarity with (68.1%) and reputation of the business (60.0%). Only 24.7% of participants had heard of dark kitchens and 9.1% had knowingly purchased from one. After reading a working definition, 54.9% said they would purchase from a dark kitchen, but most would want to know explicitly that they were ordering from these businesses. A major concern when purchasing food from a dark kitchen or takeaway outlet was trust in the food safety and hygiene standards.

Conclusion

Consumers are unfamiliar with dark kitchens and are not aware of or confident in identifying these businesses. This confusion and concerns around food safety mean dark kitchens are often viewed negatively. Consumers would prefer more transparency in where their foods are being prepared to allow for more informed decision-making.

Plain Language Summary

This study used an online survey to ask people living in the UK about their use of takeaways and what information and understanding they had about a type of delivery-only takeaway called ‘dark kitchens’. This work is important because dark kitchens are very common in the UK and are a new type of food outlet which are less well-researched. This is the first study to ask people living in the UK what they know and think about dark kitchens. The study found that only one-quarter of people had heard of the term dark kitchens and that most people (91%) had never knowingly used one to purchase food. People were worried about the quality and safety of the food and whether the business was legal. People would like to know whether the food they buy comes from a dark kitchen or not so that they can use this information when deciding where to buy their food from.

Keywords

Consumer behaviour, delivery-only kitchen, ghost kitchen, virtual kitchen

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REVISED **Amendments from Version 1**

This article has been updated in response to peer review feedback. Amendments are: inclusion of further evidence in the introduction; clarity on sample (representative criteria); clarity on PPI input; reporting of Index of Multiple Deprivation in the results; correction of some incorrect data; comparison between present data and national surveys (Living Costs and Food Survey, Food and You Survey).

Any further responses from the reviewers can be found at the end of the article

Introduction

Dark kitchens, also called ghost or cloud kitchens, are delivery-only 'virtual' commercial food spaces that do not have a customer-facing storefront and operate largely through third-party aggregator platforms (e.g., Just Eat, Uber Eats, Deliveroo). They are a contemporary addition to the food environment in the United Kingdom (UK), likely finding popularity during the COVID-19 pandemic (Keeble *et al.*, 2023). Operating at relatively low-cost within urban environments with easy access to consumers and potential for large geographical reach (Rinaldi *et al.*, 2022), dark kitchens offer a lucrative business model (de Souza *et al.*, 2022; Food Standards Agency, 2022) within a rapidly growing market (Statista, 2022). Indeed, the worldwide market size is predicted to increase to $177.85 billion by 2032, an increase of more than $122 billion since 2022 (Statista, 2024).

The growth of dark kitchens presents additional complexity when evaluating the place-based food environment and potential impact on health (Keeble *et al.*, 2020; Rinaldi *et al.*, 2022), compounded by lack of clarity of how many exist and how to define them. There is a need to understand the complexity of the changing foodscape from both a professional and consumer awareness perspective. However, dark kitchens are particularly difficult to monitor and regulate (Food Standards Agency, 2022) as the number, type and impact is largely unknown. The lack of clarity in nutritional quality of foods offered by many of these businesses (Fernandez & Raine, 2021; Keeble *et al.*, 2020), and potential for poor food safety practices (Crawford & Benjamin, 2019) are cause for concern, and best practice is yet to be established.

Increasingly, consumers are keen to understand where their food is coming from, with recent purchasing trends related to ingredient provenance and transparency of the food supply chain leading to improved consumer trust and brand loyalty which drives intention to purchase (Cai *et al.*, 2022; Moralez, 2019). While there is some evidence of consumer attitudes towards dark kitchens (e.g., Pookulangara *et al.*, 2023), there is limited understanding of consumer awareness of dark kitchens and how the dark kitchen sector influences consumer decision making and purchase behaviours. However, the online third-party aggregator platforms do provide a level of data transparency for the consumer by providing food hygiene ratings and other purchaser reviews on their platforms which are easy to access, to allow the consumers to make more informed food choices.

Aim and objectives

This study aimed to explore consumers current awareness of and engagement with traditional and dark kitchen takeaway outlets, and specifically their knowledge of dark kitchens. The study objectives were:

- Establish consumer usage of traditional and dark kitchens takeaways
- Understand how consumers currently perceive risks and benefits of dark kitchens, and how this changes their engagement.

Methods

Patient and Public Involvement (PPI)

During project development, the research team consulted with individuals from local authorities across Yorkshire and the Humber and from the Public Involvement in Research Group (PIRG) – a PPI network at Sheffield Hallam University. Two PIRG members were included in the project steering committee and had oversight of the project. These individuals contributed to project development.

Ethics

All procedures underwent independent review by the Sheffield Hallam University research ethics committee and the application was approved on 06 February 2024 (ethics approval number: ER61546845). All participants provided written, informed consent. Procedures adhered to the Declaration of Helsinki.

Participants

Participants were healthy adults (18 years of age or older) living in the UK. A representative sample of the national population was recruited through the Prolific platform; sample size was stratified based on sex, age and ethnicity in line with census data (Office for National Statistics, 2024). The study aimed to recruit a minimum of 2,000 participants.

Study design, materials and analysis

The study involved a brief online cross-sectional survey through Qualtrics, lasting approximately 15 minutes. The questionnaire included a series of standardised demographic questions aligned with census question format, which included age, gender, ethnicity, household composition, and total pre-tax household income. Participants' engagement with takeaways and dark kitchens (e.g., typical spend per week, frequency of purchase), purchasing behaviours and decision making (e.g., reason for purchase, influential factors when considering purchasing a takeaway, importance of food safety and hygiene measures), and knowledge and understanding around dark kitchens (e.g., prior knowledge of dark kitchens, awareness of dark kitchens within local area) were measured primarily through quantitative, closed-ended questions with further open-ended questions requesting additional information. Participants responded to up to 33 questions in total. The survey was designed with input from Patient and Public Involvement (PPI) and stakeholder groups, and was refined and piloted prior to the study to ensure data collected answered the research aims. A copy of the survey is available via the Open Science Framework (https://doi.org/10.17605/OSF.IO/6SWBK). Descriptive statistics were used

to analyse data and where available summaries of qualitative data are provided to support descriptive statistics. The study procedures were pre-registered on Research Registry (unique identifying number: researchregistry10007). The study is reported using STROBE guidelines.

Results

In total, 2,023 participants responded to the online questionnaire between April and June 2024. Mean age of the participants was 46.3 ± 16.7 years (range: 18 to 91 years). Further demographic characteristics are displayed in Table 1. A representative sample of the UK population were recruited, with demographic profiles (for age, sex and ethnicity) aligning with the most recent census data (Office for National Statistics, 2024). Most participants (n = 1,990, 98.5%) were above the income tax threshold at the time of completion of £12,571 (Table 2). Prior to being involved in the study, only 24.7% of respondents had heard of dark kitchens, mainly through their interactions on social media and online platforms, and only 9.1% had knowingly purchased from a dark kitchen restaurant. However, based on reading a working definition of dark kitchens, 54.9% of consumers said that they would purchase from a dark kitchen. The remaining participants would not purchase from a dark kitchen as they would prefer to see the establishment, know that they could see where their food was being prepared, or were dubious

Table 1. Participant demographic characteristics (n = 2,023).

Gender	***n***	***%***
Female	1,017	50.2
Male	985	48.7
Genderqueer / Gender non-conforming	9	0.4
Non-binary	2	0.1
Transgender man	1	0.1
Transgender woman	1	0.1
Declined to state	8	0.4
Ethnicity	***n***	***%***
English, Welsh, Scottish, Northern Irish or British	1,604	79.3
Any other White background	95	4.7
Indian	50	2.5
African	42	2.1
Any other Asian background	34	1.7
Chinese	33	1.6
Pakistani	32	1.6
Irish	30	1.5
White and Black Caribbean	24	1.2
Caribbean	17	0.8
Bangladeshi	12	0.6
Any other Mixed or multiple ethnic background	12	0.6
Not listed or other	10	0.5
Arab	8	0.4
White and Asian	7	0.4
Any other Black, Black British, or Caribbean background	7	0.4
White and Black African	6	0.3
Gypsy or Irish Traveller	0	0.0
Roma	0	0.0
Employment status	***n***	***%***
In full-time employment	771	38.1
Not in paid employment (e.g., homemaker, retired, disabled)	386	19.1
In part-time work	279	13.8
Unemployed / Job seeking	84	4.2
Other	59	2.9
Declined to state	444	21.9
Student status	***n***	***%***
No	1,537	76.0
Yes	162	8.0
Declined to state	324	16.0
Index of Multiple Deprivation (total n = 1,866)	***n***	***%***
Quintile 1	288	15.4
Quintile 2	387	20.7
Quintile 3	418	22.4
Quintile 4	379	20.3
Quintile 5	394	21.1

Table 2. Annual pre-tax household income (n = 2,021).

GBP (£)	***n***	***%***
£4,999 or less	38	1.9
£5,000 to £12,570	94	4.7
£12,571 to £20,999	201	9.9
£21,000 to £30,999	372	18.4
£31,000 to £40,999	314	15.5
£41,000 to £50,999	282	14.0
£51,000 or more	720	35.6

about hygiene standards and legality of such establishments. The majority (65.9%) of respondents would want to know explicitly whether they were ordering food from a dark kitchen.

Many participants purchase a takeaway at least once a week (n = 748, 31.7%) (Table 3), with a typical spend of up to £20 per purchase (Table 4). Purchases were often made using aggregator/third party mobile applications such as Just Eat, Deliveroo and Uber Eats (51.3%) or brand-specific mobile application (e.g., through the McDonalds app) (28.6%). Most of these takeaway purchases (n = 1,911, 67.9%) were for adults within the household, whilst 16.7% (n = 471) of purchases were reported to be for children and young people in the household. A further 15.3% (n = 429) of purchases were for people outside of the household such as family, visitors and friends.

The most common reasons that people purchased from a takeaway were for a treat (79.3%), for enjoyment of the food or taste (60.8%) and for convenience (58.2%) (Table 5). Other reasons for purchasing a takeaway include being too tired or ill to cook, it was too late to start cooking, or to purchase foods that they could not prepare in the home (e.g., do not have the equipment or ingredients available). When ordering a takeaway, the most common considerations were the taste of the food (88.1%), quality of the food (83.5%), value for money (77.8%), familiarity with the business (68.1%) and reputation of the business (60.0%) (Table 6). Participants were less concerned with ethical standards of the food or business (9.1%), sustainability of the food or business (4.7%), provenance of ingredients (4.6%) and allergen control (4.2%). Other factors considered included availability of vegan, halal and gluten-free options.

The food hygiene rating of a business was considered by 47.3% of participants (Table 6); in line with this, 56.0% (n = 1,105) of participants reported they checked food hygiene

Table 3. Frequency of takeaway purchase (n = 2,023).

	n	%
Every day	1	0.1
5 to 6 times per week	6	0.3
3 to 4 times per week	48	2.4
Once or twice a week	693	34.3
Once a fortnight	503	24.9
Once a month	392	19.4
Less than once a month	326	16.1
Never	52	2.6
Declined to state	2	0.1

Table 4. Total household spend (GBP, £) on food per week (n = 2,023).

Spend on food shopping*	***n***	**%**
£0.01 to £19.99	20	1.0
£20.00 to £39.99	196	9.7
£40.00 to £59.99	354	17.5
£60.00 to £79.99	435	21.5
£80.00 to £99.99	422	20.9
£100.00 to £149.99	447	22.1
£150.00 to £199.99	108	5.3
£200.00 or more	37	1.8
Declined to state	4	0.2
Spend on eating out†	***n***	**%**
£0.00	297	14.7
£0.01 to £19.99	787	38.9
£20.00 to £39.99	510	25.2
£40.00 to £59.99	249	12.3
£60.00 to £79.99	94	4.6
£80.00 to £99.99	47	2.3
£100.00 to £149.99	26	1.3
£150.00 to £199.99	5	0.3
£200.00 or more	5	0.3
Declined to state	3	0.1
Spend on takeaways/dark kitchens	***n***	**%**
£0.00	326	16.1
£0.01 to £19.99	868	42.9
£20.00 to £39.99	590	29.2
£40.00 to £59.99	164	8.1
£60.00 to £79.99	39	1.9
£80.00 to £99.99	17	0.8
£100.00 to £149.99	12	0.6
£150.00 to £199.99	3	0.1
£200.00 or more	2	0.1
Declined to state	2	0.1

* This includes foods purchased at shops, supermarkets, markets, etc., but does not include food eaten out of the home (e.g., takeaways, eating at a restaurant).

† This includes eating out at restaurants, cafes and canteens, but does not include takeaway establishments.

Table 5. Reasons for ordering food from a takeaway or dark kitchen (n = 1,966).

	n	%
It is a treat	1,560	79.3
I enjoy the food/I enjoy the taste	1,196	60.8
It is convenient	1,144	58.2
For a special occasion (e.g., birthday)	727	37.0
There is a large variety of foods I wouldn't cook at home	388	19.7
I do not have enough time to cook	379	19.3
It is part of my/our routine (e.g., get a takeaway every Friday)	298	15.2
I want to try something new	264	13.4
It is often an impulsive purchase (e.g., I've seen an advert)	252	12.8
Other	93	4.7
I can't cook/I am not a confident cook	56	2.8
It is cheaper to purchase takeaway food than cook food in the home	32	1.6
I have limited access to other sources of food	26	1.3

Table 6. Factors considered when purchasing from a takeaway or dark kitchen (n = 1,972).

	n	%
Taste of the food	1,737	88.1
Quality of the food	1,646	83.5
Cost or value for money	1,535	77.8
Familiarity with the takeaway/restaurant	1,342	68.1
Reputation of the takeaway/restaurant	1,183	60.0
Speed/convenience of ordering	1,079	54.7
Location or proximity of the business	1,039	52.7
Trustworthiness of the takeaway/restaurant	995	50.5
Food hygiene rating of the business	932	47.3
General cleanliness standards of the business	863	43.8
Timing of delivery	858	43.5
Healthiness or nutritional quality	260	13.2
Ethical standards of the food or business (e.g., animal welfare)	180	9.1
Sustainability of the food or business	93	4.7
Where ingredients are sourced (i.e., provenance)	90	4.6
Allergen control	83	4.2
Other	32	1.6

ratings before they order from a takeaway. Of these, 93.7% (n = 1,033) stated the food hygiene rating would affect their willingness to purchase from the business, with many participants stating they would only order if the business received a rating of at least 4 out of 5. Low ratings were of concern due to perceived poor hygiene standards of the staff, poor hygiene training or the preparation of foods in an unhygienic environment, with some participants particularly concerned about the likelihood of food poisoning and associated symptoms. Participants also described how low hygiene ratings would also prevent them from enjoying the food and would reflect the quality of the food provided. However, some participants noted that the food hygiene rating is only relevant where they are unfamiliar with a business, and this would not matter if they had previously ordered from the business.

Discussion

As far as the researchers are aware, this is the first study to explore consumer knowledge and engagement with dark kitchens in a UK context. The research showed that awareness of dark kitchens was generally poor amongst UK consumers, although takeaway consumption and prevalence of takeaway purchasing was high, with over a third of consumers having takeaways at least once per week, spending around £20 per week. This is slightly higher, but comparable to the Living Costs and Food Survey (Office for National Statistics, 2017), which suggested that the amount spent on takeaway foods and snacks consumed per household ranged from £2.80 to £12.70 per week. Most takeaways were ordered by consumers using third-party aggregator apps such as Just Eat, Deliveroo and Uber Eats or brand-specific apps to make purchases, rather than visiting the premises themselves. Whilst most consumers considered taste, quality, cost and familiarity with the business, few consumers had knowingly purchased from a dark kitchen and most would use a dark kitchen despite not being able to visit the premises. Therefore, whilst the awareness of dark kitchens was low, the prospective purchase was high which aligns with previous research conducted by Hakim *et al.* (2022) who found that consumers demonstrated an intention to buy food produced in dark kitchens, even if they did not know how to describe or define them.

In the present study, participants viewed the food hygiene rating of a food business – based on an inspection from local authority environmental health officers – as a proxy of food quality, where lower hygiene ratings are synonymous with lower quality foods. Food quality is a broad term which characterises aspects of foods that are important to governments, the food industry and consumers, including external factors (e.g., size, colour), internal factors (e.g., microbial load, foreign bodies, nutritional profile), texture and flavour (Tanner, 2016). As such, a large proportion of the sample did not want to purchase food from a dark kitchen due to concerns related to food hygiene and cleanliness standards, the compliance with organisational, legal and regulatory frameworks. These findings align with the Food and You Survey, which reported that consumers' most common concerns were related to food safety and hygiene (33%) and food quality (29%) (Food Standards Agency, 2024). However, only 21% reported they had concerns with food, suggesting that the unknown nature of dark kitchens may increase consumer concern. This links with findings

by Hakim *et al.*, 2022 and Cai *et al.*, 2022, who found better perceived food safety practices and trust in the food business determined consumers' willingness to pay for food from dark kitchens. Cai *et al.* (2022) describe the link between personal and societal benefits or risks and participants' high or low trust in a dark kitchen establishment, respectively. In the present work, more than half of the participants reported that they looked at food hygiene ratings prior to ordering food, and that the rating determined their willingness to purchase. This is higher than the 43% of respondents who reported checking food hygiene ratings of food businesses (either at the business premises or online) in the Food and You Survey (Food Standards Agency, 2024). However, this may be due to better accessibility of information on third-party online food delivery platforms. Similar to the present findings, the Food and You Survey found consumers would not consume food from a restaurant or takeaway with a food hygiene rating of zero to two. Likewise, Dsouza and Sharma (2021) surveyed consumers in India and found that post-COVID, consumers were increasingly conscious of food safety issues and recommended that safety ratings should be published to consumers.

As many dark kitchens are new, or unknown to consumers, the trust that individuals have in ordering food from these premises is variable. As a result, most respondents wanted to know whether they were ordering from a dark kitchen or a traditional takeaway restaurant for transparency. While the location of a business is available through aggregator apps, whether the business is a dark kitchen is not currently available to consumers. Aggregator and brand-specific apps should consider including information on whether the food is prepared in a dark kitchen, alongside clear food hygiene ratings, to ensure consumers are aware of the premises in which their food is being prepared and to enable informed purchasing decisions.

Strengths and limitations

This is the first study to understand consumer perceptions of dark kitchens in the UK. The relatively large, representative sample of adults enabled trends and views of respondents to be reported on this emerging addition to the UK foodscape and provide novel insights into consumer knowledge of and engagement with dark kitchens. Whilst surveys enable researchers to capture a lot of data quickly, further qualitative research may be useful to understand some of the consumer concerns and decision-making processes in more detail. Additionally, the Prolific platform has engaged users who complete surveys regularly. This may mean participants were more technologically-literate and had more regular access to technology than a group of consumers who would respond to a paper-based survey. Therefore, there is potential that their competence of using online apps and websites is greater than some other UK consumers meaning that accessing food online is commonplace and familiar, and this should be considered when interpreting the data.

Conclusion

Participants frequently use takeaways and are familiar with aggregator websites and apps for ordering and tracking food purchases. However, consumers are unfamiliar with dark kitchens and are not aware of or confident in identifying which businesses are dark kitchens. In addition, trust in the food safety and hygiene standards of these businesses is variable. This results in dark kitchens being viewed in a negative light; consumers would prefer more transparency in where their foods are being prepared, and specifically whether this is being prepared in a dark kitchen, to allow for more informed decision making. As the dark kitchen sector continues to evolve, it is additionally important to capture the views of wider key stakeholders, such as those working in dark kitchens or regulating the sector.

Ethics and consent

All procedures underwent independent review by the Sheffield Hallam University research ethics committee and the application was approved on 06 February 2024 (ethics approval number: ER61546845). All participants provided written, informed consent. Procedures adhered to the Declaration of Helsinki.

Participants

Participants were healthy adults (18 years of age or older) living in the UK. A representative sample of the national population, based on sex, age and ethnicity was recruited through the Prolific platform. The study aimed to recruit a minimum of 2,000 participants.

Data availability

Underlying & extended data

Supporting documents are accessible for review via the Open Science Framework (OSF).

Open Science Framework: NIHR Dark Kitchens. https://doi.org/10.17605/OSF.IO/6SWBK (Beaumont, 2024).

This project contains the following data:

- NIHR160326 WP1 Dataset (the anonymised/deidentified raw data, prior to data analysis).
- NIHR160326 WP1 Information Sheet (a copy of the information sheet shared with participants).
- NIHR160326 WP1 Consent Form (an example consent form signed by participants).
- NIHR160326 WP1 Qualtrics Survey (a copy of the survey completed by participants).

Reporting guidelines

Open Science Framework: STROBE checklist for 'Consumer knowledge of and engagement with traditional takeaway and dark kitchen food outlets'. https://doi.org/10.17605/OSF.IO/6SWBK (Beaumont, 2024).

Author contributions

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Publisher Full Text

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Open Peer Review

Current Peer Review Status: ✔ ✔

Version 2

Reviewer Report 18 March 2025

https://doi.org/10.3310/nihropenres.15095.r34896

✔ **Jean Adams**
University of Cambridge, Cambridge, England, UK

Thanks for responding to my previous comments. I have no further comments.

Competing Interests: I was a co-applicant on a project funded through the same scheme as this project.

Reviewer Expertise: Diet & public health, population interventions, natural experimental evaluations

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 22 November 2024

https://doi.org/10.3310/nihropenres.14917.r33549

✔ **Purvi Mathur**
[1] The ICFAI University, Jaipur, India
[2] MANAGEMENT, Birla Institute of Technology (Ringgold ID: 28698), Ranchi, Jharkhand, India

The study as it is based on the project which is undergoing in context to cloud kitchen. There are

following which are required to be added:
1.Theory need to be included. For instance the theory of consumption value is find to be appropriate for the study.
2. Add more current references as the topic is more prominent and lots of study is already undergoing or done.
3. Advice to refer a research paper related to your field on the Emerald Insight on International Journal of Contemporary Hospitality Management titled as
Consumer attitudes toward ordering from cloud kitchens: a gender and marital status perspective
Add these suggestions and incorporate changes will actually make the study more effective.

References

1. Pookulangara S, Wen H, Bharath J: Consumer attitudes toward ordering from cloud kitchens: a gender and marital status perspective. *International Journal of Contemporary Hospitality Management*. 2023; **35** (5): 1859-1879 Publisher Full Text
2. Mathur P, Mathur V: Consumer Purchase Intention and Behavior Toward Cloud Kitchen (Pandemic Opportunity) with Reference to India: An Empirical Examination. *Jindal Journal of Business Research*. 2023; **12** (2): 194-208 Publisher Full Text

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Supply Chain, Technology Management, Consumer Behaviour

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 06 Feb 2025

Jordan Beaumont

Reviewer Comment: Theory need to be included. For instance the theory of consumption value is find to be appropriate for the study.

Author Response: While the theory of consumption value provides a useful framework to understand the reasons behind consumer choice, this was not considered when designing the study. Instead, we focussed on an exploratory approach. The data from our studies does not align well with this theory, and it feels erroneous to restructure the study around such theory.

Reviewer Comment: Add more current references as the topic is more prominent and lots of study is already undergoing or done.

Author Response: While we acknowledge the relative contemporary nature of this research, we believe the articles cited are up-to-date and published within the last 4 years. There is a lack of appropriate evidence when considering consumer engagement within a UK context (hence conducting our study), and while there are some studies from a global perspective, the local food environment is an important factor in this study.

Reviewer Comment: Advice to refer a research paper related to your field on the Emerald Insight on International Journal of Contemporary Hospitality Management titled as Consumer attitudes toward ordering from cloud kitchens: a gender and marital status perspective

Author Response: We have now cited this work in the introduction, which now reads:

"While there is some evidence on consumer attitudes towards dark kitchens (e.g., Pookulangara et al. (2023)), there is limited understanding of consumer awareness of dark kitchens and how the dark kitchen sector influences consumer decision making and purchase behaviours."

Competing Interests: None.

Reviewer Report 07 November 2024

https://doi.org/10.3310/nihropenres.14917.r33230

? **Jean Adams**

University of Cambridge, Cambridge, England, UK

This is an interesting paper on an emerging topic.

My key concern is the representativeness of participants and hence to whom findings are generalizable and how definitive the conclusions can be. Although it is claimed that participants are representative of the population in terms of age, sex and ethnicity no clear comparative data supporting this claim is cited. There is also no comment made on representativeness according to socio-economic position. Some acknowledgement in the discussion is made that participants may have been more technologically literate that the wider population, but the implications of this for how data should be interpreted are not made clear.

There are also very few comparisons drawn to other data on takeaway purchasing that could also help with determining how representative the sample is. For example, how does the 40% purchasing takeaway food at least weekly and £20 weekly spend compare to data from Food & You, National Diet & Nutrition Survey, and Living Costs and Food Survey? Food and You also reports concerns with food hygiene and this comparison is also not drawn.

It is not clear how the content of the survey was derived – both in terms of the question stems asked and the response options available. Related, there is no discussion of the validity of the questions asked.

Food hygiene is indicated as a proxy for food quality, but there is little justification for this or what the definition of 'quality' is in this context. For instances, 'food quality' is often used to mean nutritional content, but I don't think food hygiene is a good proxy for nutritional content.

It would be helpful to give some indication of whether food hygiene ratings are currently available on food ordering apps.

There are some inconsistencies in the text – for instance:

1. it's claimed in the Plain Language Summary that dark kitchens are very common in the UK, but then noted in the introduction and discussion that it's not clear how common they are.
2. The aims in the abstract focus only on awareness and engagement with dark kitchens, whereas the main text aims additionally include traditional kitchens. Indeed, whilst the abstract and introduction frame the paper in terms of dark kitchens, the title is more inclusive and it seems very few questions in the survey were specific to dark kitchens
3. It's stated in the text that 40.0% purchased takeaway at least weekly, but in table 3 the figures are 0.1+0.3+2.4+34.3 = 37.1%
4. Findings related to concern with hygiene are presented in the abstract as specific to dark kitchens, but in table 6 they seem more generic to any takeaway purchasing

There are some other minor slips with referencing – for instance:

1. Keeble et al 2023 posit that increasing popularity of dark kitchens may have occurred during the covid-19 pandemic, not that they did
2. Keeble et al 2020 indicate that the nutritional quality of food available through online delivery services "remains unclear" – not that it is "low"

Some numbers in the tables don't add up and other details are missing. All tables should be checked carefully – for instance:

1. Student status % don't sum to 100 in Table 1

2. It's not clear in Table 2 if income per week, month, year or if it's adjusted for household composition
3. It's not clear in Table 4 if spend is per individual, per household, or something else.

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: I was co-applicant on a project funded under the same scheme as this work but I have never worked with any of the co-authors of this article.

Reviewer Expertise: Diet & public health, population interventions, natural experimental evaluations

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 06 Feb 2025

Jordan Beaumont

Comment: My key concern is the representativeness of participants and hence to whom findings are generalizable and how definitive the conclusions can be. Although it is claimed that participants are representative of the population in terms of age, sex and ethnicity no clear comparative data supporting this claim is cited.

Response: Our participant sample aligns with the latest census data; the Prolific platform takes the intended sample size and stratifies it across three demographics: age, sex and ethnicity.

For example, the estimated number of people with gender identity different from their sex registered at birth based on census data is 0.5% compared with 0.7% in our dataset.

Similarly, the current study aligns with census data for minority ethnic groups (e.g., Black, Black British, Black Welsh, Caribbean or African, Census = 4.0%, current study = 3.3%; Mixed or Multipleethnic groups, Census = 2.9%, current study = 2.5%).

We have made this clearer in the manuscript by adding the following sentences:
"A representative sample of the national population was recruited through the Prolific platform; sample size was stratified based on sex, age and ethnicity in line with Census data (Office for National Statistics, 2024)." (method, page 3)

"A representative sample of the UK population were recruited, with demographic profiles (for age, sex and ethnicity) aligning with the most recent Census data (Office for National Statistics, 2024)." (results, page 4)

Comment: There is also no comment made on representativeness according to socio-economic position.

Response: We have now added in data on socioeconomic position, based on Index of Multiple Deprivation (determined using postcode data). This has been included in Table 1.

Comment: Some acknowledgement in the discussion is made that participants may have been more technologically literate that the wider population, but the implications of this for how data should be interpreted are not made clear.

Response: The following text has been amended/added to address this: "Therefore, there is potential that their competence of using online apps and websites is greater than some other UK consumers meaning that accessing food online is commonplace and familiar, and this should be considered when interpreting the data."

Comment: There are also very few comparisons drawn to other data on takeaway purchasing that could also help with determining how representative the sample is. For example, how does the 40% purchasing takeaway food at least weekly and £20 weekly spend compare to data from Food & You, National Diet & Nutrition Survey, and Living Costs and Food Survey?

Response: We have compared our data with that from the Food and You survey, and included the following comments in the discussion (page 9) for context:

"This is slightly higher, but comparable to the Living Costs and Food Survey (Office for National Statistics, 2017), which suggested that the amount spent on takeaway foods and snacks consumed per household ranged from £2.80 to £12.70 per week."

"These findings align with the Food and You Survey, which reported that consumers' most common concerns were related to food safety and hygiene (33%) and food quality (29%) (Food Standards Agency, 2024). However, only 21% reported they had concerns with food,

suggesting that the unknown nature of dark kitchens may increase consumer concern."

Comment: Food and You also reports concerns with food hygiene and this comparison is also not drawn.

Response: We had added this comparison to the discussion (page 9), which now reads: "This is higher than the 43% of respondents who reported checking food hygiene ratings of food businesses (either at the business premises or online) in the Food and You Survey (Food Standards Agency, 2024). However, this may be due to better accessibility of information on third-party online food delivery platforms. Similar to the present findings, the Food and You Survey found consumers would not consume food from a restaurant or takeaway with a food hygiene rating of zero to two."

Comment: It is not clear how the content of the survey was derived – both in terms of the question stems asked and the response options available. Related, there is no discussion of the validity of the questions ask ed.

Response: The survey incorporates standardised questions (e.g., census demographic questions) with those generated by the research team in response to study aims. The team worked with PPI and stakeholder groups to produce a draft survey, which was then piloted and refined. A copy of the survey has been made available via the Open Science Framework (link in text). The following statement has been added into the method to provide clarity on this approach: "The survey was designed with input from Patient and Public Involvement (PPI) and stakeholder groups, and was refined and piloted prior to the study to ensure data collected answered the research aims."

Comment: Food hygiene is indicated as a proxy for food quality, but there is little justification for this or what the definition of 'quality' is in this context . For instances, 'food quality' is often used to mean nutritional content, but I don't think food hygiene is a good proxy for nutritional content.

Response: To provide further clarity, we have added the following statement to the discussion (page 9): "Food quality is a broad term which characterises aspects of foods that are important to governments, the food industry and consumers, including external factors (e.g., size, colour), internal factors (e.g., microbial load, foreign bodies, nutritional profile), texture and flavour (Tanner, 2016)."

Comment: It would be helpful to give some indication of whether food hygiene ratings are currently available on food ordering apps.

Response: This has been added on page 2, which now reads: "However, the online third-party aggregator platforms do provide a level of data transparency for the consumer by providing food hygiene ratings and other purchaser reviews on their platforms which are

easy to access, to allow the consumers to make more informed food choices."

Comment: There are some inconsistencies in the text – for instance:

- it's claimed in the Plain Language Summary that dark kitchens are very common in the UK, but then noted in the introduction and discussion that it's not clear how common they are.

Response: This has been amended to: "This work is important because dark kitchens are present in the UK and are a new type of food outlet which are less well-researched."

- The aims in the abstract focus only on awareness and engagement with dark kitchens, whereas the main text aims additionally include traditional kitchens. Indeed, whilst the abstract and introduction frame the paper in terms of dark kitchens, the title is more inclusive and it seems very few questions in the survey were specific to dark kitchens

Response: This has now been amended and reads: "The present work explores consumer understanding of and engagement with dark kitchen and traditional takeaway establishments."

- It's stated in the text that 40.0% purchased takeaway at least weekly, but in table 3 the figures are 0.1+0.3+2.4+34.3 = 37.1%

Response: This has been corrected.

- Findings related to concern with hygiene are presented in the abstract as specific to dark kitchens, but in table 6 they seem more generic to any takeaway purchasing

Response: This has been amended and now reads: "They are a contemporary addition to the food environment in the United Kingdom (UK), possibly finding popularity during the COVID-19 pandemic (Keeble et al., 2023)."

Comment: There are some other minor slips with referencing – for instance:

- Keeble et al 2020 indicate that the nutritional quality of food available through online delivery services "remains unclear" – not that it is "low"

Response: This has been amended and now reads: "The lack of clarity in nutritional quality of foods offered by many of these businesses (Fernandez & Raine, 2021; Keeble et al., 2020), and potential for poor food safety practices (Crawford & Benjamin, 2019) are cause for concern, and best practice is yet to be established."

- Keeble et al 2020 indicate that the nutritional quality of food available through online delivery services "remains unclear" – not that it is "low"

Response: This has been amended and now reads: "The lack of clarity in nutritional quality of foods offered by many of these businesses (Fernandez & Raine, 2021; Keeble et al., 2020),

and potential for poor food safety practices (Crawford & Benjamin, 2019) are cause for concern, and best practice is yet to be established."

Comment: Some numbers in the tables don't add up and other details are missing. All tables should be checked carefully – for instance:
1. Student status % don't sum to 100 in Table 1
2. It's not clear in Table 2 if income per week, month, year or if it's adjusted for household composition
3. It's not clear in Table 4 if spend is per individual, per household, or something else.

Response: These errors have been addressed, and all tables have been checked for errors and amended as required.

Competing Interests: None.