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# Deprivation and Healthy Food Access, Cost and Availability: A Cross-Sectional Study

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## Abstract

**Background:** Food access, cost and availability have been identified as determinants of dietary choice. It has been suggested that these are socioeconomically patterned, however the evidence is inconclusive. This study investigated whether differences exist in the access to, and cost and availability of healthy food between areas of contrasting deprivation.

**Methods:** An ecological, cross-sectional study was conducted in two of the most and two of the least deprived wards in Plymouth. Food retail outlets (FROs) (*n*=38) were identified and mapped using Geographic Information Systems (GIS) to assess 'physical access', by foot, to food retail provision. Healthy food basket (HFB) surveys were conducted (*n*=32) to compare the cost and availability of 28 healthy food items between the more and less deprived areas.

**Results:** Areas of poor access to food retail provision were identified in both study areas, with a higher number of households in the more-deprived areas being affected than in the less-deprived, after accounting for car ownership levels. Median [IQR] HFB availability was lower in more-deprived than the less-deprived areas (48%, [33%] *vs.* 75%, [14%]; P=0.003), and in convenience stores than supermarkets (54%, [29%] *vs.* 78%, [24%]; P=0.001). Descriptive summaries revealed negligible differences in total median HFB cost between the more-deprived and less-deprived areas (£55.97 *vs.* £55.94), and a larger cost difference between convenience stores and supermarkets (£62.39 *vs.* £44.25).

**Conclusions:** Differences were found in the access to, and cost and availability of healthy foods in areas of contrasting deprivation. These appeared related to FRO type rather than deprivation alone.

## Introduction

The 'food environment' has been implicated as a critical determinant of food choice[1]. If UK diets matched nutritional guidelines, almost 70,000 premature deaths from chronic non-communicable diseases (NCDs) could be prevented annually[2]. This is particularly pertinent to low socioeconomic groups (LSGs), due to the documented social gradient in the nutritional quality of the diet, finding that those on the lowest incomes consume more salt, sugar and saturated fat, and less fruit and vegetables[3]. However, dietary choice is multifaceted and complex, due to influences from a range of biological and societal factors[4]. Increasingly, research has focused upon the influence of the food environment on dietary choice, suggesting that food access, cost, and availability may be important determinants of the nutritional quality of the diet[5].

Food access refers to physical access to food retail provision[5] and is dependent upon geographical location and resources such as transport accessibility[4]. Geographic Information Systems (GIS) is considered useful for assessing food retail access[6], due its capacity to map and spatially analyse data[7]. Availability refers to the types of food retail outlets (FROs) in a geographical area, and the foods that they sell[8]. Previous research has measured the availability and cost of healthy food items using Healthy Food Basket (HFB) surveys[9,10], which have been found to have sufficient sensitivity to discriminate well between stores[9].

It has been suggested that food access, cost and availability are socioeconomically patterned, with research from the United States (US) finding that lower income areas have lower access to healthy foods[11]. Specifically, it was observed that the FROs in these areas offered lower healthy food availability, whilst also charging higher prices[12,13]. Areas where it is difficult to purchase healthy food items at a reasonable price are referred to as 'Food Deserts'[13]. The existence of Food Deserts is widely accepted in the US[14], however is vigorously debated in the literature elsewhere[13,15].

In the United Kingdom (UK), a comprehensive review of the evidence concluded that "Food Deserts do exist in the UK, but only for individuals who do not or cannot shop outside of their immediate locality, and when the locality itself has poor retail provision of healthy foods"[13]. It has previously been shown that deprived areas have reduced access to shopping facilities[16], which has been attributed to the rise of large, out-of-town superstores that tend to favour car owners[17]. As those from LSGs are less likely to own a car[18], this supports the existence of a social gradient regarding healthy food retail provision. However, a more recent systematic review contradicted this finding, concluding that unsubstantial evidence exists to suggest that food access is socioeconomically-patterned in the UK[14]. Research into the relationship between the food retail environment and dietary intake is still underdeveloped in the UK[5], and therefore the evidence remains inconclusive.

It is clear that more UK-specific research is needed regarding healthy food provision in the food retail environment. Therefore, this study aims to explore whether the level of deprivation affects the access to, and the cost and availability of, foods representative of a healthy diet.

## Methods

### Study Design

This exploratory ecological cross-sectional study investigated healthy food retail access in areas of contrasting deprivation in Plymouth; a South West UK coastal city. FROs were identified using primary and secondary data sources, and were mapped using GIS to determine areas of poor physical access, by foot, to food retail provision. Healthy food availability and cost were assessed and compared using a HFB survey. All data were collected during one week in May 2016, to minimise seasonable variations in food availability and cost.

### Food Retail Outlets

In line with previous research, the food retail environment was investigated and compared at electoral ward level[19,20,21]. The Indices of Multiple Deprivation (IMD) Electoral Wards Rank[22] was used to identify two of the most and two of the least deprived of the 20 wards in Plymouth, and were grouped to form two areas of contrasting deprivation. Electoral wards are aggregations of Lower Super Output Areas (LSOAs), which vary in size to maintain an average population of 1500 residents[23]. Identified wards in this study included St Budeaux and Honicknowle, ranked the third and fourth most deprived in Plymouth respectively; and Plymstock Dunstone and Plympton St Mary, ranked the two least deprived. The more-deprived area is comprised of 24 LSOAs and has a total population size of 28,173[24], whilst the less-deprived area, comprised of 21 LSOAs, has a population size of 25,173[24].

FROs were consecutively sampled from an extensive list of all identified FROs in the four wards, generated using secondary data sources including Local Authority databases, Google Maps, Yell.com, and websites of major food retailers and symbol groups (e.g. Premier). In line with other studies, 500m was deemed a reasonable distance to travel to FROs by foot[21] and thus FROs within 500 metres of the ward boundaries were included in the study, because residents on ward boundary edges would still have access to these FROs[19]. Included FROs were superstores (25-60,000 sq.ft.), supermarkets (3-25,000 sq.ft.) and convenience stores (<3000 sq.ft.), as defined in the UK by the Institute of Grocery Distribution (IGD)[25]. All other FROs were excluded, due to the observation that food shopping in England is most commonly completed ‘under one roof’[20].

To validate the secondary data sources used, all identified FROs were verified visually or by telephone contact, because primary data collection in the form of field work has been identified as the ‘gold standard’ for verifying the food environment[26]. Due to some identified discrepancies between the

classification of FROs on Google and retailers' own websites, the researchers re-classified FROs as per the IGD definitions. The definition of a convenience store is well-established[27], however due to practical limitations, store managers were relied upon to verify the classification between supermarket and superstore. From this, the 39 verified FROs were identified and invited to participate in the research. Consent to conduct in-store data collection was sought by postal letter and non-respondents were followed-up in-person.

ArcGIS version 10.4[28] was used to map the spatial co-ordinates of all 39 verified FROs, and to create 500 metre geographical buffer zones around each. Areas within the ward which fell outside of these zones were considered to have poor physical access, by foot, to food retail provision. Census datasets relating to car ownership were also incorporated at LSOA level[29]. This was to enable a visual appraisal of the percentage of households without car availability, that are located in areas identified to have poor physical access, by foot, to food retail provision.

**Healthy Food Basket Survey**

The cost and availability of 28 healthy foods were measured using a HFB survey (detailed in **Table 1**); an adaptation of the previously validated Healthy Eating Indicator Shopping Basket[30] (HEISB). The intention was to use a range of products representing a healthy, balanced diet, and therefore the adaptations were designed to better reflect the composition of the Eatwell Guide[31] and the South West UK locality of the study. An adapted version of food item descriptions and list of acceptable substitutions[9] were used to reduce the risk of systematic error during data collection. The costs of food items were recorded according to the cheapest own-brand product available in the sizes specified[9]. If this information was unavailable, the price-per-kilogram of product was recorded, along with the product weight, to enable the price-per-unit to be calculated. In line with previous research, promotional prices were not recorded[10]. Informed, signed consent was sought from FRO managers in order to conduct the surveys.

**Data processing and analysis**

Data were inputted into Microsoft Excel in duplicate, and cross-checked for consistency by another member of the research team to improve the inter-rater reliability. All data analysis was conducted by deprivation level (more-deprived, less-deprived), by FRO type (convenience store, supermarket) and by FRO subtype (more-deprived convenience stores, more-deprived supermarkets, less-deprived

convenience stores, less-deprived supermarkets) categories. No superstores were identified in the study areas.

Consistent with methodology from similar studies[9], to enable price comparisons between the HFB items across the FROs, varying product sizes were standardised to the specified unit in the substitution list. For those items without a weight, average weights for these items were determined, using values from three supermarket websites. Due to the small number of stores which stocked the full HFB a full HFB cost was calculated by deprivation level and FRO type using median prices-per-item.

The Mann-Whitney U test was conducted to determine differences in percentage HFB availability between deprivation level and FRO type. The Kruskal Wallis ANOVA was also conducted to determine differences in percentage HFB availability between FRO subtype. Dunns Pairwise Comparison with Bonferroni adjustment provided post-hoc analysis[32]. Statistical analysis was conducted using Microsoft Excel and IBM SPSS version 22.0[33]. Statistical significance was set at $P \leq 0.05$.

**Ethical Considerations**

Ethical approval was granted by the School of Health Professions Bachelor's Degree Ethics Subcommittee. To minimise risk of reputational harm, FRO data remained anonymous throughout the study process.

## Results

### Food Retail Outlets

Thirty-eight FROs were confirmed within the study areas, of which 32 consented to participate in the HFB survey, five declined, and one was closed for refurbishment at the time of surveying. The proportion of the total number of FROs is higher in the more-deprived than the less deprived areas (*n*=23 (61%) *vs.* *n*=15 (39%), respectively), with a higher proportion of convenience stores to supermarkets, both in the more-deprived (*n*=19 (83%) *vs.* *n*=4 (17%), respectively) and less-deprived areas (*n*=10 (67%) *vs.* *n*=5 (33%), respectively. The six non-participants of the survey were equally matched in terms of deprivation level and FRO type.

### Access

All identified FROs are shown in **Figure 1**, including 500 metre geographical buffer zones. Areas outside of these buffer zones were deemed to have poor physical access, by foot, to food retail provision. The percentage of households without car availability in these identified areas of poor access ranged from 13% to 46% in the more-deprived areas and 4% to 22% in the less-deprived areas.

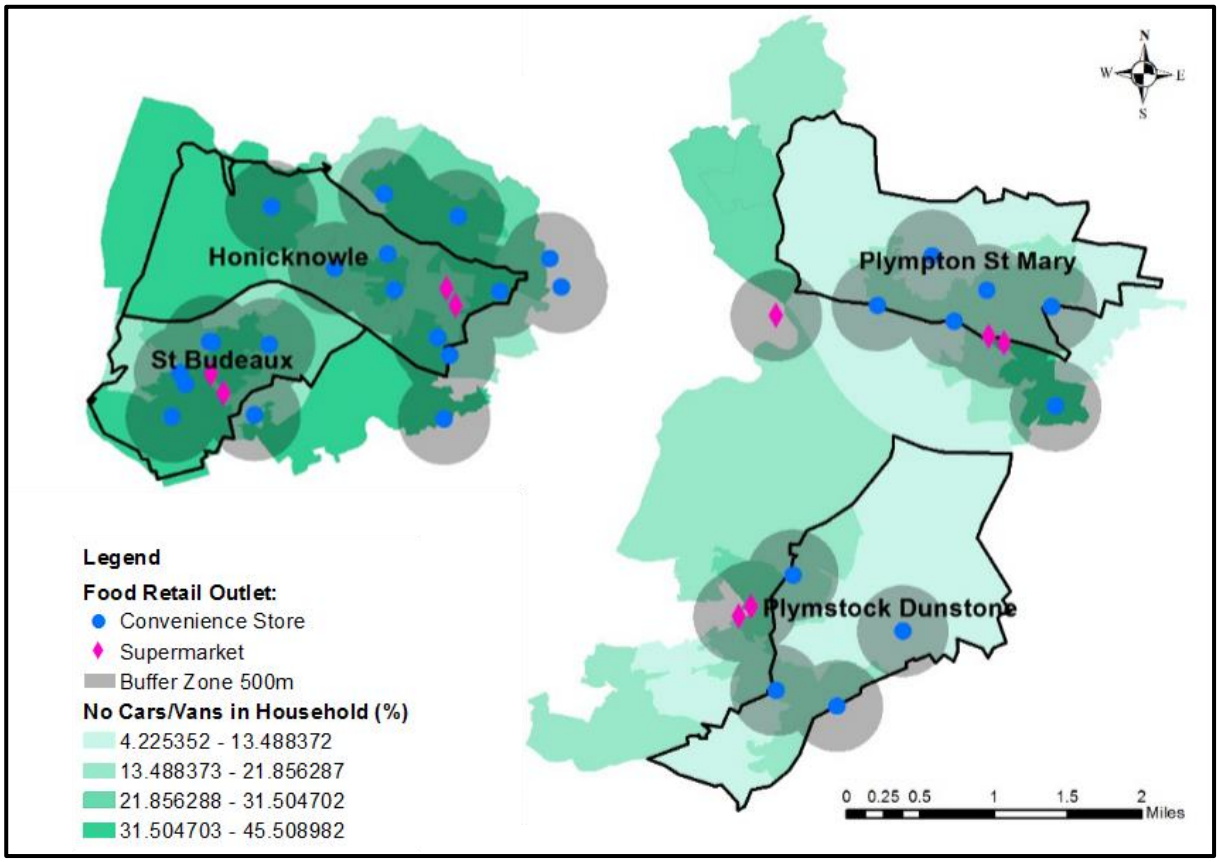

***Figure 1*** *Geographic Information Systems mapping of Food Retail Outlets in the more-deprived areas (Honicknowle and St Budeaux) and the less-deprived areas (Plympton St Mary and Plymstock Dunstone). Areas outside of the geographical buffer zones indicate poor physical access, by foot, to food retail provision, and car ownership data shows the percentage of households without car availability by Lower Super Output Area.*

**Healthy Food Basket Survey**

Descriptive summaries revealed negligible differences in median HFB cost between the more-deprived and the less-deprived areas (£55.97 *vs.* £55.44). However, a larger cost difference was found between convenience stores and supermarkets (£62.39 *vs.* £44.25). Subgroup analysis found that the median HFB cost was lower in both convenience stores and supermarkets in the more-deprived areas, than in convenience stores and supermarkets in the less-deprived areas (£60.15 and £42.30 *vs.* £63.60 and £45.48, respectively).

Across the 32 FROs surveyed, four (13%) stocked all 28 HFB items, whilst 21 (66%) stocked at least half of the HFB. Median [IQR] HFB availability was lower in the more-deprived areas compared to the less-deprived (48% [33%] *vs.* 75% [14%]; U=195.000, P=0.003), and in convenience stores compared to supermarkets (54% [29%] *vs.* 78% [24%]; U=153.500, P=0.001). This data is reported in **Table 1**. Median HFB availability differed by FRO subtype ($H^2$=16.272, P=0.001), with the largest difference identified between convenience stores in the more-deprived areas and supermarkets in the less-deprived (P=0.018). Differences in availability were also found between convenience stores in the more-deprived areas and convenience stores in the less-deprived (P=0.044); and between convenience stores in the more-deprived areas and supermarkets in the less-deprived (P=0.047).

**Table 1.** Differences in Availability of Healthy Food Basket Items (%) by Deprivation Level and Food Retail Outlet Type.

| | **Deprivation Level** | | **Food Retail Outlet Type** | |
|---|---|---|---|---|
| | High (*n*=20) | Low (*n*=12) | Convenience Store (*n*=25) | Supermarket (*n*=7) |
| Food Item (*n*=28) | Stocked[a] (*n* (%)) | Stocked[a] (*n* (%)) | Stocked[a] (*n* (%)) | Stocked[a] (*n* (%)) |
| Brown rolls | 13 (65) | 13 (65) | 18 (72) | 7 (100) |
| Potatoes | 19 (95) | 19 (95) | 24 (96) | 7 (100) |
| Brown rice | 4 (20) | 4 (20) | 5 (20) | 3 (57) |
| White rice | 20 (100) | 20 (100) | 25 (100) | 7 (100) |
| Pasta | 20 (100) | 20 (100) | 25 (100) | 7 (100) |
| Weetabix | 18 (90) | 18 (90) | 22 (88) | 7 (100) |
| Wholemeal bread | 15 (75) | 15 (75) | 20 (80) | 7 (100) |
| Apples | 16 (80) | 16 (80) | 21 (84) | 7 (100) |
| Bananas | 14 (70) | 14 (70) | 19 (76) | 7 (100) |
| Grapes | 12 (60) | 12 (60) | 16 (64) | 7 (100) |
| Orange | 10 (50) | 10 (50) | 14 (56) | 7 (100) |
| Orange juice | 19 (95) | 19 (95) | 24 (96) | 7 (100) |
| Broccoli | 10 (50) | 10 (50) | 14 (56) | 7 (100) |
| Carrots | 12 (60) | 12 (60) | 17 (68) | 7 (100) |
| Cucumber | 14 (70) | 14 (70) | 19 (76) | 7 (100) |
| Lettuce | 13 (65) | 13 (65) | 17 (68) | 7 (100) |
| Onions | 20 (100) | 20 (100) | 25 (100) | 7 (100) |
| Peas | 18 (90) | 18 (90) | 23 (92) | 7 (100) |
| Peppers | 13 (65) | 13 (65) | 18 (72) | 7 (100) |
| Tomatoes | 19 (95) | 19 (95) | 24 (96) | 7 (100) |
| Semi-skimmed milk | 20 (100) | 20 (100) | 25 (100) | 7 (100) |
| Skimmed milk | 14 (70) | 14 (70) | 19 (76) | 7 (100) |
| Low-fat yoghurt | 12 (60) | 12 (60) | 16 (64) | 7 (100) |
| Lean beef mince | 3 (15) | 3 (15) | 2 (8) | 6 (86) |
| Chicken breast | 13 (65) | 13 (65) | 16 (64) | 7 (100) |
| Salmon | 6 (30) | 6 (30) | 8 (32) | 7 (100) |
| Baked beans | 20 (100) | 20 (100) | 25 (100) | 7 (100) |
| Low-fat spread | 10 (50) | 10 (50) | 14 (56) | 7 (100) |

[a] Category consists of groups: 'in-stock', 'out of stock, awaiting delivery', not stocked but 1st substitute available', not stocked, but 2nd substitute available'.

## Discussion

This exploratory study investigated whether deprivation level affects the access to, and cost and availability of healthy foods. Areas of poor physical access, by foot, to food retail provision were identified in both study areas. However, within these areas of poor access, local data shows that more households in the more-deprived areas did not have access to a car or van compared to in the less-deprived[29] (**see Figure 1**). Previous research has failed to demonstrate socioeconomic patterning regarding the access to healthy food retail provision[34], however it has been found that those living in the more-deprived areas are less likely to have access to a car[27]. Despite their use of taxis[13] and online food shopping[35], individuals without car access are significantly more likely to travel home from food shopping by foot[36]. Therefore, they are likely to be particularly susceptible to changes in the local food retail environment regarding the provision of healthy food. Interestingly, the more-deprived areas contained more convenience stores and fewer supermarkets than the less-deprived areas[9]. As less individuals in the more-deprived areas had access to a car or van[29], this suggests a heavier reliance upon convenience stores for those living in more-deprived areas.

In terms of the cost of healthy food, it was expected to find that convenience stores charged more on average for the full HFB, and that this is supported by existing literature[13]. Therefore, it was surprising that negligible differences were found in the cost of healthy food between the more and the less-deprived areas. Whilst this aligns with findings by White et al.[13], it contrasts with others in the literature. Dawson et al.[9] found that healthy food cost less in less deprived areas, whilst Cummins and McIntyre[12] found that it cost more. An explanation for this finding is that cost data were only obtainable for in-stock items, therefore causing a bias towards the FROs that had higher availability and corresponding lower costs. Previous researchers have also encountered difficulties in comparing the cost of food baskets[9,13,21], with Beaulac et al.[14] attributing the mixed findings to the low methodological quality of the studies cost comparisons. As such, findings relating to HFB cost in the present study, and indeed other food basket surveys, should be interpreted with caution. Despite this, the findings from the present study suggest that the average cost of healthy food is comparable between areas of contrasting deprivation, however clearly identifies considerable differences in the cost of healthy food between convenience stores and supermarkets. Considering the higher proportion of convenience stores in more-deprived areas, this suggests a social gradient in the cost of healthy food.

The differences found in HFB availability between ward deprivation level were expected. On average, availability was lower in the more-deprived areas compared to the less-deprived. Specifically, wholegrain carbohydrates, fruit and vegetables, low fat dairy products, lean meats, oily fish and low fat spread were less frequently stocked in the more-deprived areas (**see Table 1**). This finding accords

with previous research[9], and is important because it suggests that residents of deprived areas could struggle to eat healthily[37]; thereby increasing their risk of NCDs[38]. However, findings from a larger study by White et al.[15] contradict this, countering that healthy food availability is not socioeconomically patterned, but is instead associated with store type. It is plausible that the findings from this small scale local research are a result of the high prevalence of convenience stores in the most-deprived area, which were found to have a lower availability of healthy foods compared to supermarkets. This finding is undisputed in the literature[38], and in previous research has been attributed to the lower demand for healthier and more perishable foods in deprived areas[15].

It was interesting to find that the more-deprived areas contained more convenience stores and fewer supermarkets than the less-deprived areas. This indicates that there is the potential for convenience stores to influence the food retail environment in deprived communities, where it is suggested that larger retailers avoid trading due to lower levels of disposable income in these areas[40]. Despite finding that convenience stores offered a lower provision of healthy foods, anecdotal evidence collected found that some convenience store retailers were willing to stock healthier food items. One ordered wholemeal bread upon customer request, whilst another stocked competitively priced, fresh produce variety packs suitable for single household customers. These observations highlight the potentially pivotal role that convenience store retailers could play in enhancing healthy food provision in deprived areas, however indicates that some stores could benefit from additional education and support to replicate this. As households in the more-deprived areas appeared most likely to depend upon these stores, these promising anecdotal findings warrant further investigation. However, it should be recognised that there is little incentive for improving the availability of healthy foods if there is no demand[41] and so this recommendation would need to be considered within the wider determinants of food choice[42]. Community and public health dietitians promote the importance of a healthy diet within their local communities, and so would be appropriately placed to lead this partnership with convenience store owners.

This study provides a unique insight into the food retail environment in areas of contrasting deprivation in a South West UK coastal city. However, due to the specific locality of the four study areas, the generalisability of the findings to other areas may be limited. Strengths include the thorough identification and mapping of food retail outlets, in addition to the comprehensive assessment of HFB availability, which further validates the previously developed HEISB tool[30]. However, methodological limitations are inherent in all research, and this study was no exception. Firstly, the study's ecological and cross-sectional design was unable to differentiate cause and effect from simple association[43]. Secondly, the linear ArcGIS assessment of distance is somewhat over-simplistic. The mapping of walking, driving and public transport routes would have generated the most

comprehensive depiction of the food retail environment, however was beyond the scope of the study. Finally, the approach taken to compare the cost of HFB items has resulted in some being disproportionately adjusted, which has consequently reduced the validity of these findings. Despite the limitations highlighted, the findings from the present study will help to inform research regarding the physical and social determinants of food choice; an area of key importance for public health professionals.

## Recommendations and Future Work

This exploratory research provides a better understanding of inequalities in healthy food provision, and offer insight into why individuals from LSGs can fail to adhere to nutritional recommendations[44]. The largest scope to make a difference lies in areas where individuals are most reliant upon their local food retail environment, which itself offers poor healthy food provision[13]. This highlights an area where public health specialists, public health dietitians and policy makers may have the largest impact. Interventions to increase healthy food provision could be achieved through partnership-working with convenience store retailers, building on the previous successes of Change4Life[45]. Such initiatives could include the redesign of store layouts to ensure prominent positioning of healthier foods, and introducing legislation to increase the display of healthier foods at the point of sale and on in-store communications. Additionally, store owners could be encouraged to increase their provision of less-perishable healthier food items[46]. It would be interesting to develop this research further, to explore the extent to which the access to, and cost and availability of healthy food influences consumer dietary choice. This could complement research investigating both the influence of the retail provision of unhealthy food[47], and the density and location of fast food outlets, on dietary choice[48,49].

## Conclusions

Differences were found in the access to, and cost and availability of healthy foods in areas of contrasting deprivation. These appeared related to FRO type rather than deprivation alone, with convenience stores consistently demonstrating lower healthy food availability than supermarkets, and at a higher cost. Future interventions to improve the access to, and cost and availability of healthy food should concentrate upon the more-deprived communities, and partnership-working between public health professionals and convenience stores could be pivotal in this process.

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**Transparency declaration:** The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported, that no important aspects of the study have been omitted and that any discrepancies from the study as planned (and registered with) have been explained. The reporting of this work is compliant with STROBE[50] guidelines.

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