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7 **Identifying Notions of Environment in Obesity Research Using a Mixed Methods Approach**

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Identifying Notions of Environment in Obesity Research Using a Mixed Methods Approach

Abstract

The research field of obesity and environment has been variously framed in a-priori ways in grid-like and/or hierarchical form. Network analysis allows a new way of considering the relationality of this field. We use machine reading, network analysis, semantic analysis and qualitative analysis of 414 highly-cited publications on environment and obesity between 2001 and 2015 to produce a network map which exhibit five distinct notions of environment, all of which are active in the field of obesity research. These are: institutional, built, food, family, and bodily. They do not come together as a single well-defined and well-described system , but overlap, interpenetrate and leave gaps. Examination of the degree to which research into obesity and environment can be understood as coherent or coordinated, shows that the field can be interpreted variously as: being simultaneously integrating and disintegrating; a partially coherent hierarchy; and/or a pattern of simplification and complexification. Future analyses incorporating larger datasets and a longitudinal comparison should give further information on the merit of each of these three interpretations. The map is proposed as a navigational tool for policy actors to coordinate efforts between stakeholders and for researchers to coordinate research plans in light of different positions in the field.

Introduction

In the past two decades obesity research has increasingly moved from studying isolated factors to adopting ecological views of the coherent complex of factors that may condition obesity (1). A key

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4 role in this development has been played by Swinburn et al. (2), who in 1999 introduced the notion
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6 of *obesogenic environments*, which they defined in their words as ‘the sum of influences that the
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8 surroundings, opportunities, or conditions of life have on promoting obesity in individuals or
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10 populations’. In addition to this definition, Swinburn et al. proposed the ANGELO framework
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12 (analysis grid for environments linked to obesity) - a 4x2 grid that ‘dissects’ the obesogenic
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14 environment into a number of factors. Along one dimension, the environment is split into four
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16 types: the physical, the economic, the political and the socio-cultural. Along the other dimension,
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18 environments are dissected into two sizes: micro and macro.
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21 Swinburn’s notion of obesogenic environments has inspired significant research into obesity
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23 ecology and it has turned attention to combinations of environmental factors such as the
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25 preponderance of motorized transport, sedentary occupation, and cheap and energy-dense food (3).
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27 Among policy-makers, especially in the United Kingdom, the concept of obesogenic environments
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29 has been used to frame obesity as a societal challenge requiring a broad coordinated effort [4-7]. In
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31 this context, the notion of obesogenic environment has become a vehicle for joining up government
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33 and research for collective effort (8). In the wider world, the notion of obesogenic environment has
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35 also caught on as a way of grasping that the current rise in obesity rates is rooted in ways of life
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37 broadly, rather than with any particular factor (9). Recently, Swinburn’s notion, and more the
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39 specifically the ANGELO grid, have been used to review the field of obesity studies (10). This
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41 review talks of an ‘explosion of obesogenic environment research’ and identifies no less than 146
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43 primary studies. But despite of this, it concludes that several cells in the ANGELO grid are sparsely
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45 covered.
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49 The rise of ecological thinking in relation to obesity, as exemplified by the notion of
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51 obesogenic environments, may be indicative of a general willingness to collaborate and combine
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53 knowledge. But this does not mean that coherence and coordination is within easy reach. On the
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4 contrary, policy approaches to control or regulate aspects of such environments appear to be very
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6 difficult to coordinate, since they involve a wide range of stakeholders (11-17). It is not unlikely
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8 that policy actors and other stakeholders have very different ideas about the issue of obesity, despite
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10 common adherence to the idea of making a coordinated effort to make environments less
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12 obesogenic. Despite the relatively broad-scale adoption of the term obesogenic environment, the
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14 growing field of obesogenic environment research field may not be summed up by Swinburn's
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16 original grid.
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19 A good deal of obesity research has an ecological perspective, much of it being directly
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21 inspired by the Swinburnian notion obesogenic environment. But there is little reason to presume
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23 that all research on obesity and environment adheres to it in a strict sense. In this analysis we
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25 attempt to understand how environment is considered in obesity research, and the degree to which
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27 this effort can be understood as coherent or coordinated, using a mixed methods network analysis
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29 approach. From the abundant scientific literature on obesity-related issues, we collected a large
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31 number of highly-cited articles that specifically address obesity and environment. Within this
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33 corpus of articles, we have systematically explored the different ways in which the notion of
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35 environment is used, by developing and applying a mixed methods design (18) that involves
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37 machine reading and semantic analysis of an extensive literature on obesity and environment using
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39 a terms-extraction algorithm, visual network analysis of co-occurring terms, and qualitative analysis
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41 of the resultant network map.
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45 The network map, we propose, is a navigational tool that researchers can use to help them
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47 understand their work in relation to other positions within the field of obesity and environment. The
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49 map should also be of use to policy actors who wish to overview and coordinate efforts between
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51 differently positioned stakeholders. The map may be a starting point for broader reflections on the
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53 configuration, differentiation and coherence of obesity research more generally.
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Methodology: A computation-based mixed methods design

The mixed methods design used to produce a map of discursive regions of obesity and environment (a particular way of framing obesity as indicated by a tendency to use particular sets of terms) involved three specific goals. First, the method was designed to investigate the practices of the most influential authors in this scientific field. We therefore built on a dataset of recent and highly-cited articles in the most widely recognized interdisciplinary publication databases. The second goal was to articulate the less visible qualitative differences among influential authors in the field. We therefore used a quantitative word extraction algorithm that prioritizes differences rather than commonalities. The third goal was to explicate different notions of environment within this body of literature . We therefore investigated each of the discursive regions qualitatively to identify their underlying assumptions, and to determine the relationships between the clusters. Our division of labour was as follows: Jensen and Hansen were responsible for the data preparation work (assessment of article relevance). Munk and Madsen were responsible for the quantitative data analysis and production of the network map. Jensen, Hansen, Ulijaszek, Hillersdal and Jespersen were responsible for the qualitative analysis. All authors read and contributed to the final text.

Building the dataset

The literature corpus comprised of 500 highly-cited papers on obesity and environment from between 2001 and 2015. The starting point, 2001, was chosen because the publication that coined the term obesogenic environments (2) began to play a role in the literature around this time. The choice of end point, 2015, was pragmatic and organizational, being the latest full year before the authorship could undertake the analysis. We settled for 500 papers because they represent, in our

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4 estimation (see below), roughly a third of the total volume of papers on obesogenic environments
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6 from that time period. We have made the assumption that the most cited third of this total volume of
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8 publications would allow us an overview of the main themes in the field across this period. The
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10 articles were sourced from Web of Science (WoS) and Scopus, which are by far the two largest and
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12 most widely recognized cross-disciplinary research publication databases in the English-speaking
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14 world. The two databases were chosen because we expected them to offer the best reflection of the
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16 practices of the dominant and most institutionally recognized actors in the field of obesity research.
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18 Scopus and WoS both have a significant bias toward English-language literature and toward the
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20 fields of biomedical science, natural science and engineering (19). Despite these biases, the
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22 databases also contain a large number of journals from the social sciences and humanities, which
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24 appear in our sample of highly-cited articles. The analysis undertaken did not allow an examination
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26 of whether or not social sciences and humanities talk about environment differently, but this could
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28 be done with larger datasets in the future. The likely bias of these databases might be viewed as a
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30 source of error, but the particular selection of articles in these prestigious databases also helps in
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32 discovering the prevailing discourses among the most powerful actors in the field (20). This is an
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34 issue for our research, but also more broadly for all obesity science, as the platformization of the
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36 internet structures what can and cannot be found, in the scientific literature and more broadly. In a
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38 similar way, our choice of selecting highly-cited articles, rather than randomly sampled articles or a
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40 fixed number of articles from each year, reflects our intention of identifying a broad spectrum of the
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42 most influential and broadly recognized notions of obesogenic environment. However, this
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44 sampling strategy works to the disadvantage of relatively small disciplines that have little influence
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46 on the field in general.
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51 On a more pragmatic level, data sampling had to take account of the differences in coverage
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53 between Scopus and WoS. While both WoS and Scopus are stable enough in volume across
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journals and over time for cross-disciplinary and longitudinal comparisons (23), their coverage has also been found to diverge, with Scopus generally covering more journals and disciplines in a less systematic way than WoS (24, 25).

The search was carried out in February 2016. From WoS we produced a ranked list of 1044 papers by querying the ‘topic’ as *obesity*, the ‘title’ as *environment*, and restricting the search to *articles*. From Scopus we produced a ranked list of 891 papers published between 2001 and 2015 by querying ‘article title, abstract or keywords’ as *obes**, ‘article title’ as *environment*, and ‘document type’ as *article*. Since Scopus and WoS do not offer the same search interface, it was necessary to use different search strings to approximate the search results on the two platforms. As Scopus has a tendency to estimate a higher number of citations than WoS for the same article, we could not simply merge the two lists to retrieve the 500 most cited papers without skewing the selection in favour of Scopus results. Since we wanted full text copies of the articles, we also had to work within the boundaries of the access granted by our library (Aalborg University Library). We therefore decided to retrieve the most cited fully accessible papers from each of the two lists, checking for and eliminating duplicates as we went along, until reaching a total of 500 papers.

Figure 1 shows the distribution of papers by year of publication. As expected, recently published papers were not yet widely cited and were therefore less prevalent in the set. The scarcity of papers between 2001 and 2005, however, can both be due to a lack of published material on the topic of obesogenic environments, or a result of papers not being cited very much in that period. To ensure that all papers were on topic, we assessed them manually, reducing the corpus from 500 to 414 papers. This reduction of the set did not significantly alter the distribution of papers over time (Figure 1). In the final sample, the number of citations to each paper ranged between 17 and 800. A full list of the 414 articles included in our sample can be found in the supporting information for this article.

[insert Figure 1]

Figure 1: Distribution of papers before and after manual cleaning.

Semantic analysis of the corpus

We used the open source software, CorTexT (24) to obtain a ranked list of multi-terms from the corpus through successive stages of semantic analysis. The first of these stages is known as Part of Speech (PoS) Tagging. PoS tagging analyses the sentence structure to attribute a word class to each of the terms found in a sentence (noun, verb, adjective, adverb, etc.). Having performed PoS on the corpus we were able to build a list of all noun phrases (combinations of nouns and adjectives) found in the corpus (this process is known as chunking). After automatically correcting orthographical errors and lemmatizing each term to its stem, noun phrases that are identical on the stem level were merged. For instance, the phrases ‘diet quality’, ‘quality diet’ and ‘quality of the diet’ were merged as ‘diet quality’. If a shorter multi-term was nested in a longer multi-term, the longer multi-term was prioritized. For instance, if choosing between ‘diet quality’ and ‘high diet quality’ as a phrase, the latter would be prioritised. We set the maximum multi-term length at 4. This was a qualitative decision taken after reviewing the results of setting the length at 2 and 3, which turned out to force artificial cuts in many of the multi-terms, as for example ‘quality of the diet’. We then proceeded with a ranking procedure aimed at prioritizing the terms that carry the most *specific* information about the research question. By specificity we mean terms that appear with a high frequency in a small part of the sample – as opposed to generic terms that are used evenly in all parts of the sample. As we explain the following, the ranking according to specificity was based on the calculation of a so-called specificity score. The procedure was as follows: we first counted the frequency of each multi-term in the corpus and set a minimum frequency to reduce the list. Because

we were interested in the discourse that is *particular* to a specific subset of papers on obesity and environment rather than the discourse that is generic to all papers on obesity and environment, we set the minimum frequency to 3 documents, indicating that a multi-term must be present in at least 3 different papers in order to be considered. We then calculated the specificity score of the remaining multi-terms (25). Specificity presumes that terms generic to all papers will exhibit an unbiased distribution across the corpus and will be therefore irrelevant to this analysis while, conversely, the terms that occur in specific parts of the corpus are relevant because they help show differences in notions of environment across the field. For instance, if ‘diet quality’ occurs frequently in 50 papers but is never found in the rest of the corpus it will receive a high specificity score, where as if it occurs with equal frequency in all the papers it receives the lowest specificity score. In this way, we calculated how much the distribution of each multi-term across the corpus deviated from its unbiased distribution (chi-squared) and ranked the multi-terms according to how much they deviated – that is according to their specificity.

Finally, we produced a list of the top 500 most specific multi-terms. The size of the terms list (500 items) was chosen based on several iterations in CorTextT with smaller and larger lists. The number 500 was a pragmatic choice between shorter lists that appeared to leave out several relevant multi-terms (e.g. ‘ecological models’ and ‘food outlet density’), and longer lists that appeared to include large amounts of superfluous terms (e.g. ‘high levels’ and ‘age and gender’). CorTextT allows the terms list, including the ways in which terms are stemmed and merged, to be edited. One significant artefact of our dataset was the names of authors and journals that figured prominently in the extracted list of high-specificity multi-terms. Given that this information is already contained as metadata associated with each paper and tells us little about the ways in which the topic of obesogenic environments is framed, we decided to filter out author and journal names from the terms list. We also manually cleaned out a small number of overly generic terms that were not

captured by CortexT's specificity filter (e.g. 'corresponding author', 'email address' and 'research agenda').

Visual network analysis

To identify discursive patterns in the corpus (i.e. specific styles in the way obesity and environment are talked about), we produced a network of co-occurring multi-terms, within the same article. If two different multi-terms were used in the same article they would be connected by an edge (or a line, in everyday usage) in the network. The more frequently two terms co-occur, the heavier the edge becomes. A heavier edge is visually represented as a thicker line in the network. We filtered out the weakest edges to improve the clarity of the visualisation. CorTexT facilitates this by engaging a distributional measure that normalises the weight of an edge on the global connections of its two nodes. Edges between nodes with a high likelihood of being connected (because they are already globally well connected) must be heavier to be taken into account in analysis than edges between nodes with low likelihood of being connected.

The visual layout of the network (Figure 2) was obtained by spatialising the nodes with a spring based (or force vector) algorithm (26). This introduces a repulsive force between all nodes and allows the edges to act as springs holding connected nodes together. Heavier edges act as stronger springs, causing frequently co-occurring terms to be held more closely together than less heavy edges. Visual proximity between nodes can therefore be interpreted as their tendency to be used in the same contexts (in our case papers). Conversely, distance between nodes can be interpreted as the extent to which they are rarely (or never) used in the same context. Clusters of closely connected terms can be interpreted as a subset of papers with a tendency to frame discussion of the notion of obesity and environment in the same way. These clusters are what we refer to as

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4 *discursive patterns*, because the presence of a cluster shows a recurrent practice of using particular
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6 terms together that is distinctive to a certain subset of papers within the dataset.
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8 To aid the visual identification of clusters, community detection (i.e. the search for
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10 interconnected clusters of co-occurring themes) was performed using the Louvain method (27).
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12 This method explores different ways of partitioning the network until it finds the solution with the
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14 highest modularity score. A higher modularity score is obtained by minimizing the number of edges
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16 that cross between partitions. The nodes are coloured based on this partition, and nodes of the same
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18 colour can thus be interpreted as belonging to the same community of frequently co-occurring
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20 terms. The choice of colour carries no meaning. The supporting information for the electronic
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22 version of this article contains a zoomable overview map as well as magnified pictures of each of
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24 the clusters in the map.
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30 [insert Figure 2]
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32 Figure 2. Network map of the discursive patterns in 414 articles related to environment and obesity
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34 research.
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38 Qualitative analysis of the map 39

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41 Each cluster in Figure 2 represents a discursive region. The aim of the qualitative analysis was to
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43 explicate these ‘ways’ or more precisely the underlying notions of obesity and environment and the
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45 figures of thought that appear to guide researcher’s choices of how to frame and speak about their
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47 research.
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49 To structure our qualitative analysis, we posited that any particular notion of obesity and
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51 environment could be characterised by describing three key elements: (a) the kinds of elements and
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53 processes that constitute the environment ; (b) the kind of ‘object of research’ which is believed to
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4 be contained and influenced by that environment; and (c) the presumed mechanisms of interaction
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6 between object and environment. This simple conceptualization was used both to guide our
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8 qualitative analysis and to summarize its results.
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10 The qualitative analysis was conducted as a three-step-process. Firstly, we assessed the
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12 terms in each cluster as they appeared on the map in order to generate preliminary descriptions of
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14 the environment, object of research and mechanism of interaction specific to each cluster. Those
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16 preliminary descriptions were then checked against the underlying article corpus typical for each
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18 cluster. If confirmed, illustrative articles were searched for, to serve as examples in the description
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20 of clusters. Secondly, we compared the identified environment, object of research and mechanism
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22 of each cluster to other clusters, clarifying how they differed from, and/or were related to each
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24 other. In this comparison, the edges connecting the different clusters on the map were used as
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26 indicative of the differing extent of shared notions between the clusters. In some cases, the second
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28 step called for an iteration of step one. Thirdly, the qualitative analysis was condensed into short
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30 descriptions focused on the notion of environment, the object of research, and the mechanism of
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32 interaction for each cluster.
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36 In general, the qualitative analysis pursued an iterative approach in which the starting point
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38 was always the map and its clusters, terms, colours and edges. Whenever the map needed further
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40 interpretation, or whenever preliminary assumptions needed to be substantiated, the underlying
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42 corpus of articles was consulted.
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Results

Five notions of obesogenic environment were identified: institutional, built, food, family, and bodily (Figure 2 and Table 1).

[insert table 1]

Table 1. Five environments related to obesity, including their objects of research and key mechanisms of interaction.

Institutional environment

The environment in this cluster consists of *institutions* – predominantly schools and other organisations providing child care. The object of research is *institutional food services* as these appear in regulated food environments, and the mechanism of interaction is *policies and their implementation*. The centre of concern and regulation are school lunches and to some extent other meals. Many of these studies originate in countries with state funded or state subsidised school meals (e.g. (28)). Studies can both examine existent supply of, or interventions into, institutional food services.

Articles typical to this cluster contain a number of terms that specify the environment or the object of research. The object is specified with terms such as “school meals”, “vending machines”

“sugar sweetened beverages”, whereas the environment appears in the form of institutions and regulatory bodies such as “Department of Agriculture”, “Department of Health” or “school districts” which are stakeholders in the making of institutional food policies. Specific policies (the mechanism of interaction) are also mentioned - for instance “dietary guidelines”.

The foods named are often calorie-dense highly processed products such as “french fries”, “snack bars” and “ice cream”, making them easy to single out as risk foods and targets for intervention. A smaller, less pronounced theme is that of “physical education”, which also appears in this cluster. In all, the cluster points to policy efforts towards making schools and institutions into sites for obesity prevention.

Built environment

The built environment cluster is concerned with the physical surroundings of humans – especially as designed and built, and how this influences energy expenditure, which in turn influences population health (e.g. (29)). Its focus is overwhelmingly on measurement and reporting. It differs from the institutional environment, which largely describes the regulatory context in which schools provide food for children. The key object of research of the built environment cluster is *population obesity*, which is predominantly defined and measured by Body Mass Index (BMI) and sometimes by other anthropometric measures such as skinfold thickness (e.g. (30)). The key mechanism of interaction is *energy expenditure* through physical activity.

The primary focus of this cluster is to define, measure and test a number of different aspects of the built environment that might influence the levels of physical activity of people in it. Studies included in this analysis either examine the existing outlay of environments or report from interventions into it. A common background assumption is that the current infrastructure planning has favoured passive modes of transport, such as cars, trains and escalators (e.g. (31)). Articles also

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4 focus on how the neighbourhoods that promote the integration of physical activity into everyday
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6 life activities – such as walking to the grocery store instead of driving. The articles featured in this
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8 cluster place emphasis on relationships between place and obesity, as well as on place and health
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10 behaviours which might lead to obesity. An often-used research design is to compare
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12 “neighbourhood walkability” of cities as measured by built environment features such as “street
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14 connectivity”, “recreation facilities”, and the availability of “green spaces”, the “air quality” or the
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16 “physical activity” of its residents (29, 32, 33). Other features of the urban environment, such as
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18 “traffic safety” and “crime safety”, are also used as bases for comparative studies and as potential
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20 mediators of physical activity behaviour.
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Food environment

Articles typical to this cluster focus on themes related to the *food environment*, which differs from the institutional environment in that it is concerned with the general availability of food in non-institutional contexts. It is assumed to interact with *population obesity* - the object of research - through the interaction mechanism of *energy uptake*. Food environment is often measured in terms of the immediate availability of food in the near neighbourhood, as signified by terms such as "neighbourhood food environment" or "local food environment". Obesity is typically measured by BMI (e.g. (34)). These articles examine a broad range of phenomena, which are presumed to influence energy uptake. Calorie uptake is often not measured directly but rather indirectly assessed through studies of the availability, content and quality of the food in the immediate neighbourhood environments, or by measuring the spatial accessibility to "fast food restaurants", "full service restaurants", types of "grocery stores", "convenience stores" and others (e.g. (35)). Other studies examine the availability of particular food items such as "fresh fruit and vegetables" (e.g. (36)). Neighbourhoods with notably poor availability of healthy foods or food outlets are sometimes described as "food deserts" with detrimental health outcomes (e.g. (37)). The food environment cluster includes a more predominant focus on socio-economic status than the other clusters, which is indicated by terms such as "health disparity", "neighbourhood poverty" and "social cohesion" (e.g. (38)). In general, the interaction mechanism of energy uptake plays a key role in most of the articles typical of this cluster.

Family environment

This cluster is concerned with the environmental features defined by parental regulation and the family home. In this case, the object of research is *population obesity in children and adolescents*, which is typically measured by BMI. The key mechanism of interaction is *energy expenditure and*

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4 *intake*, which is influenced by family practices such as eating habits, diet, physical activity and
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6 sedentary behaviour. These practices are indicated by terms such as “screen time”, “home food
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8 environment”, “parental influences”, “food choice” and “fruit and vegetable intake”. “Maternal
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10 education” maps alongside “parental education”, there being no independent mapping for fathers.
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12 The cluster focuses on both supply- and demand-sides of energy balance, setting it apart from the
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14 clusters that only focus on supply (food environment) or demand (built environment). It shares a
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16 similar focus on children and youth as the institutional environment.
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19 Within this cluster, there is an additional research interest in the long-term effects of early
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21 life on the health outcomes in adulthood and old age. This life course perspective often informs
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23 obesity prevention policies that target family environments (39).
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26 In sum, the articles typical of this cluster explore a broad range of family environment
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28 features that are assumed to influence energy intake and expenditure, and consequently the
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30 production of obesity among the younger generation. As this particular subset of the population also
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32 comprises the future adult population, this cluster is concerned with interventions directed at
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34 existing obesity levels in children and adolescents as well as with long term obesity prevention.
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38 Bodily environment

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41 In this cluster, the environment is an internal physiological one, unlike all the other clusters. The
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43 object of research is *deposition of fat in the human or rodent organism*, a process that can
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45 potentially lead to obesity. Fat deposition is influenced by several types of interactional
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47 mechanisms, including inner *physiological processes and gene expression*, which in turn may be
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49 influenced by a further set of environmental factors. The *bodily environment* is considered in both its
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51 normal and pathological functioning (e.g. 40)).
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54 A theme present in this cluster is the study of how the expression of particular genes
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4 increases the likelihood of obesity (e.g. (41)). The appearance of the terms “obese women” and
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6 “maternal obesity” in this cluster without any male, paternal or parental counterparts points to a
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8 specific interest in the inner bodily environments of women and possible intra-uterine effects on
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10 health (for an article from the sample discussing effects of heredity, intra-uterine conditions and
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12 postnatal environments see (42)). Although it might seem as if this cluster shares an interest in long-
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14 term effects of nutrition on obesity with the food environment cluster, this similarity masks a vast
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16 difference in approach. While studies of food environment focus on large-scale food availability
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18 and population BMI, the studies in this cluster invariably address detailed processes in the inner
19
20 bodily environment. Thus the kinds of environment-gene interaction studied here point towards a
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22 configuration of environment less focused on how the environment impacts calorie input and output
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24 and more on how environmental factors might influence the expression of genes or the regulation of
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26 inner bodily mechanisms. In this sense, articles typical of this cluster draw on a notion of
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28 environment which is significantly different from the other clusters.
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32 When nutrition is of concern in this cluster, the focus is often on the risk of chronic disease.
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34 This focus on risky diets is indicated by terms such as “fatty acids”, and “high-fat diets”. Similarly,
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36 attention is paid to inner bodily mechanisms like “lipid metabolism” and “glucose intolerance.”
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38 Chronic conditions often or normally associated with obesity appear prominently in the bodily
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40 environment cluster as indicated by terms such as “cardiovascular disease”, “coronary heart
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42 disease”, “diabetes”, and “metabolic syndrome”.
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50 Discussion

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53 The mixed methods design used in this study identifies five clear discursive regions (or notions of
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55 environment) within the field of obesity research. These are the institutional, the built, the food, the
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4 family and the bodily environment. Each of these entails a different object of research and a
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6 different set of mechanisms of interaction between object and environment. This observation raises
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8 a broader set of questions about the configuration of the field of obesity research. In what follows,
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10 we consider three possible interpretations of the network pattern identified here. These are as: a
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12 pattern of simultaneous integration and disintegration; a partially coherent hierarchy; and/or a
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14 pattern of selective simplification and complexification.
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19 Interpretation one: A pattern of simultaneous integration and disintegration 20

21 The first of these possible interpretations fastens attention to some of the physical properties of the
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23 map (Figure 2). While the five clusters are the most important features of the map, and the clusters
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25 represent a large number of terms which relate closely to each other, some terms are related to more
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27 than one cluster. Where several terms are shared between two clusters, the individual clusters
28
29 appear less tightly knit and the two clusters are drawn more closely together. If, on the other hand, a
30
31 cluster is composed almost exclusively of its own terms, that cluster will appear more tightly knit
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33 and at a distance from the other clusters.
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36 The tension between strict separation and rapprochement between clusters of research can
37
38 be related to overall visions or normative ideas about how the field should do its work. The rise of
39
40 ecological models of obesity (2) as well as broad-scale systemically oriented policy efforts such as
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42 the UK Foresight Report (4) are both indicative of ambitions to make the field as coherent and
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44 coordinated as possible (8). In this view, more shared terms between the clusters read as a (positive)
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46 sign of greater integration, while tightly knit clusters might well be seen as reflecting more
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48 isolation. Our results show evidence of both integration and isolation. For example, at the bottom of
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50 Figure 2, the bodily environment cluster is relatively tightly knit and disconnected from the others.
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4 In contrast, at the top of the map, the four other clusters (institutional, food, built and family
5 environments) are more interconnected and less tightly knit.
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10 Interpretation two: A partially coherent hierarchy 11

12 Although all of the clusters define different objects of research, we could also attempt to look for
13 more systematic connections between them. For example, the sizes of these objects of research
14 might be fitted into a micro-to-macro series of levels ranging from matters that are physically small,
15 such as genes or adipose cells within an organism, to matters of a much larger magnitude, such as a
16 nationwide system for the provision of school lunches. Pursuing this idea of levels, these
17 environments might be arranged by size, with, for example, level 1 consisting of minute processes
18 within the individual organism (bodily environment); level 2 being the family environment; and
19 level 3 being the food environments and the built environments that encompass entire
20 neighbourhoods. A level 4 might be institutional environments, which often operate on a
21 nationwide level, and contain all of the previously mentioned objects.
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34 While this idea might work to some extent, the levels as represented by the clusters
35 identified in this analysis are not discrete. For instance, a food environment is not perfectly
36 contained within a policy environment, as many things other than policy influence the food
37 environment (e.g. weather patterns, climate change, food retail and marketing strategies, and
38 cooking fashions). Similarly, the bodily environment is not perfectly contained within the family
39 environment, as the bodies of children and adolescents are subject to many other influences beyond
40 their familial patterns of energy intake and expenditure. In short, the five clusters do not add up to a
41 single well-defined and well-described system. The clusters do not comply with the presumption of
42 the ANGELO grid that obesogenic environments can be dissected into four types and two levels,
43 leaving no residuals. Instead, the five clusters overlap, interpenetrate and leave gaps. To depict the
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field of obesity research as a kind of levelled hierarchy would therefore require multiple caveats. At best, the field might be depicted as a somewhat fragmented and partially coherent hierarchy. Given such lack of unity, the field of obesity research resembles a broader pattern of ‘disunity’, which has been described in several other fields (43, 44). One particularly well-described example is post-Cold War physics where subfields have been shown to engage in a complex pattern of interdisciplinary, mobile and market-driven collaborations with a broad range of other sciences (45). In this way, modern physics has moved beyond its earlier quest for positioning particle physics as the inevitable building block of all things and all sciences (45). In a similar way, the field of obesity research seems to have a ‘disunited’ character with its many simultaneous engagements rather than a single starting point from which everything else can be derived.

Interpretation three: A pattern of selective simplification and complexification

Rather than forcing the idea of a hierarchy based on the physical size of the obesity-objects, a third possibility would be to view the five clusters on our map as a pattern of simultaneous simplification and complexification. Any research project begins with a choice of focus, and by implication, a choice of building on a number of pragmatically simplified assumptions (46). In the present context, a study focusing on the obesogenic effect of institutional environments on thousands of school children might, for instance, build on the operational assumptions that obesity can be measured by BMI and that the food environment can be measured in terms of the prevalence of potentially obesity-encouraging objects such as vending machines. Other studies might draw on entirely different operational assumptions. For instance, a study of the obesogenic effects of an adverse prenatal environment might assume that these basic biological mechanisms can be identified by experimentally manipulating the food consumption of pregnant rats and their offspring, and by measuring their blood pressure and a range of metabolic parameters (47). The

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4 chosen operational assumptions that end up being taken for granted (and thus simplified) are not
5 self-evident by any inherent quality but rather appear so because certain methods, metrics or
6 concepts have been preferred or agreed upon amongst a group of researchers, creating a path
7 dependency effect. This applies to all research, including this study.
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12 On this interpretation, what Figure 2 shows is not a series of objects of research that more or
13 less fit together; rather, it shows how the deployment of particular simplifications, assumptions, or
14 standards has facilitated the development of complex understandings of particular obesity-related
15 phenomena. In other words, what appears on the map is a consequence of the tools available for
16 simplification. For example, researchers can learn more about the institutional environment because
17 they can count the number of physical education lessons and soft drink vending machines in
18 schools. They could alternatively learn more about the bodily environment because they can set up
19 experiments with rodent models. They could also learn more about the food environment because
20 they can relate BMI statistically with the average distance to the nearest fast food restaurants, and
21 so on. Every step along the way, and regardless of the type of research object in question, a more
22 complex understanding of obesity is made possible by the availability and deployment of particular
23 kinds of simplification. The development and dynamism of the field is therefore not only a question
24 of the findings made by obesity researchers, but also a question of how they continually invent new
25 standards, devices and measurements that allow them to define new study objects. The five notions
26 of environment in Figure 2 can therefore be seen as an outcome of currently available productive
27 simplifications.
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48 Conclusion

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50 Like other contemporary scientific fields, obesity research is characterised both by visions of unity
51 and by practices of disunity. The mixed methods design employed here gives a systematic empirical
52 analysis of the status and configuration of the field, as based on highly-cited scientific literature on
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4 obesity and environment. While any such analysis is subject to bias especially according to the
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6 sampling frame used to obtain the articles used, we have identified five distinct notions of
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8 environment (institutional, built, food, family and bodily environments) in a broadly sampled
9
10 dataset of 414 highly-cited articles. We have also shown that these multiple notions of
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12 environments invite deeper inquiry into the status and the configuration of the interdisciplinary field
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14 of obesity research. The field can be interpreted variously as: being simultaneously integrating and
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16 disintegrating; a partially coherent hierarchy; and/or a pattern of simplification and
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18 complexification. This study involved an analysis of 15 years of scientific publication in this field
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20 cross-sectionally; future analyses incorporating larger datasets and a longitudinal comparison
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22 should give further information on the merit of each of these three interpretations. The database for
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24 analysis might also be expanded with government reports and other types of policy documents to
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26 explore the degree to which the same or different notions of environment inform policy and
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28 administrative discourses. Finally, we propose that a time lapse version of this map be generated,
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30 which would allow us to see how the field is changing, and aid the understanding of both how the
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32 field is configured and how its practice might be strategically altered to focus research where it
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34 might be most needed.
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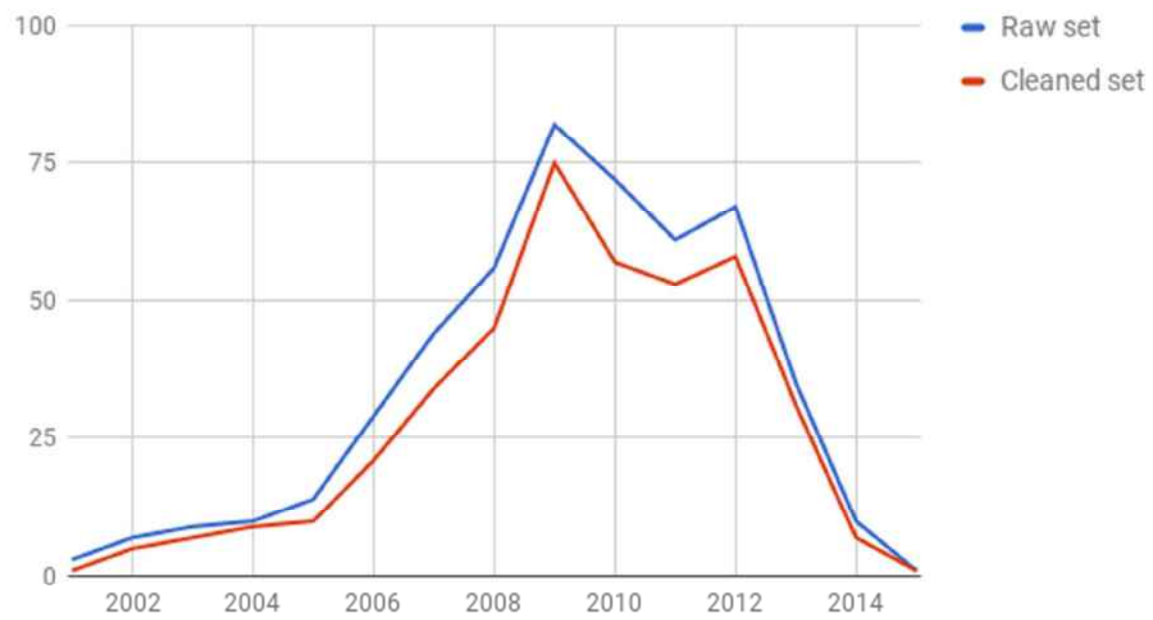
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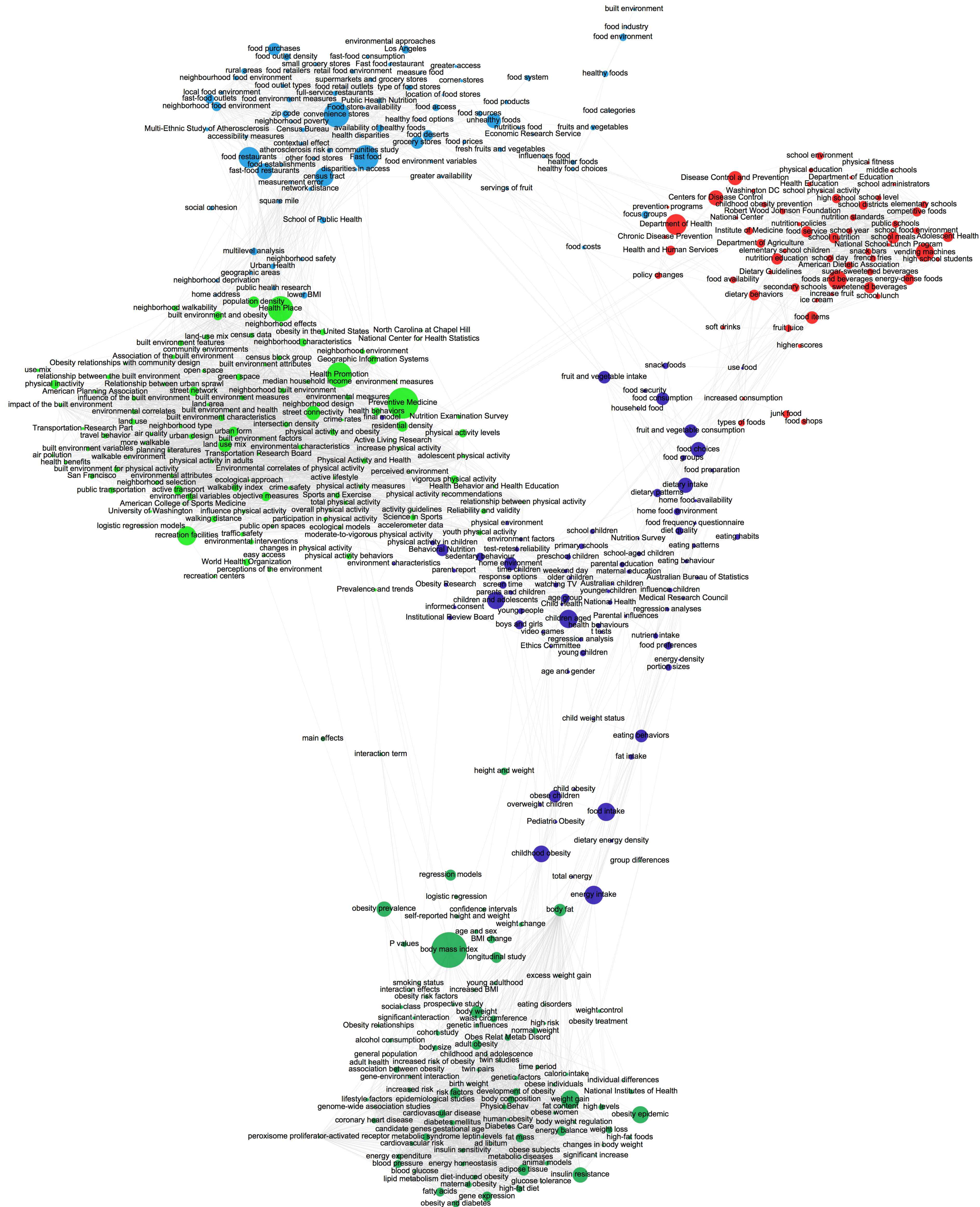
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Environment (a)	Obesity object (b)	Interactive mechanism (c)	Colour of cluster on figure 2.
Institutional environment	Institutional food services	Policies and their implementation	Red
Built environment	Population obesity	Energy expenditure	Light green
Food environment	Population obesity	Energy intake	Light blue
Family environment	Population obesity in children and adolescents.	Energy expenditure and intake	Purple
Bodily environment	Fat deposition in human or rodent organisms	Physiological processes, gene-environment interaction	Dark green

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Supporting information for

Identifying Notions of Environment in Obesity Research Using a Mixed Methods Approach

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- 5. Figure 2: Closeup of cluster 4
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- 7. Full reference list: Articles included in the sample

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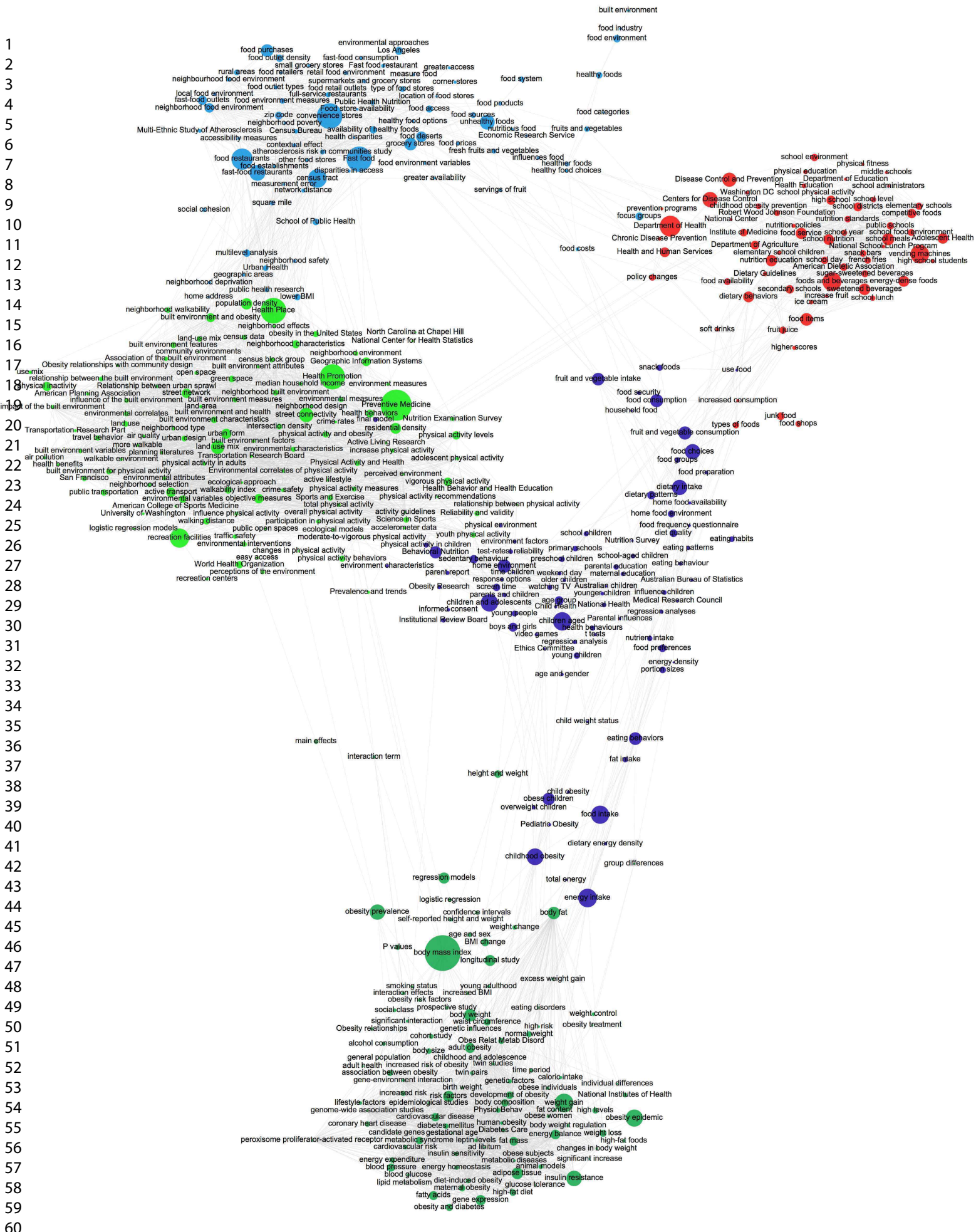


Figure 2: Network map of the discursive patterns in 414 articles related to environment and obesity research. Nodes represent noun phrases, edges represent co-occurrence of noun phrases in the same papers. The size of the nodes represent the frequency with which the noun phrase occurs in the dataset. The colour of the nodes represent the cluster assigned to the node through Louvain modularity. Closeups of each cluster are available on the following pages.

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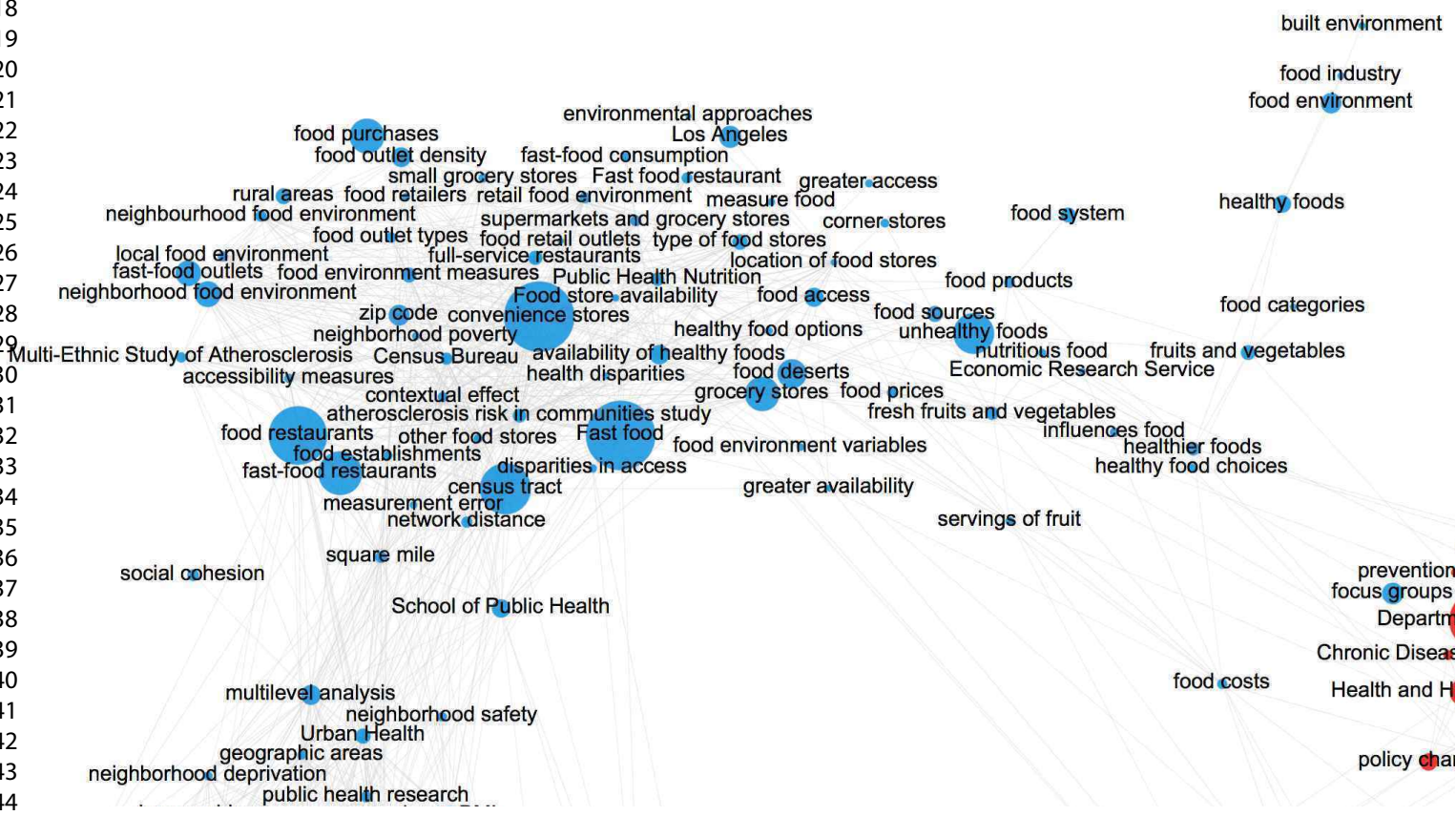


Figure 2: Closeup of the light blue cluster on the food environment. Nodes represent noun phrases, edges represent co-occurrence of noun phrases in the same papers. The size of the nodes represent the frequency with which the noun phrase occurs in the dataset. The colour of the nodes represent the cluster assigned to the node through Louvain modularity. Close-ups of each cluster are available on the following pages.

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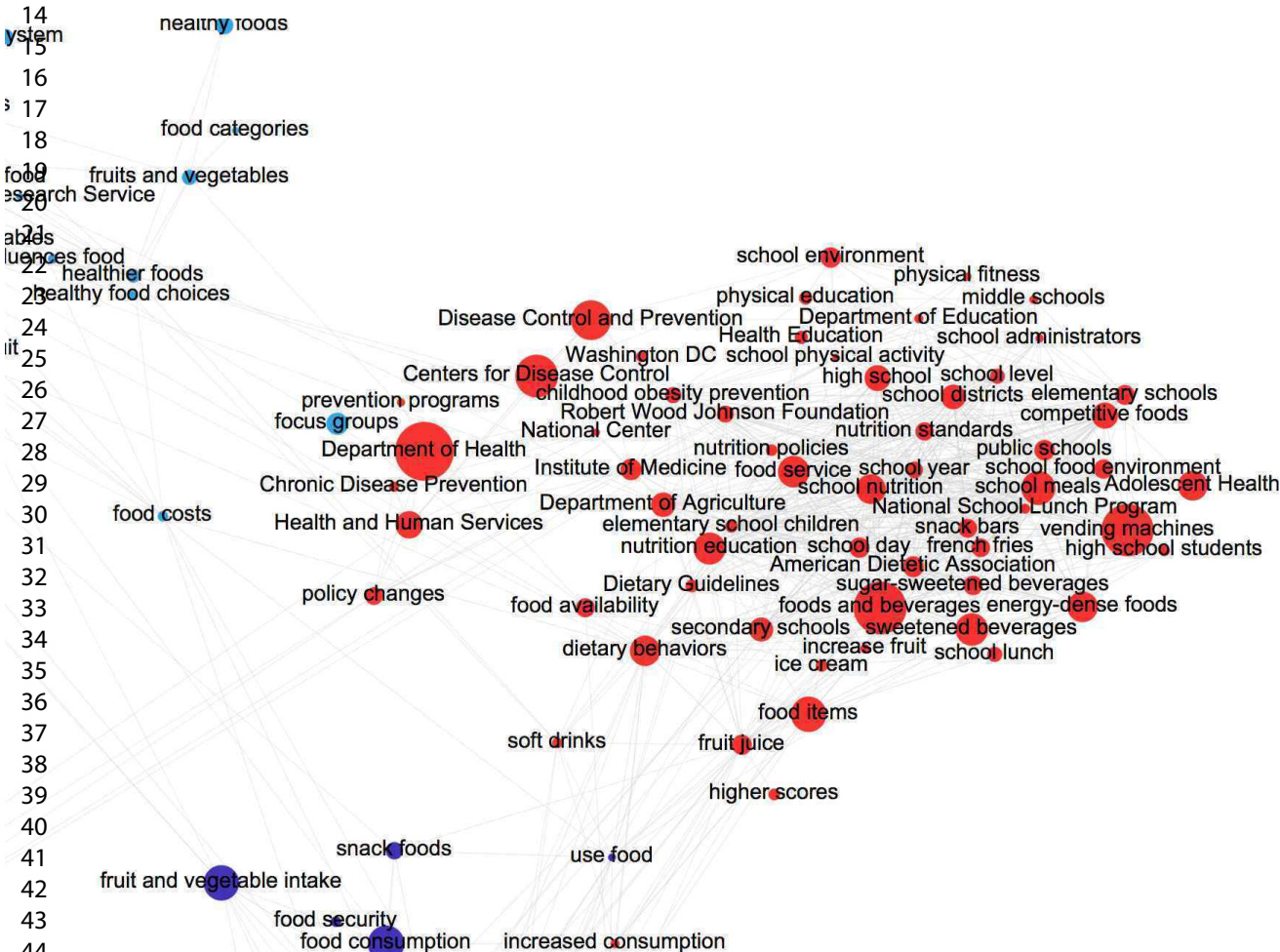


Figure 2: Closeup of the red cluster on the institutional environment. Nodes represent noun phrases, edges represent co-occurrence of noun phrases in the same papers. The size of the nodes represent the frequency with which the noun phrase occurs in the dataset. The colour of the nodes represent the cluster assigned to the node through Louvain modularity. Close-ups of each cluster are available on the following pages.

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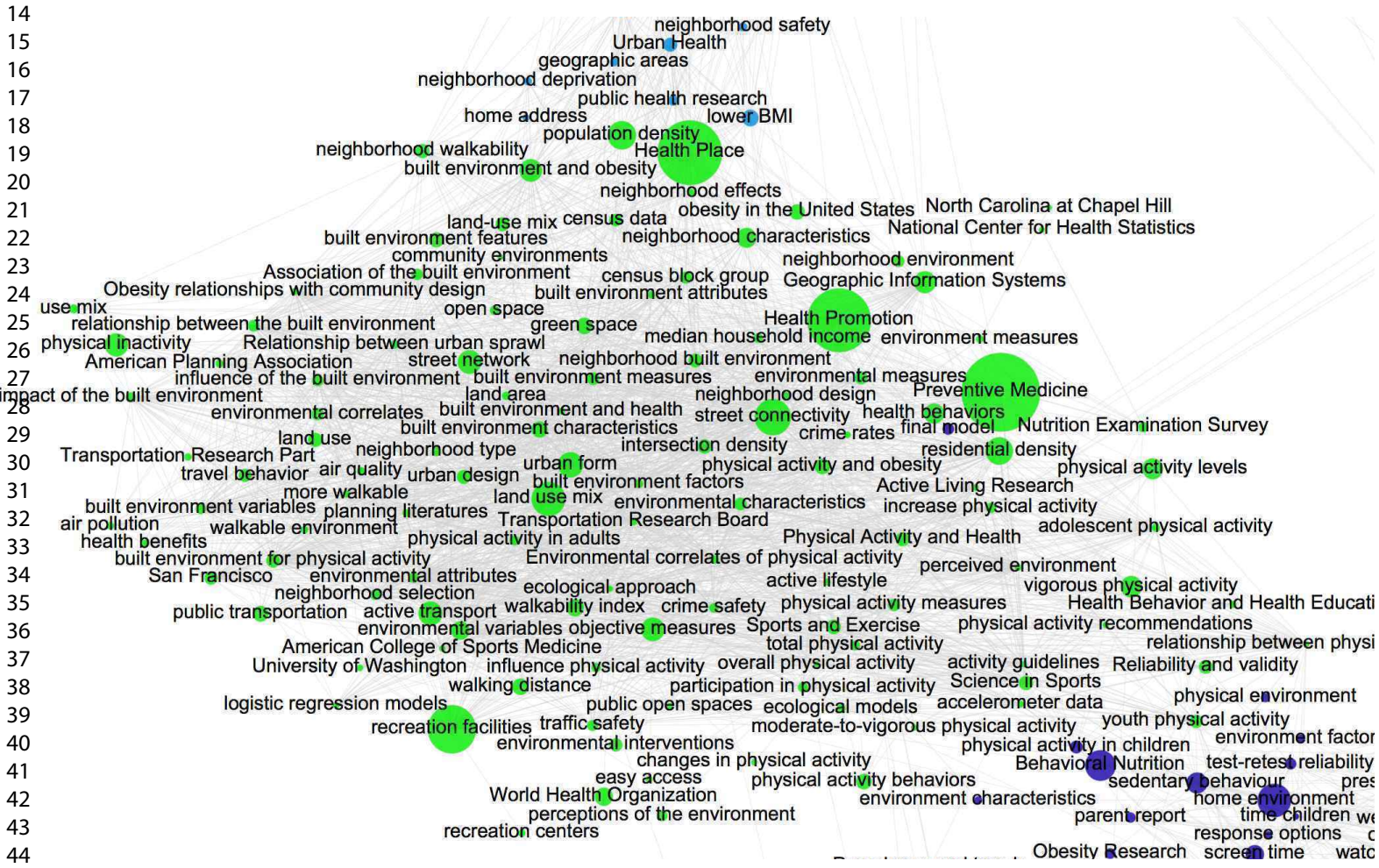


Figure 2: Closeup of the light green cluster on the built environment. Nodes represent noun phrases, edges represent co-occurrence of noun phrases in the same papers. The size of the nodes represent the frequency with which the noun phrase occurs in the dataset. The colour of the nodes represent the cluster assigned to the node through Louvain modularity. Close-ups of each cluster are available on the following pages.



World Obesity Journals

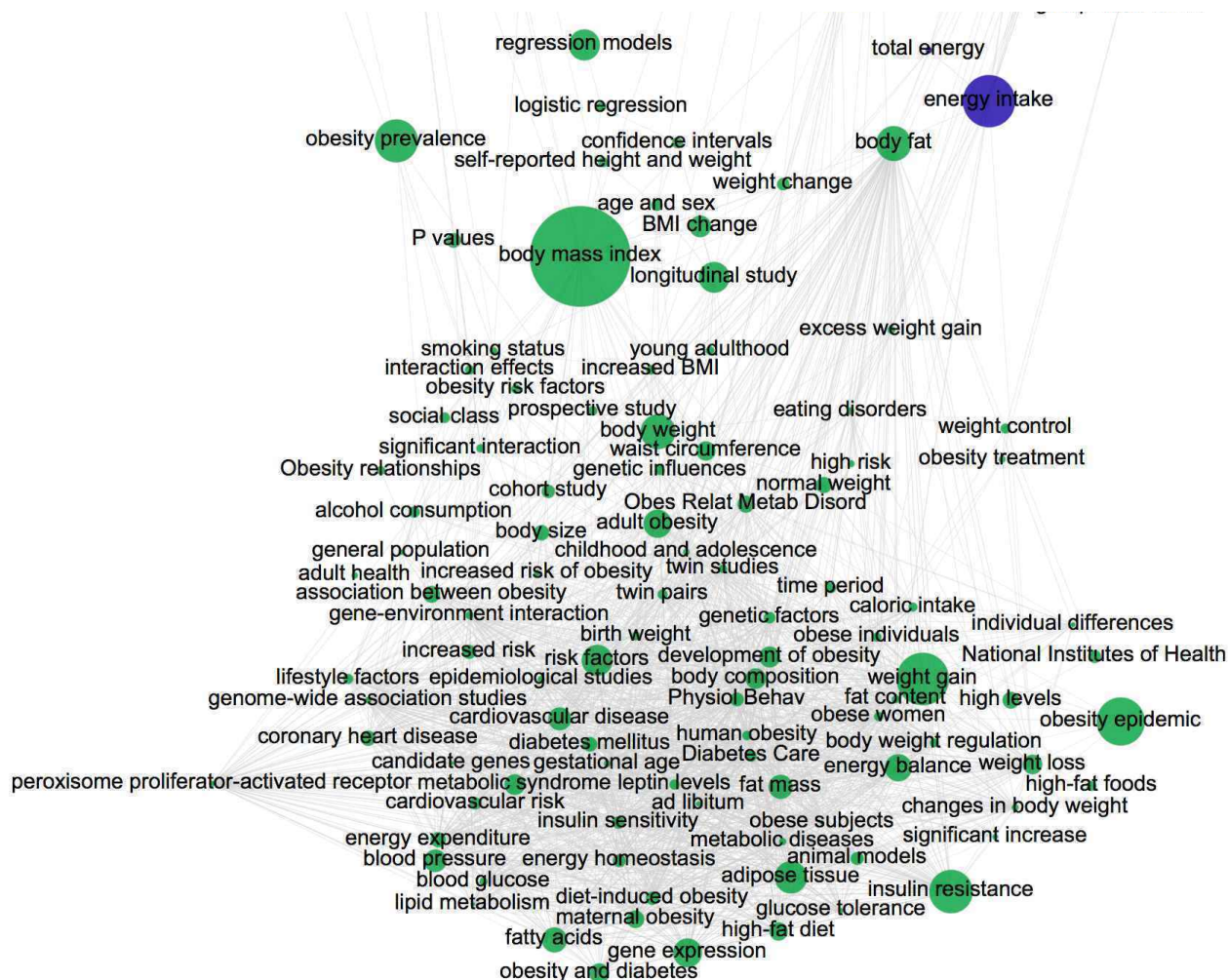


Figure 2: Closeup of the dark green cluster on the bodily environment. Nodes represent noun phrases, edges represent co-occurrence of noun phrases in the same papers. The size of the nodes represent the frequency with which the noun phrase occurs in the dataset. The colour of the nodes represent the cluster assigned to the node through Louvain modularity. Close-ups of each cluster are available on the following pages.

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