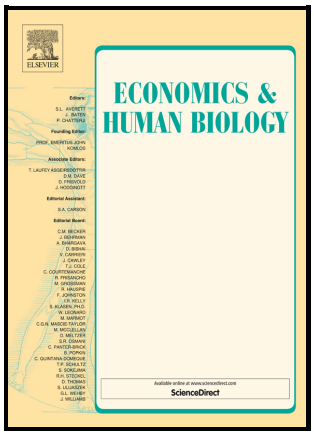

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Nathalie Müller, Francesco Fallucchi, Marc Suhrcke

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Peer effects in weight-related behaviours of young people: A systematic literature review

Nathalie Müller*

Luxembourg Institute of Socio-Economic Research (LISER) & University of Luxembourg

Francesco Fallucchi

University of Bergamo

Marc Suhrcke

Luxembourg Institute of Socio-Economic Research (LISER) & University of York

January 21, 2024

*Corresponding author. Luxembourg Institute of Socio-Economic Research (LISER), 11, Porte des Sciences, 4366 Esch/Alzette, Luxembourg.
E-mail address: nathalie.mueller@liser.lu (N. Müller)

Abstract

Individual preferences and beliefs are perpetually shaped by environmental influences, with peers playing a key role in this dynamic process. Compelling evidence from qualitative and quantitative studies has highlighted the significant impact of peer influence on health-related decisions. This systematic literature review critically synthesises findings from 45 studies published between 2011 and 2022, providing a comprehensive understanding of the nature of peer effects on dietary, physical activity and sleep behaviours during youth. The majority of studies indicated that social norms drive directional changes in eating and physical activity. Yet, our analysis revealed a notable gap in exploring alternative mechanisms, including social comparison and social identity, despite their potential relevance. Studies, generally classified as moderate to high quality, predominantly relied on self-reported data, potentially affecting the validity and reliability of measures. Meta-regression analyses suggest a small, but significant association of sample size with the magnitude, sign and significance of the reported peer effect. Moreover, studies focusing on physical activity are more likely to report significant outcomes, whereas findings on peer influence on sleep-related studies tend to reveal less pronounced effects, compared to studies on dietary behaviours. Experimental designs do not appear to increase the likelihood of finding significant effects when compared to other study designs. In conclusion, this synthesis emphasises the need for further research into the underlying mechanisms on peer effects to better inform policy-makers in designing effective policies for curbing unhealthy weight-related behaviours in young people.

Keywords: Health behaviour, Meta-regression analysis, Peer effects, Social norms, Systematic review, Youth

JEL classifications: C10, D83, I12, J13

1 Introduction

Poor health behaviours and the persistently increasing prevalence of obesity across all age groups and world regions have become a burden for health systems worldwide. According WHO data in 2016, a substantial prevalence of overweight and obesity was observed among European children and adolescents, with one out of five (21.4%) US children facing obesity challenges. Moreover, adults experienced even higher prevalence, reaching 23.3% in the European Region and to 36.2% in the US (World Health Organization, 2022). A steady increase in these figures implies major future direct and indirect costs for the people concerned, as well as for society as a whole. The OECD (2019) estimates that OECD countries will, on average, spend 8.4% of their total health care budget to treat health conditions that are associated with excess body weight. Obesity is intricately linked with the metabolic syndrome, a cluster of modifiable risk factors associated with cardiovascular disease and type 2 diabetes (Després and Lemieux, 2006). Various factors, spanning from behavioural to economic determinants, have emerged as prominent drivers of these health conditions, heightening the risk for severe chronic diseases and posing a significant public health

challenge (Rosin, 2008). In spite of its growing recognition in diverse academic fields, the association of sleep with physiological and psychological mechanisms driving weight gain and the metabolic syndrome is often overlooked in comparison to more widely known drivers. While the impact of poor dietary choices and physical inactivity on body weight is well-documented, an evolving body of research sheds light on the substantial influence of sleep behaviours on metabolic health and other health-related outcomes (Dulloo et al., 2017; Grimaldi et al., 2023; Oftedal et al., 2019).

Recognising the steady increases in body size in youth[1] and in an attempt to address this public health challenge, national public health agencies as well as international organisations have actively engaged in the development of action plans and policies to promote healthier lifestyles (Office of Disease Prevention and Health Promotion, 2022; World Health Organization, 2016). Yet, despite these efforts, achieving sustainable changes in people's behaviour at scale remains difficult (Swinburn et al., 2019) and there continues to be a strong public policy and research interest in the factors contributing to the trend of high and rising obesity levels in young people. In addition to economic, socio-demographic and convenience factors, social interaction and peer effects stand out as potential explanations for the spread of obesity (Cawley, 2015). Formally, the latter is nowadays described as the tendency of individuals to behave in a certain way based on how common that behaviour is among the people they are interacting with (Manski, 1993). Christakis and Fowler (2007) demonstrated in their seminal study the impact of social networks in shaping individual obesity levels, highlighting the importance of social factors in the study of weight-related outcomes. A rapidly expanding body of empirical research followed, reporting positive associations between peer behaviour and individual body weight outcomes (e.g., Auld, 2011; Cohen-Cole and Fletcher, 2008; Mora and Gil, 2013; Nie et al., 2015; Trogdon et al., 2008).

While the core idea of peer effects has remained consistent throughout the years, the understanding and study of peer effects evolved, driven by methodological challenges to provide credible estimates on the magnitude and nature of peer effects. Manski (1993) showed that in standard social interaction models, the pure effect of one individual on another is indistinguishable from contextual or correlated effects. These factors can complicate the identification of the endogenous peer effect, where an individual's outcome is directly affected by the behaviour of their peers. One main challenge in measuring peer effects emerges from structural simultaneity inherent to reciprocal influences of peers, also commonly known as the reflection problem: while peers exert influence on individual outcomes, simultaneous spillovers from individuals onto their respective peer group can occur. Researchers have adapted various strategies to address this identification issue, ranging from the use of lagged peer outcomes as covariates when examining health behaviours (Ali et al., 2011; Clark and Lohéac, 2007), the estimation of instrumental variable regressions (Auld, 2011; Mora and Gil, 2013; Trogdon et al., 2008) or natural experiments and randomisation to identify the causal effect of social interactions (Condliffe et al., 2017; Golberstein et al., 2016; Yakusheva et al., 2011). When carefully applied, these models may elucidate the relationship between individual health-related behaviours and their peers.

Despite these challenges in the study of peer effects, researchers have made steady progress towards a better understanding of the influence of social interactions. Previous systematic reviews and meta-analyses of empirical research exploring the relationship between social networks and weight-related outcomes have generally supported the hypothesis of peer influence and behavioural adaptation. These studies have shown that weight-related behaviours and outcomes during certain life stages may be associated with the attitudes, behaviours, and interactions of their peers. This can occur through homophily, where individuals with similar attributes and behaviours self-select into friendships, or through social influence, where peers have an impact on each other's decisions and behaviours over time (Chung et al., 2017; Cunningham et al., 2012; Montgomery et al., 2020). While the number of primary and review studies on peer effects keeps growing, important gaps do remain. First, existing research strongly focuses on children and adolescents up to the age of 18, while dedicating limited attention to young people beyond 18. Transitioning from adolescence to adulthood marks a decisive developmental period characterised by significant cognitive, behavioural and social changes, that may critically shape lifelong health habits (Elkins et al., 2017; McDade et al., 2011). Second, there is little doubt about the potency of peer influence on individual outcomes, yet credible evidence of the underlying mechanisms is limited. This is partly due to the complexity of studying social networks and the difficulty in isolating the effect of peers from other confounding factors, as described above. Until now, research has proposed different mechanisms underlying peer effects, including conformity (Bernheim, 1994; Jones, 1984), social learning (Bandura, 1977; Bikhchandani et al., 1992) and social utility (Bursztyn et al., 2014), to name but a few. Any of these mechanisms might be utilised as a reference by which peers affect individual behavioural outcomes, leading to the adoption of both health-enhancing and health-harming behaviours. Importantly, the generated spillovers in health outcomes from one individual to another create multiplier effects, resulting in larger aggregate effects (Glaeser et al., 2003). Above all, expanding our knowledge about the drivers of peer effects in weight-related behaviours is an important first step to better inform policy, as these may serve as potential entry points for policy intervention. If policymakers were provided with a better knowledge of how and through which mechanisms the diffusion of behaviours works, these insights could be used as leverage to improve young people's

[1] As the paper unfolds, we refer interchangeably to this cohort as "youth" and "young people" to describe individuals aged 15 to 24, aligning with the definitions by United Nations General Assembly (2002).

health trajectories. Hence, the need of - and benefit from - seeking to disentangle the different models and mechanisms underlying peer effects in young people's weight-related behaviours.

Considering these developments and the current imperative towards a better understanding of the driving factors of behavioural adaption, this review's key objectives are threefold: to provide a transparent synthesis and critical appraisal of current evidence on social influence in weight-related behaviours, to examine the potential drivers of peer effects, and to derive and discuss policy implications, offering insights for future research and decision-making. While peer effects and their drivers are a central focus of this study, it is important to note that the underlying processes do not operate in isolation; rather, they involve complex dynamics with other individual and demographic factors. For details on the interplay of diet, physical (in)activity and sleep behaviours with factors not covered in the primary analysis, we provide a conceptual framework (Figure S1 in the Supplementary Data). This review further enhances its synthesis by incorporating a meta-regression analysis on a subset of the reviewed studies to examine the contribution of study-level characteristics to the heterogeneity among reported research findings. In conclusion, this synthesis emphasises the need for further research into the underlying mechanisms on peer effects to better inform policy-makers in designing effective policies for curbing unhealthy weight-related behaviours in young people.

2 Methodology

This systematic review was conducted and reported in adherence to the preferred reporting standards for systematic reviews and meta-analyses (PRISMA) (Page et al., 2021). The protocol of this review is pre-registered in PROSPERO under registration number CRD42022370974. In the interest of transparency, it is important to note that the meta-regression analysis was not pre-registered. Our initial study design did not allow for a priori specification of the meta-regression parameters. Hence, the decision to perform the meta-regression was based on a subset of results from quantitatively comparable studies. As an additional robustness check, we adopted a methodology similar to that used by Card et al. (2010). For this approach, we categorised the outcomes of all studies based on whether the observed peer effect is significantly positive or statistically insignificant.

2.1 Systematic Literature Search

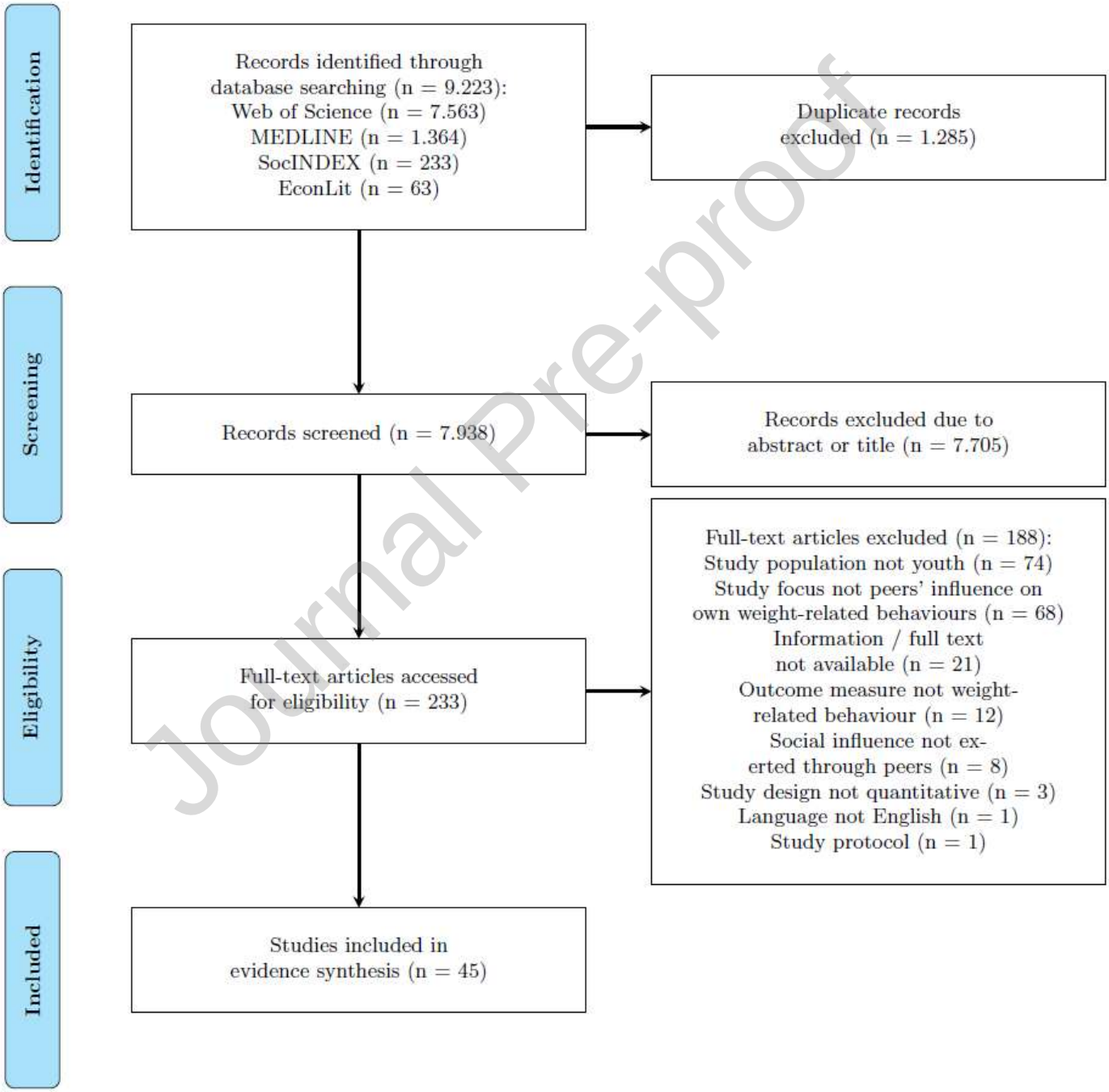
We conducted a systematic search for studies that empirically assessed the association between peer effects and young people's weight-related behaviours. In February and March 2022, we searched Web of Science, EconLit, MEDLINE and SocIndex databases for studies published from January 2011 up to February 2022, targeting peer-reviewed full- text articles in English. Synthesising evidence from this decade allows us to cover the most recent developments in a dynamic field that undergoes changes over time, including changing contexts (e.g., the rise of social media) and methodological advancements (e.g., usage of wearables for data collection). The search strategy was thus developed to capture relevant papers covering the following key topics: weight-related health behaviours including diet, activity levels and sleep, and peer effects among youth. For each database, we included keywords from the main topics (peer effects) AND (weight-related behaviours) AND (youth), applied to titles, keywords and abstracts. The filters applied for the search are year and language of publication. Further, we performed manual searches of reference lists and citations. We excluded review articles, conference papers or commentaries and grey literature such as theses and dissertations.

2.2 Study Eligibility Criteria

Studies were eligible, if they examined peer effects on health behaviours, focusing specifically diet, physical (in)activity and sleep outcomes, within a sample of young people (mean age from 15 to 24 years old). Other behaviours that potentially affect body weight and metabolism, as, for example, stress, alcohol and tobacco consumption, were excluded. These behaviours have extensively been covered in previous reviews and meta-analyses (Henneberger et al., 2021; Leung et al., 2014; Wardle et al., 2011). Further, this review was restricted to quantitative studies that employ experimental (e.g., field and laboratory studies) and non-experimental research methods (e.g., cross-sectional and longitudinal designs). Studies addressing social influence on psychopathological behaviours (e.g., eating disorders or compulsive exercise) were outside the scope of this study and were therefore excluded, as were studies that did not provide a direct measure of peers' weight-related behaviours. Note that influence may be exercised through other forms of social interaction, including direct verbal encouragement or displays of contempt, shaping individuals' behaviours through external pressures. While these aspects are important, we prioritise the direct impact of peers' observable health behaviours. To maintain a focused and comprehensive analysis of the resulting peer effects and their underlying mechanisms, we excluded studies evaluating influence through social pressure or coercion, as well as studies measuring social support by combining an array of different social support types (e.g., co-participation in exercise and giving evaluative feedback) into a single global score.

2.3 Selection and Coding

The study selection process is illustrated by Figure 1. The first step in this process was to identify all records through the database search complying with our search strategy, followed by an export and merge of the data sets. After the elimination of duplicates, an initial screening of titles and abstracts for obvious irrelevance was performed, which led to an exclusion of the majority of records. Subsequently, full-text articles of the preliminary selected articles were obtained to assess their eligibility based on the predefined inclusion and exclusion criteria. For all excluded articles, we provide a rationale explaining as to why they have been discarded. We developed a standardised table to extract the following data from the selected studies: author(s) name, journal and publication year, aims of the study, study characteristics (study design, data, regression method), sample characteristics (sample size, socio-demographic characteristics) and primary outcomes (peer group, health-related behavioural outcome measures, explanatory and mediating variables, results).



2.4 Methodological Quality Assessment

The methodological quality of the selected studies was assessed using Joanna Briggs Institute (JBI) critical appraisal checklists for analytical cross-sectional and (quasi-)experimental studies (Moola et al., 2020; Tufanaru et al., 2020). We adapted these checklists to allow for consistent study assessment while accommodating the wide range of quantitative study designs. The checklists were then used independently by the three researchers, and any ambiguities were resolved by discussion. The quality review comprised a rating of the sample selection,

comparability, study design and methodology applied, as well as a rating of the validity and reliability of peer variables and health-related behavioural outcome measures, whereby higher ratings indicated higher study quality. The results from the quality assessment did not determine the final study inclusion.

Note that we did not include the availability of data and codes for statistical analyses among the criteria to assess the quality of the studies. The reason is that the great majority of the studies did not provide data, and only one of those did provide the code to replicate the results. We also checked the current state of the replication policy in place in the journals hosting the selected articles and, as of November 2023, none of them has strict requirements about data availability.

2.5 Meta-Regression Analyses

Statistical analyses were performed using the "metafor" package (Viechtbauer, 2010). Effect sizes from 19 eligible studies were pooled and estimated using the restricted maximum likelihood (REML) method. These effect sizes included regression coefficients and were used to evaluate the association of study-specific factors and the reported peer effects. While standardised regression coefficients are rarely employed in economic research (Stanley and Doucouliagos, 2012), there has been a growing focus on their application in meta-analytic syntheses of research in recent years. In the current study, for original studies that only reported unstandardised regression coefficients or did not present standard errors alongside the reported coefficients, conversion and imputation methods based on Nieminen (2022) were implemented to calculate the effect sizes. As an additional robustness check, effects from the full set of study outcomes were categorised into significantly positive and statistically insignificant outcomes to examine the likelihood of reporting positive and significant peer effects across studies and methodologies. Finally, publication bias is assessed by applying Egger's regression test (Egger et al., 1997), a simplified selection model (McShane et al., 2016) as well as by visually inspecting the symmetry of funnel plots (provided in Supplementary Data). While these method do not directly examine publication bias, they aid in identifying asymmetry in the funnel plot, which is potentially attributable to publication bias.

3 Results

The initial database search yielded 9.223 articles. After screening for titles and abstracts, 233 articles remained for the full-text examination. This final record selection process required whether title or abstract indicated any association between young people's social interactions and their impact on others' weight-related behaviours. Finally, we obtained a list of 45 studies that were deemed eligible for the evidence synthesis (see Figure 1 for further details of the search and study selection process). Tables 1 – 3 list the papers that fit our eligibility criteria analysing social influences in different health behaviours and provide a comprehensive overview of respective study characteristics. In what follows, we summarise the study results and present separate evidence for dietary behaviours, physical (in)activity as well as sleep-related decisions. While all studies addressed whether and how others influence individual health-related behaviours and decisions, only a few of them gave particular attention to the underlying mechanisms; furthermore, studies varied greatly in their methodological approaches to assessing peer influence.

3.1 Descriptive Characteristics

The database search yielded 13 experimental, 12 longitudinal and 20 cross-sectional studies. The majority of the studies (n = 25) were based in the United States; 14 studies were conducted in Europe, 3 in Asia, 3 in Brazil and 1 in Australia. Sample sizes varied from 51 to 8000, comprising young people aged on average between 15 and 24 years. Twenty-one studies investigated eating behaviours only, such as fruit and vegetable (FV) intake, high energy-dense (HED) foods or sugar-sweetened beverages (SSB), with the second-largest group of papers studying physical activity (PA) (n = 17). Three studies examined peer effects on sleep behaviours only, such as bedtime decisions, sleep quality and quantity. Four studies focused on a set of different weight-related behaviours, studying physical activity combined with diet (n = 3) or sleep duration (n = 1). The majority of papers used self-reports to measure health outcomes and peer-related variables.

3.2 Risk of Bias and Study Quality

Tables 1 – 3 provide information about the ratings of the studies. Overall, most of the identified studies met at least half of the study assessment criteria set by the JBI critical appraisal checklists for analytical cross-sectional and (quasi-
)experimental studies. Studies were considered to be of good quality, when they met more than 80% of the assessment criteria and studies were ranked as low quality studies, when they met less than 60% of the assessment criteria. Most of the studies used self-reports to assess the outcome of interest, which may have compromised the validity and reliability of these measures. Yet some studies did not adjust for potential confounders in their data analysis or showed a lack of description about effect size in statistical tests. Some experimental studies were also found to be at

risk of selection bias. In these studies, study participants in the comparison groups displayed differences in mean characteristics, meaning that treatment and control group may not have been comparable in certain aspects.

3.3 Peers' Weight-Related Behaviours

3.3.1 Diet

Twenty-four articles assessed the impact of social influence on dietary behaviours, with a number of them reporting significant peer effects on food intake. Five studies dealt with peer effects on young people's healthy eating behaviours only (Graham et al., 2013; Meng et al., 2017; Nix and Wengreen, 2017; Wengreen et al., 2017; Zhylyevskyy et al., 2013), seven papers focused on unhealthy food (Cruwys et al., 2012; Fortin and Yazbeck, 2015; Hirata et al., 2015; Jones and Robinson, 2017; Robinson, Benwell, and Higgs, 2013; Robinson et al., 2016) and sugar-sweetened beverage consumption (Jones and Robinson, 2017; Melbye and Helland, 2018; Robinson et al., 2016), and twelve papers examined both, healthy and unhealthy dietary behaviours. Among these studies, daily fruit and vegetable servings and the frequency of high-energy-dense food intake have been employed as preferred outcome measures. Overall, fourteen studies investigated individual behaviours in response to peer fruit and vegetable consumption, with the majority of them suggesting positive associations. Experimental research supported these findings, estimating that participants' daily fruit and vegetable intake increased by approximately 0.2 to 0.9 cups in response to perceived peer behaviours (Liu and Higgs, 2019; Nix and Wengreen, 2017; Wengreen et al., 2017). Yet, amidst the generally positive associations found, some authors yielded different conclusions, reporting no significant associations between peer's intake amount and frequency and an individual's own fruit and vegetable consumption (Ali et al., 2011; Pelletier et al., 2014; Robinson, Harris, et al., 2013; Yuan et al., 2013; Zhylyevskyy et al., 2013).

Eleven studies used young people's consumption of high-calorie food and beverages to examine unhealthy dietary behaviours in non-experimental settings (Ali et al., 2011; Fortin and Yazbeck, 2015; Gesualdo and Pinquart, 2021; Hawkins et al., 2020; Jones and Robinson, 2017; Lally et al., 2011; Melbye and Helland, 2018; Pelletier et al., 2014; Perkins et al., 2018; Robinson et al., 2016; Yuan et al., 2013). In these studies, results were generally more unanimous and overall positive associations were found. For example, Ali et al. (2011) and Fortin and Yazbeck (2015) estimated that an adolescent's weekly frequenting of fast food restaurants increased when their friends went more often, a finding that was corroborated by Pelletier et al. (2014). However, some evidence indicated that differences in age groups may play a role in unhealthy consumption behaviours: while daily intake of sugar-containing drinks by high school students was still strongly predicted by their friends' and grademates' consumption (Melbye and Helland, 2018; Perkins et al., 2018), this effect vanished in populations of university students (Hawkins et al., 2020; Robinson et al., 2016).

Table 1 Characteristics of selected studies on dietary behaviours.

Author(s), year, journal	Country	N	Population	Statistical analysis / Study design	Results	Mechanisms	QA
Ali et al., 2011, PLoS ONE	USA	2760	HS	multiple linear regression; probit model, L	+ve association between friends' fast food consumption and own behaviour: β = 0.178***. NS effects for breakfast, FV servings and calorie-dense snacks.	social norms	good

Cruwys et al., 2012, Appetite	AUS	119	UG	ANCOVA, E	+ve: participants ate more popcorn when they believed a prior participant had eaten all of theirs compared to a prior participant who had eaten no popcorn: MDiff = 8.3 (in grams). This was qualified by a significant interaction between group membership of the study participant and food intake norm.	social identity; social norms	good
Fortin and Yazbeck, 2015, J Health Econ	USA	2355	HS	generalized spatial autoregressive (GSAR) model, L	+ve small endogenous peer effect for fast food consumption among friends: β = 0.129*. This effect is amplified through a small social multiplier.	-	good
Gesualdo and Pinquart, 2021, Health Psychol Behav Med	DEU	208	UNI	multiple linear regression, CS	+ve correlation between peers' eating behaviour and current eating behaviour: Sβ = 0.21*. NS association of partner's eating with own behaviour.	-	mediu m
Graham et al., 2013, J Acad Nutr Diet	USA	1201	COL	multiple linear regression, CS	+ve association between friends' behaviour and own FV consumption: β = 0.084***.	-	mediu m
Hawkins et al., 2020, Appetite	GBR	369	UNI	multiple linear regression, CS	+ve associations between amount and frequency of Facebook users' FV and participants own consumption. NS effects in HED and SSB intake.	descriptive norms	good
Hirata et al., 2015, Eat Behav	BRA DEU	83 100	UG	ANCOVA, E	+ve: subjects exposed to high intake norm consumed more chocolates compared to those exposed to low intake norm. NS between-country difference in informational eating norm effects.	descriptive norms	good

Jones and Robinson, 2017, Front Psychol	GBR	340	UNI	multiple linear regression, L	+ve: students believing that other students frequently consumed cakes and pastries also increased their consumption over time: β = 0.377**. NS effect of descriptive peer norms and consumption of SSB.	perceived descriptive norms	low
Kimura et al., 2021, Food Quality and Preference	JPN	51	UG	unpaired t-tests, E	+ve: amount and duration of unfamiliar snack consumption is higher in presence of a friend: MDiff = 0.9 (in portions).	social norms	mediu m
König et al., 2017, Appetite	DEU	402	UNI	multilevel regression, E	+ve association between snacking ascribed to popular student and own healthy: β = 0.25*** as well as unhealthy snacking: β = 0.24***. Significant gender effects.	social identity; social image	good
Lally et al., 2011, Appetite	GBR	264	HS	multiple linear regression, CS	+ve associations between descriptive norms and own FV intake: β = 0.50**, SSB consumption: β = 0.44** and unhealthy snack consumption: β = 0.49**.	descriptive norms	good
Liu and Higgs, 2019, Front Psychol	GBR	84 90	UNI	multiple linear regression, E	+ve modelling effects: vegetable intake was higher when subjects believed other study participants had eaten more vegetables: β = 36.84*. +ve modelling effects: cookie intake was higher when subjects believed other study participants had eaten more cookies: β = 18.63** and less when they believed others had eaten less. Effect was not moderated by strength of identification with	descriptive norms; social identity	good

					norm referent group.		
Melbye and Helland, 2018, Br Food J	NOR	694	HS	multiple logistic regression, CS	+ve: perceived descriptive friend norms increased probability of SSB consumption with school lunch: OR = 1.33*.	perceived norm	low
Meng et al., 2017, J Med Internet Res	USA	73	COL	intention-to-treat analysis; linear mixed-effects model, E	+ve: participants who self-tracked their fruit and vegetable consumption collectively with other group members (mean 3.37, SD 2.01) consumed more fruits and vegetables than participants who self tracked their fruit and vegetable consumption alone (mean 1.37, SD 1.44): MDiff = 2 (in servings). NS: demographic similarity among participants had no effect.	social comparison (identification; social learning); normative influence	mediu m
Nix and Wengreen, 2017, Appetite	USA	167	UG	ANOVA, E	+ve: participants believing that other students consumed more FV, reported a 0.5 cup increase in self-reported FV intake and 1 cup increase in perceived peers' intake.	descriptive norms; normative information; social approval	good

Pelletier et al., 2014, Am J Health Behav	USA	996	UNI	multiple linear regression, CS	+ve: perceived peers' fast food consumption is positively associated with own consumption, if peer is a friend: β = 0.22*** or significant other: β = 0.25**. Perceived friends' FV intake is positively associated with own consumption: β = 0.13***. NS association between own consumption others' FV intake or peers' SSB consumption.	descriptive norms; social proximity	mediu m
Perkins et al., 2018, Appetite	USA	5841	HS	multilevel regression, CS	+ve: perceived FV and SSB consumption norm were strongly associated with personal consumption among both genders.	perceived descriptive norms; social norms	good
Robinson and Higgs, 2013, Br J Nutr	GBR	100	UNI	ANOVA, E	NS effect in peers' HED food choice on own selection. Participants chose a meal higher in energy density, when they ate with an unhealthy peer. NS difference for total energy amount of food. Participants observing others making an unhealthy food choice, chose less healthy food.	social norms	good
Robinson et al., 2013, Int J Behav Nutr Phys Activ	GBR	129	YA	linear regression, E	+ve: participants consumed less high calorie snacks if they believed that students in general ate less junk food: MDiff = -11.5 (p = 0.046). NS for FV consumption and total energy intake.	descriptive norms; normative information	mediu m

Robinson, Benwell and Higgs, 2013, Appetite	GBR	64	UG	ANOVA, E	+ve: participants believing that the norm was to eat many cookies, increased their own cookie intake: MDiff = 1.46* and those believing that the norm was to eat only few, decreased their own consumption: MDiff = -1.3*.	descriptive norms	good
Robinson et al., 2016, Psychol Health	GBR	1056	UNI	multilevel regression, CS	+ve: perceived peer eating norms predicted own frequency of consumption of SSB: Sβ = 0.08** and SP: Sβ = 0.33***.	descriptive norms; social acceptance	mediu m
Wengreen et al., 2017, Appetite	USA	251	COL	multiple linear regression, E	+ve: treatment group receiving normative information increased their daily FV intake by approximately 0.89 cups.	descriptive norms	good
Yuan et al., 2013, PLoS ONE	CHN	419	UNI	multiple linear regression, CS	+ve association of roommates' unhealthy dietary intake on own eating behaviours. NS effect for FV intake.	-	good
Zhylyevskyy et al., 2013, South Econ J	USA	502	YA	ordered probit model, CS	NS effects in fruit and vegetable consumption between youths and their best (same gender) friends.	-	good

Notes: QA - Quality assessment. Study design: CS - cross-sectional; E - experimental; L - longitudinal. Population: COL - college students; HS - secondary or high school students; UG - undergraduate students; UNI - university students; YA - young adults. Results: FV - fruit and vegetables; HED - high-energy-dense snack; MDiff - mean difference; NS - non-significant ($p > 0.05$); $S\beta$ - standardised regression coefficient; SSB - sugar-sweetened beverages; +ve - positive statistically significant result associated with the peer effect.
***, ** and * denote significance at the 0.1%, 1%, and 5% levels, respectively.

3.3.2 Physical Activity

Twenty-one studies investigated the associations between peer behaviours and individual physical activity outcomes. Most papers on physical activity aimed at estimating the impact of peers' activity behaviours on individual frequency of engaging in some type of exercise per week, using continuous or discrete measures. Only Barclay et al. (2013) used a binary variable to measure individual regular exercise behaviour. However, measures of physical activity behaviour varied widely between the studies, hence limiting comparability. While the majority of studies relied on self-reports from questionnaires, three articles deployed wearable technology to gather objective data about participants' active behaviours (Li, Haynie, et al., 2016; Morrissey et al., 2015; Wang, Lizardo, and Hachen, 2021), and one paper (Condliffe et al., 2017) used time stamp information collected through student ID cards to track their average weekly gym visits.

Collectively, studies indicated mostly significantly positive associations between youth and their peers' physical activity, even across a diverse set of global contexts, including Brazil (Cheng et al., 2014; Mendonça and Farias Júnior, 2015), China (Yuan et al., 2013), Germany (Gesualdo and Pinquart, 2021), Korea (Lee and Lee, 2020), Sweden

(Barclay et al., 2013) and the USA (Ali et al., 2011; Condliffe et al., 2017; Graham et al., 2014; Li et al., 2014; Li, Liu, et al., 2016; Long et al., 2017; Morrissey et al., 2015; Shoham et al., 2012; Simpkins et al., 2013; Wang, Lizardo, and Hachen, 2021; Yakusheva et al., 2011). In terms of sedentary behaviours, some studies reported that individual inactive behaviours such as screen time and sitting were positively correlated with an increase in peer screen time (Aalsma et al., 2012; Lopes et al., 2013; Shoham et al., 2012).

Table 2 Characteristics of selected studies on physical (in)activity behaviours.

Author(s), year, journal	Country	N	Population	Statistical analysis / Study design	Results	Mechanisms	QA
Aalsma et al., 2012 Soc Sci Med	USA	160	ADOLES	multilevel regression, L	NS effect of romantic partners' health-protective behaviours (PA). +ve association between partner's behaviour and own sedentary behaviour (watching TV): β = 3.02**.	-	low
Ali et al., 2011, PLoS ONE	USA	2760	HS	multiple linear regression, L	+ve association between weight-related behaviours among friends for exercising (> 3 times a week): β = 0.079** and participating in active sports: β = 0.184***. NS effect for sedentary behaviour (watching TV).	social norms	good
Barclay et al., 2013, BMC Publ Health	SWE	5695	YA	logistic regression, CS	+ve: peer regular exercise is associated with an increase in the predicted probability that the ego will also exercise regularly, for both males and females. Interaction of these associations with relationship strength and gender homogeneity increase the probability of engaging in health behaviours.	-	medium
Barnett et al., 2014, Health Psychol	USA	129	UG	network autocorrelation model, CS	NS effects in MVPA levels among residence hall members.	-	good
Cheng et al., 2014, J Pediatr	BRA	2361	HS	structural equation modelling, CS	+ve associations between (participant-reported) friend PA and (self-reported) MVPA for males: Sβ = 0.11*** and females: Sβ = 0.07*.	social support	good

Condliffe et al., 2017, J Behav Exp Econ	USA	181	UG	linear regression, E	+ve: teams attend the gym more often than other groups at the beginning and during the experiment: β = 0.795** initially for teams without information feedback and β = 0.719* for teams with information. NS effect for teams after experiment. NS effect for individual and information treatment at the start, however it does motivate more visits to the gym in weeks 2 and 3: β = 1.031*, remaining significant after the experiment: β = 0.269*.	information feedback; conformity	good
Gesualdo and Pinquart, 2021, Health Psychol Behav Med	DEU	208	UNI	multiple linear regression, CS	+ve correlation between close social ties' PA and own current PA: Sβ = 0.34* for partners, Sβ =0.31** for peers.	-	mediu m
Graham et al., 2014, J Phys Activ Health	USA	356	HS	multiple linear regression, CS	+ve association between friends' active behaviours and own baseline PA: β = 0.69*** and MVPA: β = 0.56***.	social support	mediu m
Graham et al., 2014, J Phys Activ Health	USA	356	HS	multiple linear regression, L	NS effects in PA between youths and their friends.	social support	mediu m
Lee and Lee, 2020, Percept Mot Skills	KOR	740	HS, UNI	multiple linear regression, CS	+ve correlation of exercise participation level of friends and own exercise behaviour: β = 0.395***.	social support	low
Li et al., 2014, Int J Behav Nutr Phys Activ	USA	2439	HS	structural equation modelling, CS	+ve association between closest friend MVPA and adolescent MVPA: Sβ = 0.21***.	social support	low
Li et al., 2016a, Pediatrics	USA	561	HS	multilevel regression, L	NS association of closest friends' MVPA with own exercise behaviours.	-	good
Li et al., 2016b, BMC Publ Health	USA	2659	HS	transition model, L	+ve association between closest friends' active behaviours and own activity: adjusted OR = 1.11**for MVPA and	-	mediu m

					adjusted OR = 1.17***for VPA.		
Long et al., 2017, Health Psychol	USA	1796	HS	stochastic actor-oriented model, L	+ve: adolescents adjusted their physical activity behaviour to their friends' behaviour: β = 0.903*** in school A and β = 0.729**in school B.	-	good
Lopes et al., 2013, J Adolesc Health	PRT	268	HS	multilevel regression, CS	+ve moderate correlation between best friend's weight-related behaviours and own activity (VPA, MPA and sedentary behaviour). NS effect for walking.	social support	low
Mendonça and Farias Júnior, 2015 J Sports Sci	BRA	2859	HS	logistic regression, CS	+ve: friend co-participation in PA (≥ 300 minutes a week) increases probability to engage in active behaviours: OR = 2.51*** for males, as well as probability for older adolescents (17 to 19-year-olds): OR = 2.48***. NS for females or 14- to 16-year-olds.	social support	good
Morrissey et al., 2015, Int J Behav Nutr Phys Activ	USA	401	ADOLES	multiple linear regression, L	+ve association of friends' co-participation on MVPA: β = 0.309*** and on weekday afternoon MVPA: β =0.377***	social support	good
Shoham et al., 2012, PLoS ONE	USA	1775	HS	stochastic actor-oriented model, L	+ve: egos (high on screen time) are likely to remain high or increase their screen time if their friends are also a high screen time type. Egos (playing an active sport weekly) had a 75% predicted probability of decreasing their playing sports if alter did not play any sports.	-	good

Simpkins et al., 2013, J Res Adolesc	USA	1896	HS	stochastic actor-oriented model, L	+ve association between friend PA and own behaviour: β = 0.45*.	social norms	good
Wang, Lizardo and Hachen, 2021, PLoS ONE	USA	619	UG	multilevel regression, L	+ve associations between peers' active behaviours and own daily activity: β = 0.06***, steps: β = 0.07***, active minutes: β = 0.07*** and activity calories: β = 0.07***.	descriptive norms	good
Yakusheva et al., 2011, Econ Hum Biol	USA	144	UNI	linear regression, E	+ve and marginally significant association between roommate's behaviour prior to freshman year and own outside exercise behaviour per week: β = 0.13 (p < 0.1). NS effect for gym usage.	-	good
Yuan et al., 2013, PLoS ONE	CHN	419	UNI	multiple linear regression, CS	+ve association of roommates' active behaviours on own use of bicycle: β = 4.00** and marginally significant effect on own moderate-intensity exercise: β = 0.22 (p = 0.078). NS for vigorous-intensity activity.	-	good

Notes: Graham et al. (2014) appears twice as they run two analyses (cross-sectional and longitudinal) to study the associations in PA between adolescent girls and their friends.
QA - Quality assessment. Study design: CS - cross-sectional; E - experimental; L - longitudinal. Population: ADOLES - adolescents; HS - secondary or high school students; UG - undergraduate students; UNI - university students; YA - young adults. Results: MDiff - mean difference; MVPA - moderate to vigorous physical activity; NS - non-significant (p > 0.05); OR - odds ratio; PA - physical activity; $S\beta$ - standardised regression coefficient; VPA - vigorous physical activity; +ve - positive statistically significant result associated with the peer effect.
***, ** and * denote significance at the 0.1%, 1%, and 5% levels, respectively.

3.3.3 Sleep

Our search produced five studies dealing with peer effects in sleep behaviours (Aalsma et al., 2012; Ali et al., 2011; Li et al., 2019; Liu et al., 2017; Wang, Mattingly, et al., 2021). All studies were conducted in the United States, and most of them utilised self-reports from The National Longitudinal Study of Adolescent to Adult Health (Add Health)[2] from the 1990s to assess peer-related data. Two of these studies measured sleep by asking participants how many hours of sleep they obtained per night (Aalsma et al., 2012; Li et al., 2019), and Ali et al. (2011) coded sleep as a binary variable indicating whether the adolescent usually slept six hours at the maximum. None of these papers found any significant influence of romantic partners' or friends' behaviours on an individual's predisposition to sleep duration.

Liu et al. (2017) explored an alternative outcome measure to analyse peer effects in sleep. Other than sleep duration, they studied the influence peers exert on adolescent bedtime decisions, also using Add Health data. They estimated a nonlinear least-squares model to account for measurement issues originating from missing observations in the original data set. While controlling for demographic characteristics (age, gender and race) and family background (e.g., parents' education and occupation), their most extensive model indicated a large positive and significant relationship. With an endogenous peer effect of 0.602, adolescents were found to go to bed approximately 36 minutes

[2] Add Health is a longitudinal study following an US-American sample of individuals as they transit from early adolescence into adulthood. With data collection having started in 1994-95, it provides comprehensive data on individual characteristics over the life course, including social, behavioural and environmental information. Details can be found elsewhere (Harris, 2013).

later, if their friends delayed their own bedtime by one hour.

Wang, Mattingly, et al. (2021) was the only study using objective sleep and network data obtained via wearables. After using an extensive set of time-variant variables (e.g., weather indicators) and time-invariant variables (e.g., gender, race and ethnicity or personality traits) as controls, the authors reported that peer behaviours influence students' daily time in bed, sleep duration, as well as daily bed- and rising time: a one-unit increase in peer's sleep duration was associated with a 0.11 unit increase in own duration of sleep, which translates into 6.5 additional minutes. Wang, Mattingly, et al. (2021) found no association with sleep quality measures (e.g., hourly awakening frequency or the number of sleep episodes). Other sleep quality measures (insomnia symptoms and sleep insufficiency) were investigated by Li et al. (2019). While the authors did not report any significant association between friend insomnia symptoms and individual difficulties of falling asleep, they found an elevated risk of sleep insufficiency of 41% for those whose friends reported that they would not get enough rest per night.

Table 3 Characteristics of selected studies on sleep behaviours.

Author(s), year, journal	Country	N	Population	Statistical analysis / Study design	Results	Mechanisms	QA
Aalsma et al., 2012, Soc Sci Med	USA	160	ADOLES	multilevel regression, L	NS effects in self-reported hours of sleep between adolescents and their romantic partners.	-	low
Ali et al., 2011, PLoS ONE	USA	2760	HS	multiple linear regression; probit model, L	NS association between friends' sleep duration and own behaviour.	social norms	good
Li et al., 2019, Soc Sci Med	USA	2550	HS	multiple linear regression; poisson regression, CS	NS effects in friends' sleep duration and own sleep duration. +ve: friends' sleep insufficiency positively affects own sleep insufficiency: β = 1.41**.	-	good
Liu et al., 2017, Econometrics J	USA	8000	HS	nonlinear least-squares regression, CS	+ve: friends going to bed one hour later on average delays own bedtime by 36 minutes: β = 0.602**.	perceived social norms; conformity	good
Wang et al., 2021, SSM Popul Health	USA	619	UG	multilevel regression, L	+ve association between students' time in bed and total sleep time and own behaviour: β = 0.11***. +ve effects in bedtime: β = 0.08*** and rising time: β = 0.09***. NS effects for sleep efficiency, number of sleep episodes, sleep onset latency and frequency of awakenings.	-	good

Notes: QA - Quality assessment. Study design: CS - cross-sectional; L - longitudinal. Population: ADOLES - adolescents; HS - secondary or high school students; UG - undergraduate students. Results: NS - non-significant ($p > 0.05$); +ve - positive statistically significant result associated with the peer effect.

***, ** and * denote significance at the 0.1%, 1%, and 5% levels, respectively.

3.4 Experimental and Non-experimental Evidence

3.4.1 Field and laboratory experiments

Many of the identified studies were motivated by the increasing prevalence of health-harming behaviours and subsequent spread of modifiable risk factors like obesity across populations (e.g., Fortin and Yazbeck, 2015; Yakusheva et al., 2011; Yuan et al., 2013). One reason for the observation of 'socially contagious' health-related outcomes could be due to individuals selecting their peers based on certain characteristics, which poses a challenge in distinguishing peer effects from non-random, selection effects (Bramoullé et al., 2020). These correlated effects are most credibly approached by applying (quasi-)random assignments of study subjects to peer groups, which is commonly used in experimental designs.

Overall, our search identified 13 experimental studies, with the majority focusing on peer effects in dietary behaviours, and only two studies focusing on exercise (Condliffe et al., 2017; Yakusheva et al., 2011). Yakusheva et al. (2011) convincingly addressed the identification problem by exploiting randomised roommate assignments to study weight change and related behaviours of female university students living on campus. By regressing individual behaviours during the freshman year on own and roommate's behaviour prior to entering college, they were able to address structural simultaneity between individual outcomes within peer groups. To control for unobserved heterogeneity, dormitory fixed effects are included. They find evidence of small, but positive peer effects in weekly exercise and a significant increase in the use of weight-loss supplements. Alternatively, Condliffe et al. (2017) conducted a field experiment to identify peer effects in gym attendance among a sample of predominantly female undergraduate students. Students were randomly assigned to one of five experimental groups to explore the impact of information and group incentives, both separately and in combination. The authors ran OLS regressions of participants' average weekly gym visits, conditional on their assigned treatment condition and demographic control variables. In line with previous peer effects studies on exercise behaviours, the paper revealed significant associations: being assigned to a partner increases early within-experiment gym visits. Teams that received no information on peers' gym attendance increased their participation by 0.795 weekly visits, and teams with information feedback by 0.719 weekly visits. By contrast, the authors found that students without a partner, but with information on their peers' outcomes, showed no statistically significant effect on gym visits in the first week. However, they exhibited an increase by 1.031 weekly visits in the third week. Further, this positive association remained significant in the weeks after the experiment.

Some experiments relied on self-reported fruit and vegetable (Meng et al., 2017; Nix and Wengreen, 2017) or unhealthy snack consumption (König et al., 2017). Subjectively reported peer behaviour has been argued to overcome some of the challenges arising from the common use of average peer behaviour to measure peer effects (Kawaguchi, 2004). On the other hand, subjective reports may be prone to errors and biases, such as recall errors or social desirability bias (Bertrand and Mullainathan, 2001), and potentially become important in small sample sizes. To address these concerns, Wengreen et al. (2017) used a skin biomarker for fruit and vegetable intake to estimate the effect of normative information on food intake. They informed their study participants that 80% of their peers in college had higher skin carotenoid scores than they did. Over the course of eight weeks, this led to a rise in skin carotenoid scores, indicating an increase of 0.89 cups in daily fruit and vegetable consumption.

Yet, it is likely that results on peer effects derived from experimentally manipulated peer groups, such as random roommate assignments, may be fundamentally different from those effects that come from close relationships among people. For example, a recent experimental study (Kimura et al., 2021) estimated the influence of co-eating with friends on unfamiliar snack intake in Japanese undergraduate students. The authors reported that friend pairs ate more and longer during the snack-tasting sessions compared to those eating alone, while pointing out that conformity norms may work differently among pairs composed of strangers. Contrastingly, Robinson and Higgs (2013), examined food choice in the presence of an unfamiliar person. Study participants that were assigned to the unhealthy treatment condition (i.e., they observed another person choosing high-energy-dense food items for lunch) were less likely to select low-energy-dense foods (e.g., carrot sticks). Yet, Robinson and Higgs did not find significant differences for kilocalories consumed, which they considered indicative of less pronounced peer effects in food choice settings. These results might be taken with care, though; the sample sizes in both studies were among the smallest in the set of articles identified, with N = 51 (Kimura et al., 2021) and N = 100 (Robinson and Higgs, 2013), respectively. We are unable to derive solid conclusions about any fundamental difference between peer effects from close and distal peers based only on this evidence.

3.4.2 Observational research

We identified twenty studies with cross-sectional and 13 studies with longitudinal study designs. Notably, the majority of longitudinal studies was conducted in the United States, with nearly half of them utilising Add Health data. Only one study was conducted in the United Kingdom (Jones and Robinson, 2017). Both cross-sectional and

longitudinal studies often relied on the average of peers' reported frequency of engaging in weight-related behaviours as main predictor (e.g., Ali et al., 2011; Fortin and Yazbeck, 2015; Shoham et al., 2012; Wang, Lizardo, and Hachen, 2021; Wang, Mattingly, et al., 2021). In contrast to the experimental literature that mainly focused on eating behaviours, the observational studies investigated a wide range of outcomes, including fruit and vegetable intake (Ali et al., 2011), fast food consumption (Ali et al., 2011; Fortin and Yazbeck, 2015), soda, sweets and pastry consumption (Jones and Robinson, 2017), active behaviours per day (e.g., Graham et al., 2014; Wang, Lizardo, and Hachen, 2021) and per week (e.g., Aalsma et al., 2012; Li, Haynie, et al., 2016; Li, Liu, et al., 2016; Long et al., 2017; Shoham et al., 2012; Simpkins et al., 2013) as well as a variety of sleep behaviours (Ali et al., 2011; Wang, Mattingly, et al., 2021). While a considerable number of studies employed linear regression models to analyse their data, some papers deviated from this conventional approach in the literature, opting for alternative regression methods and analytical frameworks. Longitudinal studies, for example, utilised multilevel modelling to analyse nested data structures in the survey responses to quantify peer effects over time (Aalsma et al., 2012; Li, Haynie, et al., 2016; Wang, Lizardo, and Hachen, 2021; Wang, Mattingly, et al., 2021) as well as stochastic actor-based models to exploit social network data from the Add Health data set (Long et al., 2017; Shoham et al., 2012; Simpkins et al., 2013).

The general notion of positive peer effects in youth behaviours was supported by 75% of the cross-sectional studies and the majority of longitudinal studies, particularly regarding those studying peer effects on physical activity. There is limited observational evidence on the impact of peers on sleep behaviours and data on how peers affect sleeping behaviours remains scarce.

3.5 Meta-Regression Analysis: Exploring Moderators and Sources of Variability

The presence of heterogeneity in effect sizes between reviewed studies as evident from the previous sections warrants further investigation. Meta-regression is one method to examine the role of contextual factors at study-level that potentially contribute to the observed dispersion (Borenstein et al., 2009). In spite of the variability in measures used to quantify weight-related outcomes, 19 studies were analysed to examine the impact of a small set of four contextual characteristics, such as sample size, population and quality rating, to explain the variability in regression coefficients. The results are reported in Table 4. The fitted meta-regression models included categorical and continuous variables and have been run independently for two subgroups: dietary behaviours (1) and physical (in)activity (2). While positive associations between sample size and reported effect size were found in dietary studies, along with a negative impact from studies conducted in the United States, these effects appear to be primarily driven by one specific study (refer to Table S7 in the Supplementary Data for more details). In contrast, studies on physical activity with larger sample sizes tend to report smaller effect sizes, and an inverse relationship is observed between quality rating and effect size in these studies. This suggests that higher-quality studies are more likely to report smaller effects – a potential indicator of publication bias.

As a further robustness check, we examined the impact of additional study characteristics on the likelihood of positive and significant peer effects being reported, employing a dummy dependent variable in our analysis. The analysis was conducted across three model specifications (3)–(5), for which the outcomes of all studies were categorised according to whether they reported a positive and significant association of peer behaviours and individual health outcomes. Of the 111 observations, 74% reported positive associations. In all model specifications, the likelihood of observing significant and positive peer effects increases with larger sample sizes. One possible explanation is that larger sample sizes generally yield smaller standard errors, and thereby more precise estimates, while smaller studies may show greater variability in effect sizes, including more extreme values. Yet, the magnitude of these effects remains relatively small. Additionally, studies employing university student samples were more likely to report positive associations. In our most comprehensive model (5), the dummy variable for studies on activity-related behaviours is statistically significant and increases the likelihood of studies reporting positive associations, compared to studies on diet. Conversely, we do not find a significant difference in the likelihood of reporting positive results between studies employing experimental designs and those using non-experimental methodologies.

Table 4 Meta regression analysis: the effect of study characteristics on the magnitude of effect size (1)-(2) and the likelihood of studies reporting positive and significant peer effects (3)-(5).

	Dependent variable:				
	Diet	**PA**	**Dummy for significant effect (All studies)**		
Moderators	(1)	(2)	(3)	(4)	(5)
Sample characteristics					

Sample size n	0.000*	-0.000**	0.000*	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Country = US	-0.177*	-0.005	-0.183+	-0.154	-0.137
	(0.081)	(0.053)	(0.094)	(0.096)	(0.096)
University sample	0.063	-0.131+	0.147	0.245*	0.234*
	(0.111)	(0.060)	(0.108)	(0.110)	(0.109)
QA rating	-0.001	-0.006**	0.000	0.002	-0.000
	(0.004)	(0.001)	(0.003)	(0.003)	(0.004)
Study characteristics					
Health behaviour = PA				0.181+	0.204*
				(0.095)	(0.095)
Health behaviour = Sleep				-0.304*	-0.237
				(0.142)	(0.148)
Study design = Experiment					0.178
					(0.116)
Constant	0.130	0.819***	0.665**	0.408	0.488+
	(0.363)	(0.109)	(0.247)	(0.251)	(0.255)
Observations	21	15	111	111	111

Notes: Standard error in parentheses. PA - Physical activity; QA - Quality assessment.
***, **, and * denote significance at the 0.1%, 1%, and 5% levels, respectively.
+ indicates marginal significance at the 10% level.

3.6 The Nature of Peer Effects

The study of social interactions and peer effects has become a subject of interest to scholars in economics, health, psychology and other social sciences for many years. As of today, there exists a considerable strand of literature linking peer influence to health-related behaviours. The prevalence of young people's unhealthy lifestyles and the extent to which peer influence may be involved in shaping other people's behaviours has attracted great interest among researchers, redeploying research on the occurrence of peer effects to the different processes by which peer effects operate. Thus, one focus of this review has been on the underlying mechanisms of peer effects. We reviewed studies that adduced several economic and psychological models to explain or elicit peer effects, including conformity, social norms and normative information feedback, social comparison, image-related concerns as well as social identity. In spite of the advances made in the peer effects literature, the motives behind an individual's behavioural adaptation and convergence to other people's behaviours still resemble a black box, as do the conditions under which we observe these effects.

The dominant mechanism discussed in most of the identified studies to explain peer effects is about social norms. Social norms can help achieve collectively desirable outcomes when formal institutions fail (Nyborg et al., 2016). They are implicit rules defining societies, affecting people's everyday decisions and economic behaviour in various ways. Several studies show how social norms impact individual and wider socioeconomic outcomes. Nyborg and Rege (2003) found that norm changes in public smoking behaviour following law amendments in Norway explained the formation of considerate smoking norms even in non-targeted areas like private homes. Young (2015) reviewed

studies on norm dynamics in health- and non-health related settings and concluded that under certain conditions, policy can effectively create or modify norms and thus individual behaviour. While the formation of norms driving peer effects may happen gradually, a variety of other motives can be involved, including a person's desire to conform, or their tendency to evade social disapproval.

Other competing explanations may be that people simply learn from the choices others make or that conformity rather results from people's image concerns and aspiration towards social status (Andreoni and Bernheim, 2009; Bernheim, 1994). A related, yet distinct concept includes competitive preferences and the social comparison motive. If an individual cares about social comparison, conformity can arise, because their utility depends on how they compare to their peers (Zafar, 2011). Social comparison may give rise to behavioural adaptation if individuals use their peers' choices as a reference point for their own behaviour. For example, Condliffe et al. (2017) provided informative feedback on peers' exercising behaviours. They showed that gym attendance of those students that learned about their peers' performance (i.e., the number of peers that have met a weekly goal) increased compared to participants without such information. Condliffe et al. attributed this to a competitive effect from entering a lottery, where participants used their peers' performance as a reference point. Although the information was anonymous and increases were observed for both individuals with information and teams with information compared to their equivalents with no information, social image or status concerns may also have been at play. In a web-based experiment, Meng et al. (2017) examined social comparison processes in healthy food consumption. Participants were assigned to groups sharing a collective goal of fruit and vegetable intake, where they received experimentally manipulated information about their group members' identities and consumption behaviour. While participants who were assigned to a group aiming at a collective goal reported on average 3.37 daily servings of fruit and vegetable intake, participants not assigned to a condition where they could compare themselves to other group members' outcomes recorded only 1.37 servings.

Ten other experimental studies investigated the impact of social norms on a person's dietary behaviour. All papers focused on the effect of norm-based interventions on subjects' food intake, either by analysing fruits and vegetables consumption (Liu and Higgs, 2019; Meng et al., 2017; Wengreen et al., 2017) or high energy dense and sweet food intake (Hirata et al., 2015; Robinson, Benwell, and Higgs, 2013). However, none of these studies has been able to credibly differentiate between the possible processes at work that may all lead to the same empirical outcome, namely conformity to peer behaviour. While these studies exposed their study participants to information about their peers' behaviour, it is possible that this information has helped participants to learn about the correct behaviour (e.g., increasing fruit and vegetable intake or reducing high-calorie snack consumption). It is also possible that the normative information about others' outcomes has rather been used as a reference point for their own decisions. As a result, behavioural adaptation is consistent with a variety of explanations, from people's willingness to conform to social norms to comparison and learning mechanisms.

The reviewed evidence suggests that behavioural spillovers via social influence is more likely to occur when a norm originates from an in-group than when it comes from an out-group, with which an individual does not identify, indicating a social identity motive underlying these peer effects. For example, in a laboratory experiment with female university students, Cruwys et al. (2012) reported a significant interaction between social identity and food intake: participants ate more when an individual, that allegedly belonged to the same university and thus, to the same social group (in-group), set a high food intake norm, whereas participants reduced their consumption significantly when they encountered an in-group member in the low norm condition. When participants encountered confederates they believed were not affiliated with the same university, no such effects were found. König et al. (2017) exploited a within- subjects design to experimentally examine peer effects in fruit and sugary snack consumption. Using a predominantly female student sample, they found that a one-unit increase in healthy snacking frequency ascribed to popular peers increases own weekly healthy snacking by 0.253. The authors reported that this effect appeared to be stronger for those participants that identified themselves with the student population of their university. For unhealthy snacking such as candy bars, cookies and wine gums, König et al. (2017) found no moderating effect of identification with a reference group. Drawing on these findings, Liu and Higgs (2019) ran two experiments using a remote-confederate paradigm with female students to test whether subjects adjusted their eating behaviours in response to normative information about healthy and unhealthy snack consumption of their peers. Controlling for habitual snack food intake in the first of their studies, they estimated a positive peer effect of alleged same-university students on subjects' cookie intake in the high norm condition compared to the control group. In addition, they found a negative effect when the perceived cookie intake of peers was low compared to those who did not receive any normative information. However, in line with König et al. (2017), they could not confirm their hypothesis that the strength of identification served as a significant moderator of peer effects.

Overall, our results suggest that peer effects in weight-related behaviours are best explained by social norms. Although the reviewed studies do find evidence for the empirical importance of other mechanisms, only few studies attempted to examine how social comparison, social learning and image-related concerns, among others, explain behavioural adaptation to peer behaviour. While norm-based interventions provide reasonable means to directly study the effect of peer norms on individual behaviour, their study designs generally do not take into account other

motives that are also consistent with the observed patterns of conformity. An overview of the mechanisms discussed is provided in Table S6 in the Supplementary Data.

4 Discussion

4.1 Principal Findings

Through a systematic literature review, we identified 45 studies from the past decade that focused on the importance of close and distal others in shaping own health-related behaviours during youth. Herein, we turned our attention to evaluating the evidence not only on the presence or absence of peer effects, but also on their underlying mechanisms.

First, our review identified considerable methodological heterogeneity across studies. For a start, the utilisation of natural experiments and randomisation (as for example in Yakusheva et al., 2011 and Condliffe et al., 2017, respectively) has been a reliable tool in increasing our understanding of the causal influence of peer effects. While experimental study designs provide important means to investigate peer influence, these approaches also come with their challenges specific to the study of social interactions: randomisation cannot generally overcome the reflection problem, as has been pointed out earlier by Hsieh and Van Kippersluis (2018). Studies using observational data have adopted other strategies. Typically, the impact of peer effects has been estimated via regression methods, incorporating the average behaviour of peers as an independent variable, whilst adjusting for both the individual's background and the mean background characteristics of the peers. However, the relation between peer and individual behaviour is often assumed to be linear-in-means. Manski (1993) noted that these models also suffer from a reflection problem, which leads to considerable challenges in the identification of the endogenous peer effect. More precisely, researchers are unable to identify whether the observed effects actually stem from the group itself or whether it is the individual's behaviour as part of the group that matters. Over the years, researchers have relied on a set of different methods to estimate social interactions and draw conclusions about the particular role peers play in individual health-related decision-making processes. Balsa and Díaz (2019) briefly summarised different approaches that have been utilised to address the reflection problem in the literature on social interaction models, and Pratschke and Abbiati (2023) provides a concise summary of the main empirical research methods commonly applied in the study of peer effects using observational data, emphasising the advances made through multilevel models, social network analysis and spatial autoregressive modelling, while addressing the common identification problems.

Second, our review pointed out a range of potential mechanisms driving peer effects in health behaviours. In our main analysis, we observed mostly positive associations of other people's behaviours and own health-related outcomes. Based on our synthesis, we find that drivers of peer effects are often modelled and expressed in the form of one particular mechanism, neglecting the role of complementarities, reciprocity, risk sharing and other motives. The major problem with this lack of knowledge is that we would derive different policy implications depending on which mechanisms are more pronounced in a specific context (Nakamura et al., 2017). We shall elaborate more on this in section 4.2.

Third, we identified a number of limitations and gaps in the existing evidence base that should be noted. As illustrated in previous sections, the included studies exhibited a vast heterogeneity in measures used to quantify outcomes, which poses challenges in terms of drawing consistent conclusions about peer effects on weight-related behaviours. Some studies distinguished between exercise and sports and their respective intensities, while others did not specify the type of physical activity; there were also differences in frequency measures, for example, fruit and vegetable consumption during the past seven or 30 days or physical activity in minutes per day or times per week. An additional factor is the use of mostly self-reported measures to assess the outcome of interest, which may have compromised the validity and reliability of these metrics.

We identified a lack of research on peer effects and weight-related behaviours in non-educational contexts. More than half (56%) of the empirical evidence originated from the United States and, perhaps unsurprisingly, most studies were set in high schools and universities of industrialised countries. Thus, the analysis is especially important for high-income countries, but less generalisable for other regions and environments. Evidence on the association of peer behaviours and diet, exercise or sleep in other settings such as clubs or workplaces are also underrepresented. Consequently, other types of relationships than friendships or fellow students have received little attention, which include siblings, romantic partnerships and club mates. Additionally, only few studies examined peer influence in online settings and networks such as Facebook and Instagram, despite the already significant and growing role of online peer communities. Our review also identified another limitation in the reviewed evidence base, possibly the most important one, which is the time of data collection. Although our systematic literature search explicitly addressed studies from 2011 to 2022 for the most recent evidence, many of the identified studies employed data that was collected only before 2010. A mere eight studies from the final selection used data that was collected between 2017 and 2020, while 42% of the included papers employed data from 1994 to 2010. In view of the rise of social networking sites during the past decade in the 2010s (Ortiz-Ospina, 2019), everyday communication and peer

interaction also expanded considerably to social media platforms such as YouTube and Instagram[3]. However, although previous research found that social network site usage was significantly and negatively associated with adolescents' health behaviours, including healthy eating and sleep duration (Serenko et al., 2021), the channels through which adolescent behaviour is affected remain unknown, and research in this area continues to be scarce.

4.2 Mechanisms and Policy Implications

For the purpose of curbing unhealthy weight-related behaviours in young people, policymakers could leverage the insights gained from current evidence on peer influence to design effective policies. Based on a brief summary of how different motivations related to social interactions could be utilised in health policy settings (Nakamura et al., 2017), this section revolves around the identified mechanisms in section 3.6 and their respective policy implications. It is well established that other people's actions convey informational cues, especially in situations of uncertainty. Individuals are able to acquire knowledge about others' behaviours and the outcomes they experience through observation (Bikhchandani et al., 1998). This in turn may be used to form preferences, update beliefs and inform subsequent decisions and actions. Along these lines, Cutler and Glaeser (2010) emphasised that even social spillovers in harmful behaviours such as tobacco or alcohol consumption may result from learning about the putative benefits of these activities. From another point of view, people also get to know about prevalent norms through observational or social learning. This indicates that there are significant health-related policy implications of this motive. Educational policies could be designed to improve youth health literacy and provide information about peer behaviours and their consequences. Programs could also help to correct misperceptions through the dissemination of knowledge about the real prevalence of certain activities. For example, Amialchuk et al. (2019) reported that misperceptions about social norms exhibit a strong effect on young students' alcohol use and related behaviours. Utilising social norms to indicate what most people do as well as the disclosure of health consequences of specific actions could be used to harness social learning as an underlying mechanism of peer effects.

In contrast, the social comparison motive adopts the idea that individuals emulate their peers' behaviours, because their utility depends on how they compare to others. Peers and their behaviours serve as a reference group: an individual's utility increases as they align with other people's behavioural outcomes; by contrast, deviation from the norm may be associated with utility decreases. Arduini et al. (2019) found evidence that female students exposed to an environment with thinner peers are more likely to adapt harmful weight-related behaviours, including induced vomiting, laxative or diet pill abuse, and excessive exercise behaviours. They attributed this outcome to social comparisons with peers that had a supposedly more desirable appearance relative to themselves. Another approach was taken by Mathieu-Bolh (2020) who built a theoretical model of intertemporal food consumption, where individuals are motivated to adapt to an endogenous social weight norm because of a desire to conform. Mathieu-Bolh posited that the perception of a healthy weight depends on the degree to which individuals compare themselves to their peers. According to these results, interventions other than those targeting norm changes could show more promise, if decision-makers intend to leverage the power of peer effects. Thus, if social comparison underlies conformity as a primary driver in health-related decision-making, Nakamura et al. (2017) suggested considering the creation of incentives to opt for healthier options or, conversely, disincentivising unhealthy behaviours through the enforcement of punishment. Arduini et al. (2019) went one step further and emphasised the benefits of educational programs supporting young people in capacity building to manage negative effects of comparison processes and to develop a positive self-image.

A different, but closely related motivation underlies peer effects, if individuals do not only care about conforming to a particular reference group, but if they try to comply with a given norm, in order to maintain or gain esteem and social prestige. Individuals that are motivated by social status or image-related concerns conform because their status depends on adhering to observed social norms and deviation is viewed as a loss of prestige (Akerlof, 1980; Bernheim, 1994). While social comparison can play a role even in settings where identities are anonymous, previous studies implied that behaviour must be observable by others in order for a status-related mechanism to become effective. This had previously been demonstrated for productivity in the workplace (Mas and Moretti, 2009) and charitable giving (Zafar, 2011), among other contexts. Policy-makers could leverage this mechanism by targeting current beliefs and expectations about what others expect one to do. Exploiting media campaigns may be an obvious choice to take full advantage of their generally wide coverage and accessibility as well as their ability to shape norms, for example through the regulation of advertising and marketing practices. Additionally, social media may prove to be an even more influential lever as they provide a more tangible environment and more reciprocal interactions compared to traditional media (Fardouly et al., 2017).

Moreover, there is evidence that social identity may also play an important role in generating peer effects in health behaviours. For example, Gioia (2017) noted that there is an association of the extent of identification with a certain social group and the magnitude of peer effects. As the sense of belonging to a certain group increases, the more

[3] For instance, a great majority of US-American youth reported that they ever used YouTube (90% of 18- to 24-year-olds) or Instagram (75% of 18- to 24-year-olds) in 2019 (Ortiz-Ospina, 2019).

influential peers from the same group become. This would imply that policies targeting only a few, but the most relevant peers could generate more effective outcomes. However, despite the solid progress scholars have made toward a better understanding of the nature of peer effects, it still proves challenging to choose the most relevant peers and to understand how people interact in certain domains.

Finally, we found that most studies generally attributed behavioural changes to the influence of social norms, especially those investigating dietary behaviours. While social norms are clearly a potential candidate to explain such behaviour, we find no research that is able to disentangle the effect of social norms, and in particular empirical and normative expectations (Bicchieri and Xiao, 2009), from other potential explanations. Following the seminal work by Krupka and Weber (2013), previous research in behavioural economics has successfully managed to disentangle the role of social norms from social preferences in prosocial behaviour (Gächter et al., 2013; Kimbrough and Vostroknutov, 2016). Yet, the challenge would be to apply this knowledge for better understanding the different mechanisms behind weight-related behaviour in the field.

4.3 Limitations of the Review

Our systematic review synthesised the association between peer effects and weight-related behaviours, as well as the underlying mechanisms leading to behavioural adaptation among young people. While this review may be able to provide some first tentative guidance for decision-makers to leverage the insights gained from current evidence on peer influence, the number of studies actually investigating the driving factors was limited. Another limitation of this review is that we limited our search of electronic databases to peer-reviewed articles published in English, omitting grey literature or unpublished studies as well as those published in other languages than English. It is possible that some relevant works have been excluded based on the applied criteria, which may directly affect the validity of our study and give rise to publication bias. Asymmetrical funnel plots, Egger's regression test for funnel plot asymmetry and a simple selection model indicate potential publication bias, specifically regarding studies reporting null or negative effects with high standard errors. Further, the methodological heterogeneity across the reviewed studies precluded the comprehensive conduct of a quantitative meta-analysis of the observed patterns. Instead, we applied a meta-regression analysis using a subset of the reviewed studies to examine the effect of study-specific characteristics on the magnitude of effect sizes. To ensure the robustness of our findings, we further compared our results with models assessing the impact of study characteristics on the sign and significance of the reported peer effects.

While our review combined a large body of evidence from high-income countries with studies from emerging countries such as Brazil, China, and Korea, to deepen our understanding of the nature of peer effects, the scarcity of studies from populations outside the United States or Europe may have had an impact on the external validity of our findings, considering different cultural norms and social dynamics across countries. Our meta-regression indicated that studies from the United States, in particular, did not emerge as a significant predictor of the magnitude, sign, or significance of peer effects in health behaviours. In line with this finding, previous studies have reported similar magnitudes of peer effects across different cultures, such as the United States and China (Nie et al., 2015) as well as cross-cultural similarities in susceptibility to peer effects (Hirata et al., 2015). However, although certain aspects of peer effects seem to transcend cultural boundaries, it is important to note that comprehensive generalisability requires further research. Moreover, most of the included studies investigated peer effects on dietary and physical activity behaviours, whereas only five studies on peer effects in sleep behaviours met our inclusion criteria. Four out of the five studies on how peers may affect own sleep-related behaviours make use of the Add Health data set from the US, with data collected in the mid-1990s. While Add Health has provided important means to inform behavioural and social science, any inference from the findings should be made with caution.

5 Conclusion

In this systematic literature review, we synthesised studies adducing several economic and psychological models to explain peer effects, including conformity, social norms and normative information, social comparison, social image, social support as well as social identity. The evidence on behavioural drivers, through which young people's weight-related outcomes are affected by their peers, does not deliver a clear understanding of which mechanisms matter the most for this population. Youth may experience heterogeneous effects depending on their own developmental stage, but also conditional on the composition of their peer group and interpersonal dynamics. Although the nature of our study design did not allow for a comprehensive meta-analysis, we performed a meta-regression based on a subset of results from quantitatively comparable studies.

The necessity and benefits of seeking to disentangle the different mechanisms underlying peer effects have been discussed by Nakamura et al. (2017) in a broader context. Building and extending on their model, we provided further insights into possible interventions to leverage the insights gained from current evidence to design effective policies in health-related contexts. Ultimately, while some policy implications can already be inferred from the current evidence, a deeper and more fine-grained understanding of the exact mechanisms underlying peer effects in the

present context would allow policymakers to systematically leverage the insights for a better design of effective policies to improve the health-related trajectories of young people. For instance, correcting misperceptions and harnessing the influence of normative information have been shown to positively impact weight-related behaviours. However, this may only be an effective way, if individuals actually engage with their environment and learn from their peers, allowing them to retrieve relevant information to update their beliefs and make their own informed choices. Considering that motives differ empirically as do their implications, the scarcity of studies credibly disentangling the underlying mechanisms of peer effects further accentuates the rationale for more robust evidence.

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CRediT author statement

Nathalie Müller: Conceptualization, Methodology, Formal analysis, Investigation, Data Curation, Writing - Original Draft Preparation, Visualization.
Francesco Fallucchi: Conceptualization, Methodology, Writing - Review & Editing, Supervision.
Marc Suhrcke: Conceptualization, Methodology, Writing - Review & Editing, Supervision, Funding acquisition.

Highlights

- Forty-five studies examined social influence on weight-related behaviours.
- Behavioural adaptation was most commonly explained by social norms.
- Studies did not clearly distinguish between potential drivers of peer effects.
- Understanding the mechanisms may help inform more effective behavioural policies.