The impact of social determinants on health outcomes in a region in the North of England: a structural equation modelling analysis

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Published version

NEWTON, Dillon, STEPHENSON, John, AZEVEDO, Liane, SAH, Rajeeb, POUNDEL, Narayan and RICHARDSON, Owen (2024). The impact of social determinants on health outcomes in a region in the North of England: a structural equation modelling analysis. Public Health, 231, 198-203.

The impact of social determinants on health outcomes in a region in the North of England: a structural equation modelling analysis

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Abstract

Objectives: To identify the impact of social determinants of health on physical and mental health outcomes in a UK population.

Study design: Structural equation modelling was used to hypothesise a model of relationships between health determinants and outcomes within a region in the North of England using large-scale population survey data (6,208 responses).

Methods: We analysed responses from a population survey to assess the influence of a deprivation-based index at the environmental level, education, and income on a behaviour index (smoking, alcohol consumption, physical activity and dietary habits) and the influence of all these factors on self-reported physical health and the influence of the behaviour index and income on mental wellbeing.

Results: The proposed model was well supported by the data. Goodness-of-fit statistics, most notably a low value of the root mean square error of approximation (RMSEA), supported the validity of the proposed relationships (RMSEA=0.054). The model revealed all examined paths to be statistically significant. Income and education were influential in determining an individual's behaviour index score, which, with income, was the most important predictor of both the correlated outcomes of physical health and mental wellbeing (p<0.001 in all cases).

Conclusions: Findings challenge the traditional view of singular causal pathways, emphasising that interventions should consider the underlying influencing socio-economic conditions which would influence behaviour, and therefore physical and mental wellbeing. The extent to which the model is supported by the data, and statistical significance of individual relationships accentuates the imperative for comprehensive public health strategies that integrate multiple socio-economic factors.

Keywords (3-6): social determinants of health; health inequalities; structural equation modelling; health behaviour

Introduction

Government public health reports continue to emphasise the necessity of health interventions that consider the effects of environmental and societal conditions in influencing health and health inequalities across populations [1-3]. These are supported by widely observed associations in the literature between education, income and deprivation (income and education are embedded in deprivation measures in the UK) and specific health outcomes. Many studies have identified the effects of education levels on obesity and mortality [4-6], as well as income levels and a range of health outcomes [7]; and deprivation levels on all-cause, premature and cardiovascular disease mortality [8, 9].

Collectively, these studies provide a robust empirical base that underscores the association between socioeconomic factors and health outcomes. However, the complex interplay between the factors concerned has not been extensively analysed. Whilst the health effects of socioeconomic factors are well understood, there remains disagreement about how social factors interrelate to produce health outcomes [10]. The general view of social determinants of health as specific causal pathways between single predictors and specific health outcomes has been criticised for simplifying the complex interplay between an individual's health and their socioeconomic context [11]. With increased recognition of the complex nature of socioeconomic connections with health, recent studies have urged more complex approaches

that can provide a deeper exploration of the interplay of determinants that trigger health behaviours and wide array of health outcomes [10,11].

The Current Living in Kirklees (CLiK) survey

Kirklees Council is the local authority for a mostly urban area in the North of England in the United Kingdom (UK), covering a population of about 433,000. Compared to the rest of the UK, the area covered by the local authority is ethnically diverse with poor health and social outcomes and an under-developed economy [12]. The local authority administers the Current Living in Kirklees (CLiK) survey every 3-5 years to assess residents' health and wellbeing; and to obtain comprehensive health data at various geographic levels and for specific demographic groups. The most recent implementation between November and December 2021, comprised surveys sent to 43,000 randomly sampled households, using past response rates to guide its sampling volume, and offering both online and paper formats. The targeted sample was boosted via an open online link and promotion from locally-based individuals designated as Community Champions.

The implementation of the CLiK survey was conducted to high methodological standards; with a core sampling approach comprising a stratified random sample (by deprivation quintile) designed to produce robust results at subdistrict and socio-demographic group level, to inform the commissioning, planning and provision of local services. Participation was optimised by offering paper or online alternatives for completion, and a prize draw. The survey was extensively promoted by Kirklees Council, partner organisations and by Community Champions to aid engagement among minority communities; with translated text provided in multiple languages.

This study leveraged CLiK data to explore how key social determinants impact health outcomes in Kirklees. The CLiK survey included a mixture of health-related items including information on physical and mental health status of respondents which were used as the data source in the current analysis. Using structural equation modelling (SEM), the study aimed to fill gaps in understanding the complex pathways through which social factors affect health.

Methods

Measures

A numerical measure of physical health was obtained from a self-reported item on the CLiK survey eliciting information on current levels of physical health on a 5-point scale; with higher values indicating better physical health. Mental wellbeing was assessed via survey items comprising the short form of the validated Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) (© University of Warwick 2006, all rights reserved). This short form of the scale (SWEMWBS) used seven of the WEMWBS's 14 statements about thoughts and feelings, with a focus towards levels of mental functioning. The total raw scores derived from response to the individual items were transformed into metric scores using a conversion table supplied by the score developers. Possible scores range from 7 to 35; with higher scores indicating better levels of mental wellbeing.

Responses to items eliciting information on behaviours (smoking status, alcohol status, activity and dietary factors) were also included in the CLiK survey and used to derive a behaviour index based on number of "low risk factors" per individual methodology developed in a previous study [13]. Respondents were credited as having a "low risk" factor if:

- Respondents self-reported as engaging with at least 150 minutes of moderate or vigorous activity per week (activities considered moderate to vigorous included: running, swimming, cycling, or playing sports such as football, rugby or netball). The

threshold for meeting this criterion was amended from the criteria of Li et al. to match the recommendations of the World Health Organisation (WHO 2020) and the UK Chief Medical Officer (UK Chief Medical Officer 2019).

- Respondents self-reported moderate alcohol consumption; defined as below 15 g/day for women and below 30 g/day for men. This measure was processed from response to items on the CLiK survey which provided explicit information on the equivalent units of alcohol in a variety of drinks of different types and sizes, allowing respondents to make an accurate judgement as to their mean daily consumption. This methodology is based on US guideline consumption levels and does not take into account variations in daily patterns of consumption.
- Respondents self-reported as having never smoked.
- Respondents self-reported as being likely to eat 5 or more portions of fruit and vegetables per day.

Participants were awarded a score of 1 point for each 'low-risk' factor which applied to them; hence their behaviour index could be scored from 0 to 4, with higher scores indicating a healthier lifestyle.

Respondents were also asked about their family income and highest level of education. An item on the CLiK survey eliciting a measure of family income (in bands of GBP10,000) was used to derive an income variable in which 1 point represented an additional increment (of magnitude GBP10,000) of income. Education was categorised into *Below Level 3* (i.e. no post-compulsory education) and *Level 3 and above* (i.e. A level qualifications, or equivalent; or above).

The numerical value of the index of multiple deprivation (IMD) decile for each respondent, derived from postcodes of respondents was recorded as a proxy measure of deprivation at the environmental level. IMD encapsulates a broad range of environmental and neighbourhood factors such as income, employment, health, education, crime, barriers to housing and services and the living environment. While education and income are constituent components of this index, they are measured at the individual level, rather the environmental level, and so it is deemed appropriate that IMD as a measure of deprivation, was included in the analysis alongside measures and education and income.

The full list of survey questions is linked in the Supplementary material.

Hypothesis generation and structural equation modelling

The range of measures collected on the survey facilitated a hypothesised model structure postulating linkages between the health determinants of income and education, IMD decile, the health/behaviour index, and mental and physical health outcomes. Extant theory and evidence, in conjunction with exploratory uncontrolled analyses conducted on relationships between selected key health indicators and determinants in the CLiK data set, was used for hypothesis generation. The literature revealed that low income, higher deprivation levels, low level of education and high-risk behaviours score were associated with higher levels of physical and mental health conditions [4, 5, 6, 7, 8, 9, 14, 15].

Strong associations between high deprivation levels and increased physical and mental health conditions were further established in previous studies [8, 9]. In an exploratory procedure, all relationships identified in the literature were tested using data from the CLiK survey to verify the existence of uncontrolled relationships in the study sample.

Based on the relationships established in the literature and confirmed using exploratory analysis, we hypothesised a model structure to be tested in a structural equation model. Paths were postulated from the health determinants at the individual and environmental level (i.e.

education level, income and IMD decile) and the behaviour index to the physical health outcome measure; and paths from the determinant of income and the health/behaviour index to the mental wellbeing outcome measure. To ensure that the model was over-identified (i.e. the number of observations is less than the number of free parameters), we did not consider paths from the education and IMD measures to the mental wellbeing outcome, considering that the evidence for such paths was weaker than for other paths included in the model. We also postulated paths to the behaviour index from the individual and environmental determinants. We further postulated a correlation between the physical health and mental wellbeing measures; and pairwise correlations between the health determinants of income, education and IMD.

The use of the omnibus behaviour index in the model avoids excessive complexity of the resulting model structure and ensures that the model is over-identified. The resulting recursive structural equation model initially tested illustrated in Figure 1. Paths are illustrated by straight lines with single-headed arrows indicating the direction of the relationship. Covariances between variables are represented with curved lines with double-headed arrows. Circled quantities are disturbance terms associated with the endogenous variables.

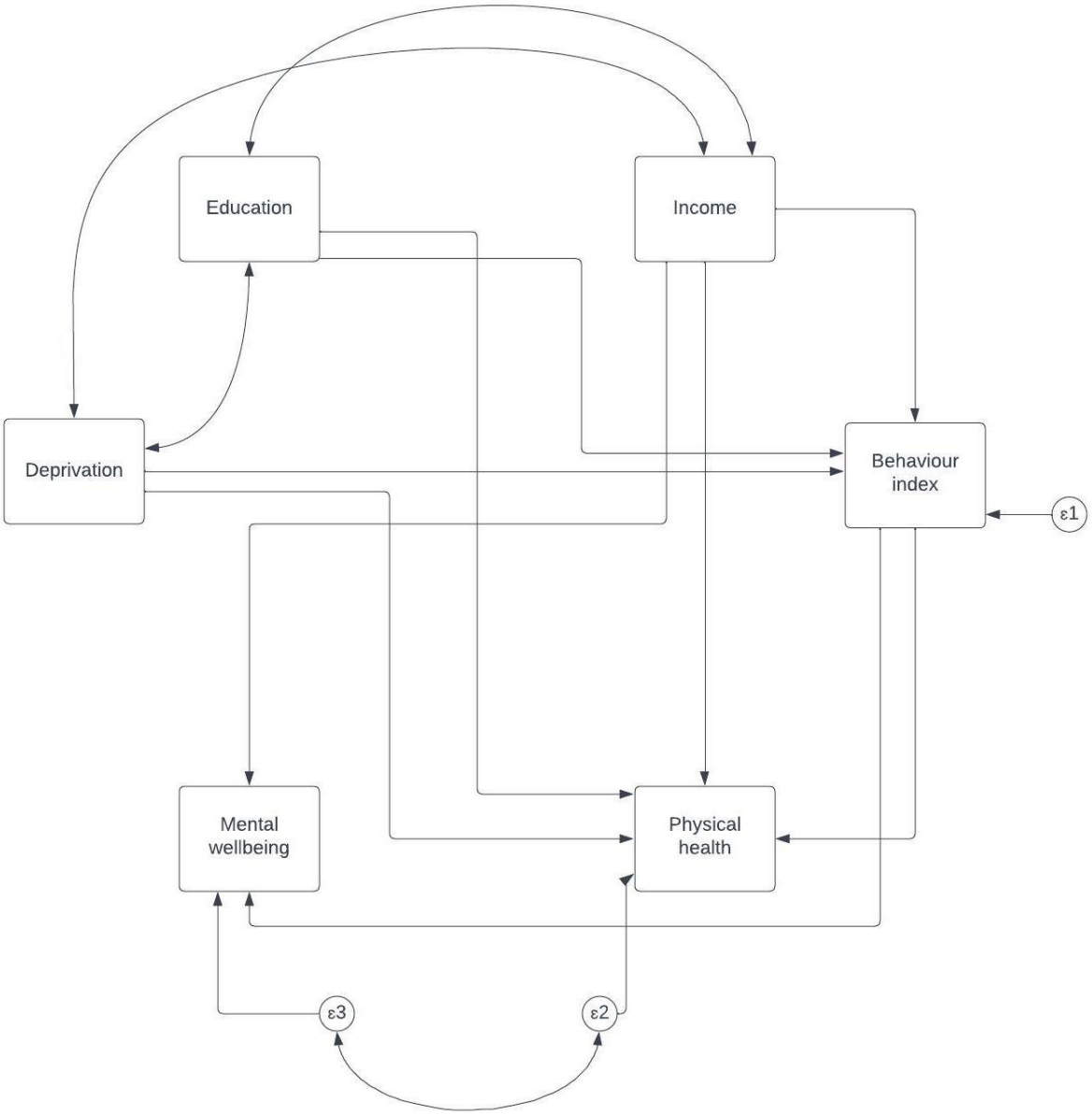

Figure 1: Structural equation model

For each postulated path in the model, we calculated both unstandardised and standardised parameter coefficients and associated 95% confidence intervals, and *p*-values. For postulated non-directional relationships, we calculated correlations and associated 95% confidence intervals. The inclusion within the structure of both 'direct' linkages between the health determinants of deprivation, income and education and the health outcomes of physical health and mental wellbeing; and corresponding 'indirect' linkages in which the behaviour index lies on the causal path between a health determinant and an outcome allows for the testing of mediated relationships, through the application of criteria for mediation derived in previous research [16].

Statistical analysis

The sample was summarised descriptively. The extent and nature of missing data was analysed, and the data was assessed for the need for imputation. Path coefficients and covariances in the structural equation model were evaluated using maximum likelihood

methods. We tested the model using a range of goodness-of-fit measures; including the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker-Lewis index (TLI) and the standardised root mean-square residual (SRMR). RMSEA and SRMR are indices of absolute fit: RMSEA compares the fit of a hypothesized model to a perfect model; SRMR is defined as the standardised difference between the observed correlation and the model implied correlation matrix. CFI and TLI are indices of incremental fit, comparing the fit of a hypothesized model with that of a baseline model (i.e. a model with the worst fit). The literature [17, 18] suggested that an RMSEA value below 0.05 indicates a close fit of the model to the data; and a value below 0.08 suggests a reasonable fit; no evidence to reject a null hypothesis that RMSEA = 0.05 represents a model designated to be a close fit. The literature [19] recommended that TLI and CFI values in excess of 0.90 indicate an acceptable model fit, and that an SRMR value below 0.06; or below 0.08 in combination of other indices within recommended ranges are indicative of good fit [20]. We considered a well-fitting model to be represented by most or all of these criteria.

In the event of our initial proposed structure resulting in a poorly fitting model, we planned a series of model re-specification steps, removing or adding additional relationships based on extant theory and evidence; however, that did not prove to be necessary as the first model tested was revealed to be a very good fit to the data.

Results

In total, 6,208 responses were received (14.4% response rate); comprising 5,160 responses from the targeted sample, plus 949 from an open online link and 99 paper responses via Community Champions. The sample comprised 2,864 males (46.1%), 3,075 females (49.5%) and 269 respondents (4.3%) who did not give their gender or preferred to self-describe themselves in some other way. Mean respondent age was 49.2 years (SD 18.2 years). 5,220 respondents reported themselves to be White British, representing 86% of those reporting a valid ethnicity. Other ethnicities included in substantial proportions included Asian/Asian British: Pakistani (257; 4% of valid response) and Asian/Asian British: Indian (164; 3% of valid response). Comparison of survey responses with publicly available demographic statistics [21, 23] revealed survey responses returned well represented the target population in terms of levels of socio-economic deprivation, with slight over-representation of females, those in older age groups and those of White ethnicity.

The amount of missing data on the endogenous variables was about 7% on the mental wellbeing measure, and negligible on the other measures. Income data was missing from 12% of respondents, education data was missing on about 6% of respondents and deprivation data was missing on about 3% of respondents. Separate variance t-tests revealed no evidence for data not missing at random on any variable. Due to the generally low level of missing data, and no evidence for data not missing at random, complete case analysis was utilised for data analysis, without imputation.

Summary statistics related to all variables included in the analysis are summarised in Table 1.

Variable	**Mean (SD)**	**Median (IQR; range)**
Physical health score (*n*=6,040)	3.58 (0.92)	4 (1; 1-5)
SWEMWBS transformed score (*n*=5,748)	22.4 (4.09)	22.4 (5.78; 7-35)
Health/behaviour index (*n*=6208)	2.59 (0.953)	3 (1; 0-4)

Income point (*n*=5469)	3.80 (2.23)	2 (5; 1-8)
Variable	**Frequency (valid %)**	
Highest level of education (*n*=5845)		
Below Level 3	2,067 (35.4%)	
Level 3 or above	3,778 (64.6%)	

Table 1: Summary of endogenous health outcome variables

Unstandardised and standardised path coefficients and covariances are summarised in Table 2. Each path is described in the table in the form (predictor) → (outcome).

Path/ covariance	**Unstandardised coefficients**		**Standardised coefficients**		***p*-value**
	Estimate	**95% CI**	**Estimate**	**95% CI**	
Deprivation → Health/behaviours	0.0311	(0.0209, 0.0412)	0.0884	(0.0596, 0.117)	<0.001
Education level → Health/behaviours	0.229	(0.169, 0.290)	0.114	(0.0846, 0.144)	<0.001
Income → Health/behaviours	0.0573	(0.0432, 0.0713)	0.127	(0.0960, 0.158)	<0.001
Health/behaviours → Physical health	0.246	(0.221, 0.271)	0.262	(0.236, 0.289)	<0.001
Deprivation → Physical health	0.0133	(0.00490, 0.0218)	0.0405	(0.0149, 0.0662)	0.003
Education → Physical health	0.148	(0.0983, 0.199)	0.0789	(0.0524, 0.105)	<0.001
Income → Physical health	0.0703	(0.0578, 0.0827)	0.166	(0.137, 0.194)	<0.001
Health/behaviours → Mental wellbeing	0.783	(0.661, 0.905)	0.181	(0.154, 0.209)	<0.001
Income → Mental wellbeing	0.216	(0.161, 0.271)	0.111	(0.0826, 0.139)	<0.001

Table 2: Unstandardised and standardised path coefficients and associated statistics

Hence all relationships tested were strongly significant at the 5% significance level. Standardised path coefficients revealed the key determinants of deprivation, education and income to make an approximately equal contribution to the prediction of the behaviours index. This index was the largest contributor to both physical health and mental wellbeing, with income also playing some role in both cases.

Physical health and mental wellbeing were positively correlated, with an effect of moderate magnitude (*r*=0.379; 95% confidence interval (CI) 0.355 to 0.404). All exogenous predictors were mutually correlated, with an effect of moderate magnitude between income point and IMD (*r*=0.297; 95% CI 0.271 to 0.323); and between income point and education level

(*r*=0.390; 95% CI 0.366 to 0.414). The correlation between IMD and education level was significant, but small in magnitude (*r*=0.152; 95% CI 0.124 to 0.179)

Goodness-of-fit statistics for this model revealed the model to be a good fit to the data. The estimated RMSEA value was 0.054 (95% confidence interval 0.038 to 0.072). There was no evidence to reject the hypothesis that the RMSEA value was 0.05 or below (*p*=0.328); suggesting that the model may be designated a close fit. The CFI and TLI values of 0.987 and 0.920 respectively both indicated very good model fit. The SRMR statistic was 0.016, indicating a very good fit according to this index. No model re-specification was conducted due to the goodness-of-fit of the initially derived model.

Discussion

The structural equation model developed to test the overall hypothesis of an interconnected model has enabled identification of the relative importance of selected social determinants in explaining behaviour outcomes in the Kirklees region of England, United Kingdom. Significant associations were identified between the determinants of deprivation, education level, income, and health behaviours and the outcomes of physical health and mental wellbeing; with evidence for multiple inter-relationships within determinants. The hypothesised model was shown to be consistent with the data according to all goodness-of-fit statistics. The high levels of statistical significance observed for all tested relationships precluded the consideration of the behaviour index score as a mediating variable on any causal path: the final criteria for mediation set out in [16] was not met in any of the tested relationships, with the strength of relationships between any of the exogenous variables and any outcome measure not substantively affected by the concurrent consideration of the health/behaviours index as a potential mediating factor. One minor limitation of the model is that while two of the three endogenous variables in the model were numerical, the physical health variable is ordinal (5-point Likert-style item), although considered to approximate to an interval measure. However, SEM relies on asymptotic theory; hence as the sample size increases, the estimates become more normally distributed. The model was derived from a survey sample of over 6200, and as such should be robust to this mild departure from normality. Although our analysis did not reveal any mediated relationships, it strongly affirmed the direct associations among key variables. Results reveal that the behaviour index, and to a lesser extent, income are important predictors of both physical health and mental wellbeing; with better outcomes associated with healthier lifestyles and higher levels of income. The behaviour index itself in turn is impacted by education, deprivation and income in roughly equal measures, with higher levels of education, lower levels of deprivation and higher levels of income all predicting scores indicative of better health behaviours. Secondary findings included a relationship of moderate magnitude between physical health and mental wellbeing; and low-to-moderate correlations between the exogenous health determinants. These results are aligned with recent studies that emphasise the influence of socio-economic determinants such as education and income on health behaviours [4, 5, 6, 7].

Overall, the study underlines the complex interaction between socio-economic determinants and behaviour outcomes, with high levels of statistical significance in observed results highlighting the extent of the evidence for linkages between the constituent relationships of the structural model. The observed correlations also suggest intertwined relationships among the determinants and outcomes, emphasising the necessity to consider the broader environment when evaluating health behaviours and outcomes.

The study highlights the need for more nuanced approaches that consider multiple socio-economic factors and substantiates the growing consensus that it is not merely one determinant but a complex interplay of socio-economic factors that influences health outcomes; challenging the traditional view of singular causal pathways [10, 11]. Drawing on

the emphasis on health inequalities by Marmot [1, 3], this reiterates the need for structural interventions that include environmental determinants in addition to individual determinants to address the root causes of health disparities; although the findings of the current study suggest that environmental determinants such as deprivation may make a relatively minor contribution to outcomes, compared to individual-level factors.

Building on the findings of this study, a multi-faceted approach that considers complex interrelations between deprivation status and health outcomes is essential. More comprehensive interval-level measures of physical health may lead to improved confidence in model findings. Public health initiatives that promote increased activity, healthy eating (for example increased fruit and vegetable consumption), reduced alcohol intake and smoking cessation should consider socio-economic factors that create barriers to altering health behaviours to promote healthier outcomes. Reducing structural inequalities in the economy is necessary for improving the health and wellbeing of people, which itself receives less attention than other factors people [1, 2, 3, 22].

These results underline the requirement for local authorities and their partners to advance knowledge and methods that address the wider determinants of health inequities, enhance population health, and demonstrate the potential of the data source to evaluate the effect of socio-economic and other factors on a range of health outcomes in the population. For example, authorities could focus on targeted interventions aimed at low-income households with low levels of education and/or higher deprivation levels, based on the data showing the association of these factors with poor health outcomes. Initiatives could include the creation of educational programmes that promote healthier lifestyle choices and investment in local healthcare services tailored to treat prevalent physical and mental health conditions identified in specific localities. Moreover, our study suggests that policymaking would benefit from the further utilisation of information from public health surveys similar to the CLiK survey on which the findings of the present survey are based. This has potential to better enable more targeted public health campaigns and enhance the effectiveness and reach of health interventions. Given the strong association between IMD and both mental wellbeing and physical health, there is a pronounced need for local authorities to initiate area-level interventions. Such interventions might include community-based mental health programs or neighbourhood-level health promotion campaigns, focusing specifically on area identified as having high deprivation. By harbouring intelligence to zone in on these particular social determinants, authorities could move towards a more strategic, data-driven approach to tackling health inequities.

Further research should explore other potential mediating and moderating variables to provide insights into additional layers of complexity in the socio-economic determinants of health, and potentially address gaps left by more traditional models. Research could also test this model in different demographic and geographic settings to examine its applicability and robustness in diverse contexts.

Strengths and limitations

The sampling of the CLiK survey, on which the current analysis is based, was conducted to high methodological standards; with participation revealing good representation of the Kirklees population, albeit with slight over-representation of females, older individuals and those of White ethnicity [21]. In turn, the Kirklees population is not fully representative of the UK general population in terms of levels of income or ethnicity, although disparities are slight [23]. Inferences from the model could generalise to other metropolitan areas. At over 6,000 participants, the sample was large, but response rate was moderate.

Many of the constructs considered in this study were derived from self-reported measures, and, with the exception of the validated SWEMWBS measure of mental wellbeing, other measures have not been validated. The behavioural index utilised was based on an established tool, but amended to account for data relating to available constituents; and the use of a single index for behaviour, although simplifying our model, ensuring over-identification and improving its practical utility, may have resulted in information loss. While levels of missing data were low, and data could be shown to be missing at random, not all data may be missing completely at random. Some of the included constructs, notably education, were modelled as categorical variables which may also have resulted in loss of information. Further work is needed to validate the model using more comprehensive and representative datasets.

Conclusions

This study significantly advances understanding of the intricate ways in which it challenges the traditional view of singular causal pathways, emphasising that interventions should consider both health behaviours and the underlying socio-economic conditions that impact their health outcomes. The use of structural equation modelling and utilisation of public health data has provided a nuanced analysis that can serve as a template for future research. In addition, this paper serves as a data-driven foundation for public health programmes and policy aimed at improving health inequalities.

Acknowledgements

The research was ethically approved by the School Research Ethics and Integrity Committee of the School of Human and Health Sciences, University of Huddersfield.

Financial assistance in the development of the CLiK survey was received from: Third Sector Leaders Kirklees; Calderdale and Huddersfield NHS Foundation Trust; Mid Yorkshire Teaching NHS Trust; South West Yorkshire Partnership NHS Foundation Trust; Kirklees Integrated Care Board; Locala; Kirklees Council.

Supplementary material

The CLiK survey on which the current analysis is based is publicly available at publisheddoc.aspx (kirklees.gov.uk)

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