



STUDY PROTOCOL

REVISED **Understanding the impact funding cuts on Environmental and regulatory services and gastrointestinal infections: a longitudinal ecological study [version 2; peer review: 2 approved]**

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Abstract

Background

Gastrointestinal (GI) infections result in 17 million cases annually, with foodborne illness costing the National Health Service (NHS) £60m per year. The burden of GI infection is unequally distributed, with greater impact in more socioeconomically disadvantaged groups and areas. Local authorities (LA) provide vital services that protect public health and wellbeing. The impact of funding cuts to local services and their effect on public health is an area of concern. Environmental and regulatory (ER) services are responsible for roles such as food safety and infectious disease control. This study aims to understand the impact of local funding cuts on ER and GI infection outcomes.

Methods

We will conduct an ecological longitudinal study in England from

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version 1 14 Aug 2023	 view	 view

- Kun Li** , Nanjing Agricultural University, Nanjing,, China
- Paolo Lauriola** , International Society of Doctors for Environment, Geneva, Switzerland

Any reports and responses or comments on the article can be found at the end of the article.

2010-2019 at the LA level to examine how changes in ER expenditure overtime have impacted ER and GI infection outcomes. Data will be gathered on food hygiene enforcement, food hygiene compliance levels, GI infection hospitalisation, NHS 111 calls relating to GI infection symptoms, GI infection pathogen data, deprivation, and population density. Measures will be aggregated to LA level and statistical analysis will be carried out.

Ethics and dissemination

University of Liverpool Ethics committee have confirmed ethical approval will not be required. All data will be aggregated and anonymised, therefore only data sharing agreements will be required. Findings will be disseminated to the stakeholder group in addition to outputs through conferences and publications. These findings will help understand impact of key services on public health and should inform government and public health policy and strategy.

Keywords

Gastrointestinal infection, local funding cuts, environmental health and regulatory services, inequalities, Food safety, Food hygiene

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REVISED Amendments from Version 1

The main differences in this revised article are the change in terminology from environmental health and regulatory services (EH) to environmental and regulatory services (ER). The text, figures and tables have been updated with this terminology. In addition, we have included the sub-service Animal and Public Health; Infectious Disease Control Services as an indicator of interest. We also add some further clarifications regarding the data sources and the directed acyclic graph, to provide more detailed information to the readers.

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

Introduction

Gastrointestinal (GI) infections in the UK cause substantial morbidity and mortality in addition to placing significant stress on health care services. There are estimated to be 17 million cases of infectious intestinal disease (IID) and 1 million GP consultations due to IID annually¹. In 2018-19 there were an estimated 119,000 emergency hospital admissions due to illness with GI infection. Transmission occurs by exposure to viral, bacterial or fungal pathogens through contaminated environment, water or food sources, and human or animal contact. Foodborne GI infections place a large strain on health systems, resulting in an estimated annual cost of £60m to the National Health Service², the government-funded health service for the UK. Foodborne transmission accounts for a substantial proportion of GI infection. Foodborne pathogens account for an estimated 2.4 million cases of disease in the UK annually, these pathogens include *Campylobacter*, *Listeria STEC*, *Salmonella* and norovirus. A large proportion of illness is acquired by eating out at food establishments and takeaways, for example this route is estimated to be responsible for 37% and 26% of foodborne norovirus cases, respectively³.

Sociodemographic patterning of GI infection amongst the UK population is evident. Epidemiological studies report an unequal distribution in risk of GI infection and its outcomes amongst those of different ethnic backgrounds and of disadvantaged socioeconomic background⁴⁻⁷. Cross sectional analysis using UK population data from the IID2 survey, a study which describes IID in the community across the UK, identified increased symptom severity amongst those of more disadvantaged socioeconomic backgrounds across all age groups, in turn accounting for higher absence from school or work also reported amongst this group⁷. Research suggests there are higher rates of hospital admissions amongst those from deprived socioeconomic backgrounds in the UK, evidenced in an ecological⁵ and retrospective case control study⁶. This is supported by a longitudinal ecological study in England that identified increased rates of hospitalisation in areas of higher unemployment - as a measure of deprivation, in addition to areas with higher percentage of people from a Pakistani background⁴. There is also sociodemographic heterogeneity in the pathogen which causes GI infections in the UK. Varying by area and socioeconomic deprivation⁸⁻¹¹ and ethnicity⁸⁻¹². This heterogeneity is related to the interplay between sociodemographic factors,

risk activities and transmission routes. Though sociodemographic and spatial inequalities of GI infection are well described, the drivers behind them remain to be understood.

Local authorities in the UK provide key services for the populations of these areas, including public protective services, vital for health protection and public wellbeing. Since the introduction of austerity in 2010, local authorities have been subject to a reduction in funding of almost 50%. The decline in resources available for the delivery of these public services and how this may in turn impact public health is an area of concern.

As a public protective service, the Environmental and regulatory (ER) services are the local authority body responsible for food safety and infectious disease control. The local authority is responsible for the delivery of food hygiene controls at food premises. These include roles such as surveillance, interventions, inspections and sampling and enforcement, mainly carried out by environmental health officers (EHO's). However, the reduction in funding in recent years has impacted on local authorities' ability to carry out statutory and regulatory functions.

A report by the National Audit Office based on local authorities in England estimated that between 2012/13 and 2017/18 there has been a reduction in spending on food hygiene controls by 19%. It also identified that some local authorities are not meeting statutory food hygiene objectives, including reduced environmental sampling. The local authorities contacted attributed the reductions in sampling to reduced food hygiene staffing levels, which have decreased by an estimated 13% between 2012/13 and 2017/18. Similar trends were identified in a report covering food safety in England and Wales where EHO numbers reduced by a third, in addition to substantial reductions in sampling, prosecutions and other enforcement actions over recent years.

Increased expenditure on food safety and sanitation services have shown to be associated with reductions in notifiable enteric disease¹³. Reports indicate that funding cuts are placing significant pressures on ER services, and whilst the evidence base for the impacts of local funding cuts on public health is developing, a gap remains regarding the impact that cuts to ER may have on GI infection outcomes. To better understand this relationship, it is crucial to investigate the impacts of local funding cuts on ER services overtime and examine how these outcomes may be associated with GI infection outcomes. A longitudinal ecological approach will be used to examine the association of changes in ER expenditure on key indicators of ER in the context of food hygiene and investigate the association between these impacts and GI infection outcomes. We will explore how outcomes vary by area and by level of deprivation.

Methods

Patient and Public Involvement

This project will incorporate public and patient involvement and engagement (PPIE) throughout. To date, a PPIE panel has been held, in which preliminary plans were presented and

variables were discussed. Input was used in deliberation of variables of analysis. The PPIE group will be involved in the development of the protocol in addition to steps following this throughout the remainder of the study.

Study aim and objectives

The aim of the study will be to understand the impact of changes to ER service expenditure on ER services indicators, and how this may impact GI infection.

The main objectives of the study are to:

1. Describe the changes in expenditure of ER services, and how they vary by local authority (LA) and sociodemographic factors between 2010/11 and 2018/19
2. Describe key ER indicators, and how they vary by LA and sociodemographic factors between 2010/11 and 2018/19
3. Examine how changes in expenditure in ER services are associated with trends in ER indicators over-time, and how this association may vary by LA and sociodemographic factors.
4. Describe GI infection outcomes by LA and socio-economic and sociodemographic factors between 2010/11 and 2018/19

5. Investigate if changes in ER indicators are associated with GI infection outcomes and how this association may vary by LA and sociodemographic factors.

Study setting and location

The location of the study is England. The data collected will only pertain to LAs in England and the populations of these LAs. There are a total of 314 lower tier LAs in England (April 2020 geography). Local authorities are responsible for food safety at the district and single tier level¹⁴. The area of the LAs involved range from 5020 km² to 12 km² and populations range from 1,142,494 to 41,381 persons.

Study overview and design

The study will be an observational study, it will use a longitudinal ecological study design, looking at data from 2010/11 to 2018/19. The data used will be secondary data and will be aggregated to LA level. The use of an ecological study design is pragmatic and will allow us to analyse the data at aggregated local authority level, over time each year. The study will be quantitative and use spatial and statistical analysis throughout. Furthermore, the study will be split over several results sections, each section focusing on different the objectives as stated. We have constructed a Directed Acyclic Graph (DAG) to clarify the study aims and objectives (Figure 1). The DAG allows us conceptualise theories,

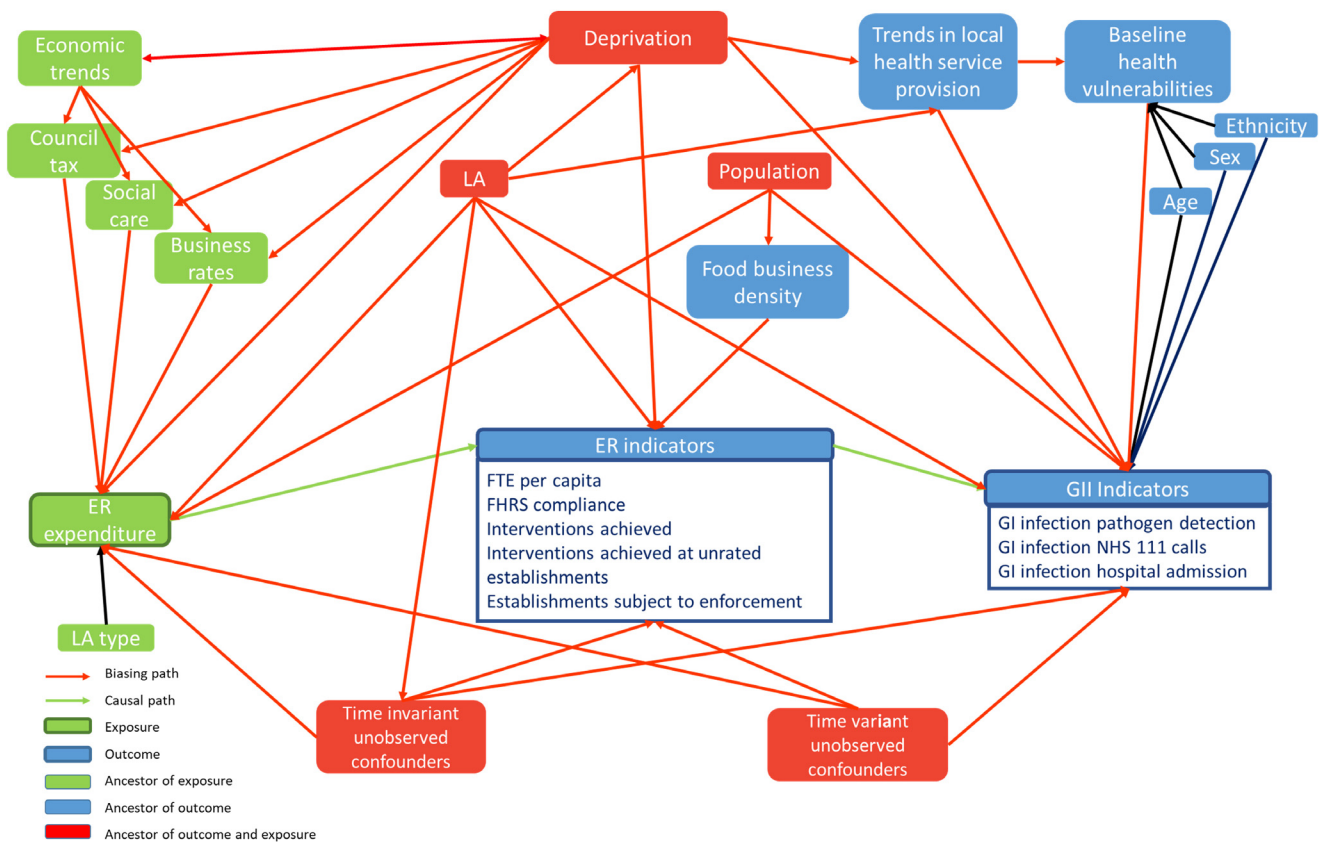


Figure 1. Directed Acyclic Graph (DAG), showing causal relationships between the exposure Environmental and regulatory service expenditure, and Environmental and regulatory service outcomes and gastrointestinal infection outcomes, also showing interactions with possible observed and unobserved confounders.

assumptions and bias in causal pathways between exposures and outcomes, which relate to the study objectives. Additionally, we specify *a-priori* the minimal set of covariates required for study in the DAG and in the next section of the protocol.

Study data

ER expenditure

Indicator(s):

- Total ER service expenditure in British sterling, per capita
 - Food Safety expenditure as a proportion of total ER in British sterling, per capita
 - Animal and Public Health; Infectious Disease Control expenditure as a proportion of total ER in British sterling per capita

Local authority expenditure data is published by the Local Government Finance - Data Collection Analysis and Accountancy division of the Department for Communities and Local Government¹⁵. This data describes the spending for Environmental and regulatory services, this is also known as the revenue outturn data (RO5). The data we will use throughout the project are data that have been prepared by the Place Based Longitudinal Data Resource (PLDR) to provide consistent measures at the LA 2020 geography over time.

ER services

Indicator(s):

- Proportion of compliant establishments
- FTE per 100,000 of the population
- The percentage of interventions achieved
- The percentage of interventions achieved at unrated establishments
- The proportion of establishments subject to formal enforcement

The Consumer Data Research Centre (CDRC) provides information on the food hygiene rating result given to customer-facing food establishments participating on the Food Standard Agency's (FSA) food hygiene rating scheme (FHRS). The data are held on behalf of local authorities. This data will be used to provide the food hygiene rating score which indicated the compliance level on a food establishment.

The FSA [collate, analyse and publish data](#) collected by LA food hygiene enforcement activities annually as local authority enforcement monitoring system (LAEMS) returns. This data will be used to derive ER indicators; the number of FTE positions, percentage of interventions achieved, the percentage of interventions achieved at unrated establishments, and proportion of enforcements.

GI infection indicators

Indicator(s):

- The number of hospitalisations with a diagnosis of acute gastrointestinal disease
- The number of NHS 111 calls due to diarrhoea and vomiting
- The number of specific GI pathogen detections for pathogens commonly associated with food poisoning:
 - *Salmonella* (Non-typhi)
 - *Campylobacter*
 - *Clostridium perfringens*
 - *E. coli*
 - *Listeria*

Hospital admissions due to GI infections are reported in hospital episode statistics (HES) which provide inpatient admissions for National Health Service (NHS) hospitals in England. The study will measure hospitalisations in England and will include cases defined using ICD-10 codes (A00–A09, K52.9) for all-cause acute gastroenteritis episodes (AGE).

The NHS telephone help line NHS 111, superseded by NHS Direct, allows people to access medical advice over the phone instead of in person consultations. The study will use data on the number of calls to NHS 111 reporting diarrhoea and vomiting symptoms in England.

The study will use laboratory pathogen data from Second Generation Surveillance System (SGSS) provided by the United Kingdom Health Security Agency (UKHSA), formerly Public Health England (PHE) which provide routinely collected national and regional surveillance data. The SGSS is the primary collection process by which data on positive cases of clinical significance and antimicrobial resistance (AMR) in England are recorded. Data requested from UKHSA SGSS will include positive laboratory detections: *Salmonella non-typhi*, *Campylobacter*, *E. coli*, *Clostridium perfringens*, and *Listeria*. These pathogens have been selected through an expert group of health professionals affiliated to the NIHR Health Protection Research Unit in Gastrointestinal Infections.

The study will also request data from HPZone at UKHSA, a national system that monitors confirmed and suspected outbreaks of food poisoning, gastroenteritis, haemolytic uraemic syndrome and infectious bloody diarrhoea¹⁶.

In addition, we will access data from EPINorth3, to provide detailed data on notifiable infections reported in the North East of England. The data will be linked to detailed information regarding exposures prior to infection by surveillance questionnaires and cover pathogens such as *Salmonella*, Shiga toxin producing *E. coli*.

Community demographics

The measure of deprivation used will be the English Indices of Multiple Deprivation (IMD), which is produced by the UK Department for Communities and Local Government using local administrative data and data from the census¹⁷. The IMD measure the relative levels of deprivation in England based on seven different bases of deprivation, these include: income deprivation, employment deprivation, education, skills and training deprivation, health deprivation and disability, crime, barriers to housing and services, and living environment deprivation¹⁸. Population density data will be calculated using midyear population estimates and the area of LA's in square kilometres provided by Office for National Statistics (ONS). As a proxy for accessibility to healthcare we explore the utility of data on distance from GP surgery.

We will use **unemployment rate** data, represented as the percentage of the economically active population aged 16 and above. In addition we will use **gross domestic household income (GDHI)**, this measure details the amount of money that the

population in the household sector have available to spend or save after income distribution measures. These data will be accessed from ONS and used to control for overall economic growth in each LA.

The data will cover years 2010/11 to 2018/19, and all data will be aggregated to the LA level. All outcome measures will be linked to a geocode which is then matched to the corresponding LA. Summary information on data, the source of the data and the corresponding measures can be found in [Table 1](#).

Software

This project will use R studio [version 4.3.0](#) for all data analysis.

Ethical considerations

Ethical approval has been sought for this research; the University of Liverpool Ethics committee confirmed ethical approval will not be required. All data will be aggregated and anonymised therefore only data sharing agreements will be required.

Table 1. Data, source, corresponding measures.

Data	Source	Measure
Local service expenditure	Local Government Finance - Data Collection Analysis and Accountancy division of the Department for Communities and Local Government	Environmental and regulatory service expenditure per capita (£)
Environmental and regulatory services	Food Standards Agency: Local Authority Enforcement Monitoring System	Full time equivalent positions
		Interventions achieved at unrated
		Establishments subject to formal enforcement
		Interventions achieved
	Consumer Data Research Centre: Food Hygiene Rating Scheme	Compliance rating
Gastrointestinal Infection	Hospital Episode Statistics	Hospital admission for acute gastroenteritis
	National Health Service 111	Phone calls for diarrhoea and vomiting
	Second Generation Surveillance System	Laboratory confirmed cases of <i>Salmonella (Non-typhi)</i> , <i>Campylobacter</i> , <i>Clostridium perfringens</i> , <i>E. coli</i> , <i>Listeria</i>
	HP Zone	Confirmed or suspected outbreaks of food poisoning, gastroenteritis, haemolytic uraemic syndrome, and infectious bloody diarrhoea
	EpiNorth3	Notifiable GI infection linked to survey data on exposure
Community demographics	Ministry of Housing, Communities & Local Government: Indices of Deprivation	Deprivation
	Office of National Statistics	Population Density
	Office of National Statistics	Gross Disposable Household Income
	Office of National Statistics	Unemployment

Data analysis

Once collected the data will be cleaned and aggregated to LA level, and variables will be derived. This will produce annual (repeated) local authority level measures. Exploratory and descriptive analysis will be carried out on the variables. Spatial mapping approaches will be used to visualise and explore geographically referenced data, to determine preliminary evidence supporting or contradicting *a priori* hypotheses. Missing data will be examined and dealt with where appropriate, using techniques such as imputation or elimination depending on the nature, extent, and reasons for missing data. Re-sampling techniques may be used by incorporating a Bootstrap approach for multiple imputation purposes. Robustness of the variables will be assessed, as variables will be checked for collinearity and interdependency. Once the indicators to be carried forward for final analysis are determined, we will then carry out more formal statistical analysis as outlined below.

Changes in spending (objective 1)

Funding data will be analysed spatially and over time, to describe any changes. Annual expenditure per capita will be analysed between 2010/11 and 2018/19. Following a graphical assessment of trends in spending, a multivariable regression model incorporating random effects for LA's and/or time as necessary will be fitted to quantify how changes in expenditure over time for LA's association with explanatory variables such as deprivation, using IMD, and population density and LA type. This will allow us to begin exploration of how expenditure per capita varies in line with socioeconomic and demographic characteristics.

Changes in ER indicators (objective 2)

The ER indicators will be described spatially and overtime. Descriptive analysis will be carried out between the indicators and factors such as deprivation, and population density and food establishment density. We will also aim explore the level of tourism for each LA, as this may create additional pressure to local services of some areas.

Association between changes in spending and changes in ER indicators (objective 3)

To analyse the association between changes ER expenditure and trends in ER indicators we will use a fixed effects, methods which have been previously used in panel models for interrogating LA finance data^{19–22}.

For the main analysis, we will use fixed effects panel regression, with fixed effects for LAs and individual years, to estimate the mean within-LA relationship between ER spend and ER indicators. We will account for secular trends across all LAs and observed and unobserved time invariant confounders (see [Figure 1](#)), including GDHI and unemployment. The fixed-effects approach removes unobserved confounders that vary between local authorities but are constant over time. We will log-transformed the exposure variable to account for expected diminishing returns on investment. Model results are, therefore, interpretable as change in ER indicators

relative to the percentage change in spend. Initially we will use linear regression fixed effects models with exposure and outcome expressed as a rate per 100 population. In robustness tests we will use a fixed effects Poisson and linear regression model, including the log of the population as an offset.

Changes in GI infection indicators (objective 4)

The GI indicators will be described over time and spatially in the UK. This will allow the identification of times and areas where prevalence looks potentially high for further statistical investigation. Spatially referenced explanatory variables of interest include measures of deprivation and population density.

Association between changes in ER services and changes in GI infection indicators (objective 5)

We will develop spatiotemporal models to estimate the association between exposures and GI outcomes accounting for socioeconomic, demographic, and environmental factors. We will explore Poisson mixed model approach and explore the spatial clustering of residuals, such as using Moan's I tests to examine if we need to incorporate a spatial model. As the outcomes are count data, we will utilise Poisson/negative binomial multivariable and multivariate regression models, depending on over-dispersion and zero inflation in the data. We will also evaluate the use of fixed effects for this objective, as this approach has been used to analyse LA spending association with health indicators^{19–22}. The models will adjust for spatial autocorrelation if we detect its presence in the residuals by using 'BYM' models that extent the count regression modelling frameworks.

Methods will be developed, and a full data analysis plan will be established with further exploration and knowledge of the data.

Power calculation

Power estimations are used in reference to sample size estimations, where they determine the number of subjects required to form the sample of the population, in aim to avoid type 2 error²³. The current study will not use sample data, rather it will use population level data. For this reason, a power calculation will not be required. However, sensitivity analysis and tests for robustness of our population data will be carried out to our assumptions.

Timeline

The study will take place over 2 years, beginning in September 2022. Before the study begins, the relevant procedures regarding data sharing agreements and permissions will be actioned.

Project governance

A stakeholder group will be established, consisting of ER workers from different LA's who work with food hygiene. Initial meetings will be set up to introduce the project and gain relevant information. Throughout the project they will be

able to contribute to the project. They will be updated periodically and be able to discuss and offer insights. or long-term secure storage of research data in a format.

The HES data to be used was made available to PLDR by NHS Digital under the data sharing agreement DARS-NIC-16656-D9B5T-v5.2 and has been risk-assessed by PLDR team and complies with HES small number analysis guidance. The data, as with all other data will be anonymised, non-identifiable and aggregated to the LA level. Safeguarded data will only be accessed, analysed, and stored on the university secure network, in line with management and practice guidelines.

Dissemination and research findings

We will produce a report and policy brief of the key implications of our work to be shared with the stakeholder group and more widely to disseminate to UKHSA, public health professionals and policy makers. Findings should inform government and public health policy and strategy. The findings will be presented at professional and scientific conferences. The results will also be published in peer review open access publications.

Strengths and limitations

A major strength is that we are able to utilise national representative data on Environmental and regulatory services expenditure, ER measures and GI infection outcomes. Importantly we can incorporate datasets that have been unanalysed in relation to funding cuts.

GI infections are common, but most episodes do not result in a healthcare attendance. We therefore we intend to use a range of GI outcomes which cover a range of healthcare interactions, severities of illness and specificities. We will access HES admissions, laboratory confirmed cases of GI (specific pathogens) and NHS111 calls and online consultations for diarrhoea and vomiting. The use of multiple data sets will improve identification of any outliers from spatial and temporal trends.

Finally, a strength is the study design, the use of longitudinal data in a spatial-temporal approach is a main strength of this study. This approach provides insight to trends or changes in exposure and outcomes overtime, whilst accounting for variation geographically. This would be missed if we analysed data at a fixed point.

As this study is ecological in design it is susceptible to ecological fallacy; we can only infer the impact of funding cuts, not establish causation, particularly at the individual-level. However, the design is appropriate for evaluation of population and area level effects, as the exposure and primary outcomes (Environmental and regulatory service measures) are population level ones. Furthermore, we will attempt to ensure that the relationships derived from our area level data focus on the implications for areas and not people.

Like with all observational studies it is possible that there are residual confounders that will influence results that we are not able to account for. We will use stakeholder discussions to identify any further confounders that we could be adjusting for.

As with large data sets over long periods of time, missing data will likely be an issue, the methods will try to mitigate this via statistical methods mentioned.

There may be a limitation associated with the level and detail of some pathogen data due to changes in questionnaire requirements in the recent years. Due to changes in methodology in outbreak detection, there may be a reported increased detection of outbreaks due to improved techniques used. Further changes in data reporting and collection methods over the time period mentioned may change. We will attempt to identify changes through contact with stakeholders such as EHOs, FSA and UKHSA, so that changes may be described and where possible quantified to assist with suitable analytical adjustments. In addition, we will use a variety of relevant data sets for outcome indicators this will limit some of these issues by improving robustness.

Finally, ER expenditure accessed data does not provide the detail on what the money is spent on beyond service level, in each LA is likely to vary and in turn impact outcomes within and across LA's both captured and uncaptured in this study. Furthermore, there will be differences across and within local authorities in regard to baseline health, in addition to healthcare provision.

Discussion

This study will allow for a greater understanding of the impacts of funding reductions to local services, and how this may in turn impact GI infection health in England. The study will focus on ER services that provide public protection in forms of food hygiene and infectious disease control. The study aims to identify the effect of changes in expenditure to these services on ER services, and the change in GI infection outcomes. This study could provide a novel understanding of impacts of changes in funding on GI infection outcomes via the route of ER services and may provide a resource for policy makers to reference in the future.

Data availability

No data are associated with this article.

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Open Peer Review

Current Peer Review Status:  

Version 2

Reviewer Report 15 February 2024

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Kun Li 

Nanjing Agricultural University, Nanjing,, China

1) Abstract:

- Instead of using GI, use GIT because it will be more easy for readers to understand. Clearly describe what you mean by longitudinal ecological study (as just humans are involved in this study and longitudinal = time?), just for the reader's ease.
- Background is of sufficient quality.

2) Introduction:

- In line 2 of the introduction add detail of "GP". You can mark GP* and can give detail at the end of introduction or can highlight like Foodborn pathogens.
- English is of sufficient quality.
- Some words can be replaced with better synonyms like "disadvantaged" can be replaced with "deprived" or some other better synonym.

3) Methodology:

- In Figure 1, GI pathogens can be listed in brackets for quick and better understanding.
- Reason why only bacterial pathogens are being focussed and not Fungi, Amoeba, Giardia, Cryptosporidium and some Viral infection, also very common in GIT infections. Because in secondary data it is not difficult to get detail of different type of poisoning. In deprived communities these types of infestations/infection are also very common and responsible for the GI manifestations you mentioned in Table 1.

4) Discussion:

- Is of sufficient quality.

Overall, it seems good and is of sufficient quality.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Veterinary Medicine.

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

Reviewer Report 15 February 2024

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Paolo Lauriola 

International Society of Doctors for Environment, Geneva, Switzerland

In my opinion, the article in its present form is acceptable for indexing, and I do not have any further comments to add.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Environmental Epidemiology, Public Health

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

Version 1

Reviewer Report 09 October 2023

<https://doi.org/10.3310/nihropenres.14561.r30515>

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Paolo Lauriola 

International Society of Doctors for Environment, Geneva, Switzerland

In general

- The overall objective of the study is important. As the Authors are presenting a proposal, I feel that it would be underlined that this article is presented to collect comments and suggestions, which are welcome.
- The overall logical framework should be revised
- There are too many Acronyms which are misleading

In particular

Abstract/Introduction:

- I think the use of the acronym (EH) is improper. Environmental Health has a very general meaning, whilst, throughout the article, it refers to the services/indicators dealing with environmental and food controls. It also used the acronym EHO, the regulatory service responsible for food safety and infectious disease control to some extent. I suggest reducing the number of abbreviations and giving them a precise meaning. Even considering the specificity of the UK NHS organisation, it must be remembered the article will be read by overseas people, too.

Plain language summary: is it necessary? Maybe it would be used to introduce the study to lay people, but this is a scientific article. I'd delete it

Introduction:

- Please explain what the IID2 survey is
- I would move the sentence "Increased expenditure on food safety and sanitation services have shown to be associated with reductions in notifiable enteric disease" after "Though sociodemographic and spatial inequalities of GI infection are well described, the drivers behind them remain to be understood". The expenditure on food safety is one of the determinants of the spread of IID, described before it is currently placed.

Methods:

- Arrows/dashes, please check
- The study overview and design must be described in more detail
- Please explain what NHS
- Why don't you use GPs' data? UKHSA has a very effective Syndromic surveillance system (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1133)
- Fig. 1 should be presented as the study hypothesis to be investigated. Instead, it seems a

result of a study which hasn't been carried out yet. Please change and simplify

Is the rationale for, and objectives of, the study clearly described?

Partly

Is the study design appropriate for the research question?

Partly

Are sufficient details of the methods provided to allow replication by others?

No

Are the datasets clearly presented in a useable and accessible format?

Not applicable

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Environmental Epidemiology, Public Health

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

Author Response 22 Dec 2023

Lauren Murrell

I think the use of the acronym (EH) is improper. Environmental Health has a very general meaning, whilst, throughout the article, it refers to the services/indicators dealing with environmental and food controls. It also used the acronym EHO, the regulatory service responsible for food safety and infectious disease control to some extent. I suggest reducing the number of abbreviations and giving them a precise meaning. Even considering the specificity of the UK NHS organisation, it must be remembered the article will be read by overseas people, too.

Response: Thank you, EH refers to the services Environmental and regulatory services, sometimes environmental health and regulatory services is used and sometimes the term regulatory services is used. However, I think it can be improved and that environmental and regulatory services is a more specific term. I will refer to EH as ER – environmental and regulatory services. We have therefore changed each occurrence of environmental health and regulatory services / EH to environmental and regulatory services / ER.

Plain language summary: is it necessary? Maybe it would be used to introduce the study to lay people, but this is a scientific article. I'd delete it

Response: Thank you for your comment, this section is a requirement by the journal NIHR open. The lay summary has been generated through our Patient Public involvement and

engagement panel and our lay co-author.

Please explain what the IID2 survey is

Response: Thank you for this suggestion, I have amended this and added detail of the IID2 study on page 4 line 20, it is a brief description, but it should give enough detail to the reader. The sentence now reads as

“Cross sectional analysis using UK population data from the IID2 survey, a study which describes IID in the community across the UK, identified increased symptom severity amongst those of more disadvantaged socioeconomic...”

I would move the sentence “Increased expenditure on food safety and sanitation services have shown to be associated with reductions in notifiable enteric disease” after “Though sociodemographic and spatial inequalities of GI infection are well described, the drivers behind them remain to be understood”. The expenditure on food safety is one of the determinants of the spread of IID, described before it is currently placed.

Response: Thank you for this suggestion. We believe that whilst this would be a possible, it would make more sense to leave this sentence where it is as it is an important part of the paragraph it introduces.

The study overview and design must described in more detail

Response: Thank you for your suggestions, I have added some more detail to the overview and design see page 6; line 30-38, page 7; lines 1-2

Please explain what NHS

Response: Thank you, we have included additional brief detail on what the NHS is on page 4 lines 9-10. The sentence now reads as:

“...resulting in an estimated annual cost of £60m to the National Health Service (NHS)², the government-funded health service for the UK...”

Why don't you use GPs' data? UKHSA has a very effective Syndromic surveillance system (

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/113685

Response: Thank you for your suggestion, unfortunately this would not be suitable for this study due to the geographic coverage of GP data, it is not available at the LA level which is required for this study. However, the UKHSA uses NHS 111 for syndromic surveillance, which we will be using alongside HP zone outbreak reports which we can access at the required level.

Fig. 1 should be presented as the study hypothesis to be investigated. Instead, it seems a result of a study which hasn't been carried out yet. Please change and simplify

Response: Correct, the figure is not intended to be presented as the results.

This Directed acyclic graph (DAGs) has been generated a-priori based on prior professional knowledge, subject expertise and the literature. It provides a simple a way for us to present the knowledge, theories and assumptions about causal relationships between variables prior to study data collection and analysis. We have therefore moved the DAG to the study overview and design section and added further explanation in the text, starting on page 6 line 36: "We have constructed a Directed Acyclic Graph (DAG) to clarify the study aims and objectives (Figure 1). The DAG allows us conceptualise theories, assumptions and bias in causal pathways between exposures and outcomes, which relate to the study objectives. Additionally, we specify a-priori the minimal set of covariates required for study in the DAG and in the next section of the protocol"

Other notes for reviewer

Since the submission of the protocol, it was decided that in addition to food safety we would also assess the spending line - animal and public health infectious disease control . This is due to the responsibilities of this sub stream in infectious disease control, therefore analysing this in addition to food safety expenditure will provide a more comprehensive understanding of crucial services within Environmental and regulatory. We include it as an indicator on page 7 line 14

"Animal and Public Health; Infectious Disease Control expenditure as a proportion of total ER in British sterling per capita"

Competing Interests: none

Reviewer Report 04 October 2023

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Kun Li 

Nanjing Agricultural University, Nanjing,, China

The title of the article "***Understanding the impact of local funding cuts on environmental health and regulatory services and gastrointestinal infection outcomes: a longitudinal ecological study protocol***" is not capturing the attention of reader somewhat, seems not interesting, not engaging the reader. It may be simple, concise and interesting.

Introduction: The choice of words should be simple somewhere in the introduction and so on. However, sufficient background information is available in the introduction and it justify the study.

In plain language summary: The reason to mention stomach bug especially should be clearly mentioned.

In methodology: The population range in the section "Study setting and location" is greater, about 1,101,113. This may be lower. Also, the authenticity and validity of the data can be rechecked, as it is not a primary data, however ensuring the strength of data validity as discussed in the given article will eliminate the outliers, hopefully. The reason to not use the *Salmonella typhi* as an indicator of GIT health may be mentioned. Alterations in the gut microbiota diversity may also be included for detailed information regarding GIT disturbances. During the process of data collection, interpretation and dissemination of information the one health professionals from all sectors should participate to improve the accuracy of data.

Discussion: Decrease in funding sources increases the stress level in the population due to unavailability of different services, which leads to GIT disturbances and serious health outcomes. This type of survey may also be included in the given study plan to support the results. In the result section, manifestation of the data in the form of tables consisting of the exact secondary data may improve the visualization and will attract the reader attention. Overall, the different sections of this article need minor improvements and overall it seems good.

The title of the article "***Understanding the impact of local funding cuts on environmental health and regulatory services and gastrointestinal infection outcomes: a longitudinal ecological study protocol***" is not capturing the attention of reader somewhat, seems not interesting, not engaging the reader. It may be simple, concise and interesting.

Introduction: The choice of words should be simple somewhere in the introduction and so on. However, sufficient background information is available in the introduction and it justify the study.

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In the result section, manifestation of the data in the form of tables consisting of the exact secondary data may improve the visualization and will attract the reader attention

Overall, the different sections of this article need minor improvements and overall it seems good.

Is the rationale for, and objectives of, the study clearly described?

Yes

Is the study design appropriate for the research question?

Yes

Are sufficient details of the methods provided to allow replication by others?

Yes

Are the datasets clearly presented in a useable and accessible format?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Veterinary Medicine.

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

Author Response 02 Jan 2024

Lauren Murrell

The title of the article "***Understanding the impact of local funding cuts on environmental health and regulatory services and gastrointestinal infection outcomes: a longitudinal ecological study protocol***" is not capturing the attention of reader somewhat, seems not interesting, not engaging the reader. It may be simple, concise and interesting.

Response: Thank you for this feedback, whilst this is a lengthy title, it is important that the title gives a clear and accurate description of the study. But we have removed redundant words to shorten this title and make it more concise. The title will now read:

Understanding the impact of funding cuts on Environmental and regulatory services and gastrointestinal infections: a longitudinal ecological study

In plain language summary: The reason to mention stomach bug especially should be clearly mentioned.

Response: The lay summary has been generated through our Patient Public involvement and engagement panel and our lay co-author. They are satisfied with how stomach bugs (GI) are discussed

In methodology: The population range in the section "Study setting and location" is

greater, about 1,101,113. This may be lower. Also, the authenticity and validity of the data can be rechecked, as it is not a primary data, however ensuring the strength of data validity as discussed in the given article will eliminate the outliers, hopefully.

Response: The population estimate refers to the 2020 estimate provided by the Office of National Statistics; the source data used in each article will be specified. While other sources and years may provide different population estimates to my example, I will keep this estimate as it is the most recent estimate that is relevant to my study period, additionally ONS is the most reliable source to use.

The reason to not use the *Salmonella typhi* as an indicator of GIT health may be mentioned.

Response:

We have decided not to use *Salmonella typhi* as it is not endemic in the England/UK and is most commonly travel related, therefore it is not included as a pathogen of interest for this work. Including it could lead to inaccurate conclusions in regards to our question. We have also added the following information to the GI infections indicators:

“These pathogens have been selected through an expert group of health professionals affiliated to the NIHR Health Protection Research Unit in GI.”

Alterations in the gut microbiota diversity may also be included for detailed information regarding GIT disturbances.

Response: Thank you for this suggestion, this would be an interesting area of research, our study however will focus on health inequalities in infectious food borne disease, this would be outside of our inclusion criteria for this study

During the process of data collection, interpretation and dissemination of information the one health professionals from all sectors should participate to improve the accuracy of data.

Response: Thank you for this suggestion. We have and will continue communicate with professionals from UK Health Security Agency and, local authorities, including environmental health staff, epidemiologists, and microbiologists. This gives us extra insight to these data and how it may be used and interpreted.

Discussion: Decrease in funding sources increases the stress level in the population due to unavailability of different services, which leads to GIT disturbances and serious health outcomes. This type of survey may also be included in the given study plan to support the results.

Response: This is a very interesting suggestion but there is no capacity or resource for primary data collection in this study and this does not sit within our study objectives.

In the result section, manifestation of the data in the form of tables consisting of the exact secondary data may improve the visualization and will attract the reader attention

Overall, the different sections of this article need minor improvements and overall it seems good.

Response: Thank you for this suggestion, but we will not be including data in this article as it is a study protocol and as such, does not include results the priority of this paper is to present the plan for the data and the study approach. I will however be presenting the exact data and results in open access publications.

Other notes for reviewer

Since the submission of the protocol, it was decided that in addition to food safety we would also assess the spending line - animal and public health infectious disease control. This is due to the responsibilities of this sub stream in infectious disease control, therefore analysing this in addition to food safety expenditure will provide a more comprehensive understanding of crucial services within Environmental and regulatory. We include it as an indicator on page 7 line 14

"Animal and Public Health; Infectious Disease Control expenditure as a proportion of total ER in British sterling per capita"

Competing Interests: No competing interests were disclosed.