UNIVERSITY OF LEICESTER

ANALYSING DETERMINANTS OF ILLNESS IN POPULATIONS: DEVELOPMENT OF A CONCEPTUAL FRAMEWORK LINKED TO A SEQUENCE OF RELATED EMPIRICAL STUDIES

Thesis submitted for the degree of
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by

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Summary

Abstract

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Thesis title: Analysing Determinants of Illness in Populations: Development of a Conceptual Framework Linked to a Sequence of Related Empirical Studies

Background

Conceptual frameworks can help researchers and services by characterising disparities in health needs and outcomes between populations, and how these are affected by risk and non-disease factors. As no published conceptual frameworks fully fitted my research needs, I developed a new framework in conjunction with a series of observational studies.

Research questions

Does a new conceptual framework for population health research help to:
1. Generate testable hypotheses
2. Establish useful sets of relevant variables for inclusion in analyses
3. Describe relationships between these variables?

The framework's configuration

The framework has two components:
1. An illness pathway with three variable groups: illness determinants, health needs, and health outcomes.
2. Two variable groups acting as modifiers of the illness pathway: context (factors not generating illness but describing the settings in which populations live) and interventions.

Observational studies

Using the framework, five population studies resulted in seven publications, which:
1. Described how both non-disease variables and clinical performance variables predict variations and persistent disparities in mortality rates between population groups in England
2. Demonstrated that current allocations of practice funding may insufficiently support general practices serving very deprived populations with greater health needs
3. Described the pervasive widespread decline of continuity of care, reflecting general practices' struggles to provide adequate patient access.

Conclusions

The framework supported my research and has service utility. The publications have contributed to knowledge and are relevant to current debates about addressing health inequalities and worsening access to primary care. These studies demonstrate my suitability to undertake research.

Lists

Acknowledgements

I owe a huge debt of gratitude to three wonderful individuals at the University of Leicester. Without their patient and wise guidance, I would not have undertaken and continued this journey into academic research. Listing them in alphabetical order:

Emeritus Professor Richard Baker, for his unfailing encouragement and enthusiasm, and for suggesting that I apply for a PhD by published work,

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Professor Kamlesh Khunti, for initially inviting me into the Department of Health Sciences, for supervising this PhD submission, and for asking me to collaborate with him on future studies.

I am also grateful to Professor Andrew Wilson for acting as a co-author and as a mentor for some of my research journey.

I would not have been able to do this without the unwavering support and patience of my wife Jennifer. Thank you.

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List of Abbreviations

BBC British Broadcasting Corporation

BMA British Medical Association

CCG Clinical Commissioning Group

CHD coronary heart disease

CLARHC Collaboration for Leadership in Applied Health Research and Care

CPRD Clinical Practice Research Datalinks

GP general practitioner

GPPS General Practice Patient Survey

IMD index of multiple deprivation

LA Local Authority

NHS National Health Service

ONS Office for National Statistics

PCT Primary Care Trust

PhD Doctor of Philosophy

PI principal investigator

QOF Quality and Outcomes Framework

SEARCH Systematic Exploration and Analysis of Relationships Connecting Health variables in populations

UK United Kingdom

List of Submitted Publications

The submitted publications are all articles published in peer-reviewed academic journals. The full texts have been bound separately.

Paper 1

Levene LS, Baker R, Bankart MJG, Khunti K. (2010) Association of features of primary health care with coronary heart disease mortality. *JAMA*, 304(18), pp. 2028-2034. **DOI:**10.1001/jama.2010.1636

Paper 2

Levene LS, Bankart J, Khunti K, Baker R. (2012) Association of primary care characteristics with variations in mortality rates in England: An observational study. *PLOS ONE*, 7(10), e47800. **DOI:**10.1371/journal.pone.0047800

Paper 3

Levene LS, Baker R, Khunti K, Bankart MJG. (2015) Variations in coronary mortality rates between English primary care trusts: observational study 1993–2010. *J Pub Health*, 38(4), e455-e463. **DOI:** https://doi.org/10.1093/pubmed/fdv162.

Paper 4

Levene LS, Walker N, Baker R, Wilson A, Honeyford CE. (2016) Debate and Analysis - Rationalising data use for general practice: a missed opportunity. *Br J Gen Pract*, 66 (649), e603-e605. **DOI:** https://doi.org/10.3399/bjgp16X686485

Paper 5

Levene LS, Baker R, Wilson A, Walker N, Boomla K, Bankart MJG. (2016) Population health needs as predictors of variations in NHS practice payments: a cross-sectional study of English general practices in 2013–2014 and 2014–2015. *Br J Gen Pract*, 67 (654), e10-e19. **DOI:** https://doi.org/10.3399/bjgp16X688345

Paper 6

Levene LS, Baker R, Walker N, Wilson A, Williams C, Bankart MJG. (2018) Predicting declines in perceived relationship continuity using practice deprivation scores: a longitudinal study in primary care. *Br J Gen Pract*, 68 (671), e420-e426. **DOI:** https://doi.org/10.3399/bjgp18X696209

Paper 7

Levene LS, Bankart MJG, Walker N, Wilson A, Baker R. (2018) How healthcare may modify the effects of illness determinants on population outcomes: the Leicester SEARCH conceptual framework for primary care. *Br J Gen Pract Open,* bjgpopen18X101603. **DOI:** https://doi.org/10.3399/bjgpopen18X101603

Main Body of Summary

1. Introduction

Population health

Kindig (2003; 2007) has defined population health as ‘the health outcomes of a group of individuals, including the distribution of such outcomes within the group’. The field of population health considers not just overall health but also variations of health within populations. These populations are often defined geographically, but other criteria may be used, such as disease diagnosis or socio-economic status.

Dzau (2018) argues that population health is a ‘convergence science’, requiring a ‘transdisciplinary approach’ for framing research questions, and that addressing specific problems requires comprehensive frameworks which can combine knowledge from multiple fields, using coordinated and integrated data. The conceptual framework described in this thesis aims to satisfy this need.

Research aim

My overall research aim has been to evaluate the veracity of a working hypothesis, a set of three linked propositions:

1. Health outcomes in populations often have multiple predictors, many of which are linked to the characteristics of those populations.

2. To improve these health outcomes, interventions should target modifiable population characteristics and risk factors as well as the diseases themselves.

3. A suitable conceptual framework is necessary to generate testable hypotheses, to establish suitable sets of relevant variables for inclusion in analyses, and to understand relationships between these variables.

I was unable to find in the literature any conceptual frameworks whose scope and configuration adequately fitted my research needs. Therefore, I decided quite early on to develop my own framework. Its configuration reflects a primary care perspective but could be applied in any healthcare setting.

Research questions

My research questions arose out of the hypothesis:

Does a new conceptual framework for population health research help to:

1. Generate testable hypotheses,

2. Establish useful sets of relevant variables for inclusion in analyses, and

3. Describe relationships between these variables?

Overview of publications included in this submission

All papers were published in peer-reviewed academic journals:

• Five papers (1, 2, 3, 5, 6) described observational population health studies that used the framework to inform research questions, to plan the analysis (guiding variable selection), and to interpret findings.

• One shorter paper (4) argued the need for optimising data management to free up time and to support primary care's population health role.

• Bringing together all of the above studies, the final paper (7) described in detail a new conceptual framework.

I believe that these publications form a coherent and substantial body of work, capable of being assessed as a single oeuvre and making a distinct and original contribution to knowledge. In this summary I will discuss the observational studies that informed the framework's development prior to considering the framework itself.

2. Previous Experience

While a medical student I worked as a laboratory technician in the University Hospital, Lausanne, Switzerland and co-authored a paper (Felber, 1975).

As part of my general practitioner (GP) training in Leicester, I was a Senior House Officer in Community Medicine at a time when government policy was to close large inpatient psychiatric units and transfer care to the community. I undertook a single point census in order to answer the research question, 'how feasible would it be to discharge current psychiatric patients into the community?' Most inpatients were either unsuitable or would require extensive support for safe discharge into the community (Levene, 1985). This was my first experience of leading a research study.

From 1986 to 2015 I was a full-time National Health Service (NHS) GP in a busy inner-city practice with a diverse population when I produced:

- The practice's diabetes management protocol (Levene, 1997), expanding it into a book (Levene, 2003; Levene, 2008). I also co-authored a book chapter (Farooqi, 2005) and a smaller book on diabetes (Levene, 2010). These were valuable experiences in writing for a professional audience and working with co-authors and editors.
- A new consultation model used for teaching as a GP trainer, and for personal use (Levene, 2008). I learned about organising and summarising complex ideas as I developed the model.

3. Observational Studies and the Framework

Starting my research

Working as a GP showed me why practices should engage, where possible, with their whole lists, i.e. have a population perspective. I also observed the important role played by non-disease related factors in both health care provision and health outcomes.

This research stream began in 2009 during a sabbatical at the University of Leicester. From the outset I used only published data to avoid time-consuming applications to ethics committees. I had read a paper that used a multivariable model to explain variations in perinatal and infant mortality between English Primary Care Trusts (PCTs) (Freemantle, 2009). I realised that this model could be used to explain variability in other outcomes, provided that data were available for the relevant variables at PCT level. Freemantle's paper inspired the first study.

Paper 1

I sought to identify which features of populations and primary health care might explain variations in coronary heart disease (CHD) mortality rates between PCT populations in England. A cross-sectional study of all 152 PCTs in England was undertaken, using three separate 2-level hierarchical multiple linear regressions (not multilevel models) for 2006, 2007, and 2008, with age-standardised CHD mortality rates in the year as the dependent variables. The explanatory variables, selected on the basis of conceptual plausibility and data availability, included:

- Population characteristics (index of multiple deprivation [IMD] scores, smoking, ethnicity, and registers of individuals with diabetes), and
- Service characteristics (level of provision of primary care services, levels of detected hypertension, and pay for performance data).

Although the mean age-standardised CHD mortality rates had declined, there were marked differences in mortality between PCTs. In the multivariable analyses for all three years, higher levels of four population characteristics (IMD scores, smoking, white ethnicity, and registers of individuals with diabetes) predicted higher CHD mortality rates, and higher levels of one service characteristic (levels of detected hypertension) predicted lower CHD mortality rates. Just over two thirds of the variations in age-adjusted mortality at PCT level could be explained.

I recognised that there were other predictors, either unidentified or not measured. Although age-standardised CHD mortality rates were higher in men than in women, this could not be investigated further because we lacked a breakdown by sex for most of the explanatory variables. The journal discouraged me from including another explanatory variable, the percentage of patients able to see their preferred GP (continuity of care), as measured by the General Practice Patient Survey (GPPS), due to a concern about the GPPS's low response rates.

The findings supported two of my original propositions:

1. Levels of population characteristics are important predictors of variations in a major health outcome.
2. The outcome was better in populations where interventions targeting a risk factor for that outcome were more successful (after adjusting for relevant population variables).

This prompted the first iteration of a conceptual framework that aimed to summarise these relationships (depicted in paper 2's Figure 1).

Paper 2

In this study I tested five null hypotheses (all-cause, CHD, all-cancers, stroke, and chronic obstructive pulmonary disease mortality) with the general form:

variations in primary healthcare service performance do not predict variations in mortality at population level, after adjusting for population characteristics.

Correspondence following the first study's publication stressed that only the dependent variable (but not the predictors) had been age-standardised. In this study, the dependent variables were changed to age-unadjusted mortality counts for the five mortality groups. The population size of each PCT was used as an offset to account for the different numbers at risk in each PCT and an age correction factor was included, the percentage of patients aged 75 years or more: 75 years has been used as the cut-off age for premature mortality by the Department of Health (Department of Health, 2013). Data from all English PCTs in 2008 and 2009 were modelled using negative binomial regression.

My framework guided the selection of relevant population and service characteristics as explanatory variables in the analyses. The continuity of care variable was included as an explanatory variable.

As before, the main predictors of mortality variations were population characteristics, especially age and IMD scores. Higher percentages of patients on a primary care hypertension register were associated with lower CHD and stroke mortality. Higher percentages of patients being better able to see their preferred GP were associated with lower chronic obstructive pulmonary disease and all-cancer mortality. No association at PCT population level was found between variations in achievement of pay for performance and mortality.

However, the study had limitations:

1. It was unable to identify any other predictors to describe the variations in each cause of mortality.
2. In retrospect, it would have been preferable to calculate continuity of care from the GPPS by multiplying the percentages of having a preferred GP and of seeing a preferred GP, rather than using only the latter. Paper 6 corrected this.

While some service characteristics were also associated with variations in mortality rates at population level, population variables were important predictors, further supporting my original propositions and demonstrating the soundness of my framework's basic configuration. The findings of both this and the previous study were consistent regardless of whether the dependent variable (CHD mortality) was an age-standardised rate or was an age-unadjusted count with an age correction factor.

Paper 3

The first two papers were published before I retired from general practice in 2015. I wanted to continue this research theme.

The next study aimed to describe variations in under 75-year (premature) CHD mortality rates across geographically defined populations, and to infer their associations with other variables. Regression slopes for mortality as a function of time were calculated for all English PCTs, giving the change in the expected age adjusted rate for each extra year.

Between 1993 and 2010, the mean age-standardised premature CHD mortality rate in England decreased from 107.76 to 35.12 per 100 000, but the coefficient of variation (standard deviation divided by mean - a measure of relative variation) increased from 0.21 to 0.27. However, after 2004 the slope of decline was significantly less, and the coefficient of variation changed little. From 1993 to 2010 the proportion of smokers decreased by almost one quarter. The estimated proportions of the population with diabetes, obesity, and controlled hypertension increased. There was a greater decline in premature CHD mortality in PCTs with higher IMD scores and percentages of smokers (2006–2010).

PCT-level data for population and service variables were unavailable prior to 2006 and no predictors were age-standardised. The study variable prior to 2006

could not be converted to a count. These limited what could be inferred about associations between the slopes of mortality rates and of the predictors.

This study described both cross-sectional and longitudinal changes in the values of variables included in the framework.

Next steps

The next two observational studies differed from their predecessors in that:

1. The population level changed to general practices; resulting in hugely increased sample sizes, and
2. The study variables were no longer health outcomes (mortality), but two aspects of primary healthcare (payments and access to care).

Reflecting on the previous studies, I decided to modify the framework:
1. An additional group of variables was inserted as an intermediate stage between determinants of illness and health outcomes. This group, health needs, includes variables describing physical, psychological and social factors, consistent with an illness model that has a broad perspective (Wade, 2004).
2. Deprivation, as measured by IMD, is a composite proxy variable. It is not in itself a direct cause of illness. However, deprivation may cause or exacerbate relevant factors, such as unhealthy behaviours. Depending on the situation, these factors may be either directly (as determinants) or indirectly (as modifiers) involved in the causal chain of an illness. To allow for this, another variable group, context, was added to the framework. It contains non-medical variables that may influence, but not directly cause, health needs and outcomes. Thus, IMD may be classified within the framework as either a determinant or a context variable.

These changes to the framework's configuration ensure that explanations of the relationships between deprivation and other variables remain conceptually plausible in different scenarios. No major changes to the framework were subsequently made (Figure 1).

Paper 5

Since the introduction of the new GP contract in 2003-2004, NHS general practice payments in England use a formula which aims to ensure that funding adequately compensates practices with greater workloads (NHS Employers, 2003). The Carr-Hill formula, also known as the Global Sum Allocation Formula, includes weighting for age and sex structure, morbidity and mortality measures, list turnover, individuals living in nursing and residential homes, and staff expenses and rurality. NHS Employers (2010) state that it 'takes into account issues such as…deprivation', but the formula does not include specific measures of deprivation (Carr-Hill, 2004). Although the formula was reviewed in 2007 and 2015, and recommendations for updating the formula were made, it has not altered hugely since its introduction. The British Medical Association has expressed concerns that Carr-Hill inadequately reflects the needs of very deprived populations (BMA, 2018).

To ascertain if practices that served populations with greater health needs had received additional funding via Carr-Hill, a cross-sectional study was undertaken of all practices in England in two financial years, 2013–2014 and 2014–2015. The research question asked if population factors related to health needs predicted variations in NHS payments to individual practices, after adjustment for organisational confounders.

The multivariable linear regressions used natural logarithms of payments as the dependent variables (as their distributions were positively skewed). Explanatory variable selection was determined by availability of data and by plausibility of association guided by my framework. In this paper and paper 6, I undertook the statistical analyses (Dr Bankart checked my work), selecting the statistical model and writing all of the required Stata code.

Several population variables predicted variations in adjusted total payments in all practice contract types, but some predictive effects were positive and others

negative. Higher payments were associated with increases in IMD scores, older patients, African-Caribbean ethnicity, and asthma prevalence in practice populations. Lower payments were associated with increased smoking prevalence and reporting of long-term health conditions. Neither South Asian ethnicity nor diabetes prevalence was predictive. A slightly different set of variables predicted variations in the payment component designed to compensate for workload. Lower payments were associated with increases in IMD scores, percentages of older patients, and diabetes prevalence. Smoking prevalence was not predictive. There was a geographical differential with lower payments in the North.

However, only one third of the variation in total payments was accounted for, despite using a wide range of predictors. Factors explaining the remaining two-thirds of the variation were either not identified or had not been measured.

The framework helped me to clarify the study's key message: the weak predictive effects of health needs and context (deprivation) on variations in the level of a healthcare variable (payments) suggest that the current NHS practice payment formula provides insufficient support to practices tackling health inequalities and serving populations with greater health needs.

Paper 6

Relationship continuity of care is an important factor in access to healthcare and is considered a key feature and probable strength of primary care. Better continuity is associated with reduced unscheduled hospital admissions (Barker, 2017), an important policy priority. To improve continuity, GPs' contracts from 2015–2016 have required all patients to have a named accountable GP to take 'lead responsibility for the coordination of all services required under the contract' (NHS Employers, 2015).

Within my framework, continuity is categorised as a healthcare performance variable and has relationships with each of the other main variable groups –

context, determinants of illness, health needs and health outcomes (Figure 1). To examine the strength of these associations longitudinally, the research question asked if IMD scores predicted variations in the slopes over time of continuity of care, after adjustment for organisational and other population factors.

Using two GPPS questions, patient-perceived relationship continuity was calculated by multiplying the percentages of:

- 'Yes' responses to having a preferred GP, and
- The sum of 'Always' and 'A lot of the time' responses to frequency of seeing preferred GP.

The effect of IMD on the linear slope of continuity over time was modelled, adjusting for nine confounding variables whose selection (representing context, health needs, and organisation of healthcare) was guided by my framework. Clustering of measurements within general practices was adjusted for by modelling general practice as a random effect, using a random intercepts and random slopes model. Unless multi-level modelling is undertaken, clustering can lead to under-estimation of the standard error, thereby increasing the risk of a type I error (rejection of a true null hypothesis), and similarity of slopes and intercepts across practices could not be assumed.

Relationship continuity declined by 27.5% between 2012 and 2017 in England. IMD scores from 2012 did not predict variations in this decline, after adjustment for the confounders. The organisational and population confounding variables themselves did not predict or only weakly predicted variations in the decline of continuity, and with very small effect sizes (a 1% increase in the value of any significant predictor did not alter the slope of continuity by more than 0.1% overall). Cross-sectionally, continuity and deprivation were negatively correlated within each year.

The decline in continuity was marked and pervasive, with, so far, no obvious immediate effect resulting from the GP contract changes. This decline has coincided with rising proportions of part-time GPs. It also reflects huge

pressures on practices, where increasing workloads are outstripping capacity, leading to fewer available appointments. Without correcting this imbalance, the decline in continuity is unlikely to be halted or reversed.

The paper generated considerable media interest. Its publication was covered in most national newspapers, and I was interviewed by both BBC Breakfast Television (University of Leicester, 2018) and BBC Radio Leicester.

A systematic analysis exploring the relationship between continuity of care and mortality was published in the following month (Pereira Gray, 2018). I was an author of two (Levene, 2012; Baker, 2012) of the 22 studies included in the analysis. Its front-page coverage in the Guardian included my comments (Davis, 2018).

The framework's configuration and description of relationships between variables helped to structure and refine:

1. The overall interpretation of the study's findings, i.e. variables related to context and health needs did not predict variations in levels of a healthcare process variable, and
2. My answers to some of the media's questions.

Overall critique of the observational studies

These studies' main strengths were the focused research questions, the informed selection of dependent and explanatory variables, and the careful description and interpretation of the findings; all aided by using a comprehensive conceptual framework. Collectively, the studies contributed to an improved understanding of which factors predicted variations, at population level, in important health outcomes (mortality) and in components of primary healthcare (funding and relationship continuity of care).

I am also aware that these studies had limitations:

1. Observational studies can only demonstrate that variations in the level of an explanatory variable may be associated with (or statistically predict) variations in the level of a dependent (study) variable, but they cannot prove causation.
2. The unavailability of some data (due to collection or publication limitations) restricted the number of variables used in the analyses, thus reducing how much variability of the dependent (study) variables could be explained.
3. Because they lack patient level data, analyses at population level 'ignore' variations within population units. The interpretation of findings needs to be cautious. To prevent ecological fallacies, extrapolation to the individual level should be avoided.

The Importance of Data: Paper 4

This shorter paper argues for improved data management in primary care.

Huge amounts of data are regularly collected from practices for an ever-increasing range of purposes, including appraisals, contractual monitoring, quality assurance, and performance management by several bodies. Separately prepared reports may use different formats to present the same datasets, entailing unnecessary duplications. Policymakers and health care providers often miss opportunities to fully analyse available data, thus limiting their understanding of local populations' health needs and of interventions' effects on outcomes beyond the QOF (e.g. premature mortality, hospital admissions).

Policymakers need to facilitate data being used not only primarily for monitoring and performance management. The paper proposed a practical framework for informing optimal data management within practices. This includes employing common formats for reporting datasets. In tackling populations' health needs, referral to a conceptual framework can inform analyses and monitoring at both practice- and locality- levels.

4. Previous Conceptual Frameworks

Principles of conceptual frameworks

A conceptual framework 'explains, either graphically or in narrative form, the main things to be studied—the key factors, concepts, or variables—and the presumed relationships among them' (Miles, 1994). It is an analytical tool that can be used to make conceptual distinctions and organise ideas, particularly in empirical research. A conceptual framework is ‘built’ by the researcher incorporating components, such as theories and research, that are often borrowed from elsewhere (Maxwell, 2005). Investigators usually have a framework underpinning their research, although they may not always refer to an explicit version.

Frameworks can vary in both scale (areas covered, complexity) and context (e.g. applied science, social science, economics). Thus, the definitions and applications of individual frameworks are not uniform. The design of a conceptual framework should be governed by its purpose (Shields, 2013), which may include:

- Exploration, such as by clarifying aims, developing working hypotheses, and generating realistic and relevant research questions
- Description
- Analysis, e.g. selecting appropriate methods and identifying potential validity threats
- Decision making, e.g. operational
- Explanation, e.g. justifying research
- Prediction, e.g. formal hypothesis specification.

Previously Published Conceptual Frameworks Used in Population Health Research

Population health seems to have lagged behind other disciplines. Psychology and sociology have used conceptual frameworks for many years (Rodman, 1980).

Published conceptual frameworks relevant to population health have varied as regards:

1. Scope, with either a comprehensive perspective (Victoria, 1997; Solar, 2010) or a more specific focus. Examples include descriptions of the different components of illness (Wade 2004), the synergistic interaction of two or more disease states producing a set of linked health-related problems (syndemics) ('Syndemics', Lancet Editorial 2017; Singer, 2017), population shifts of risk factors (Rose, 2001), primary care's impact on population health (Starfield, 2005; Rasanathan, 2009) and primary care organisation (Berenson, 2008; Bodenheimer, 2002; Bodenheimer, 2014; Kringos, 2015; Watson, 2004; Mold, 2014). A single condition, diabetes, is the subject of a framework that links socioeconomic status to different patient health outcomes. These relationships can be modified by various 'proximal… moderators', including self-care health behaviours, access, or process of care (Brown, 2004; Walker, 2014).

2. Configuration of components, usually determined by the framework's purpose. However, comprehensive frameworks may not differentiate between direct or indirect effects, or between structures and processes within variable hierarchies (Wade, 2004).

3. Intended users. Some frameworks are designed for researchers (Victoria, 1997; Rose, 2001). Others are more suitable for policy makers in healthcare systems (Solar, 2010; Graham, 2004) and may have a primary care focus (Berenson, 2008; Bodenheimer, 2002; Bodenheimer, 2014; Kringos, 2015;

Watson, 2004; Mold, 2014). Many frameworks may require adjustment for use in primary care.

However, none of the above frameworks were ideally configured for the type of primary care-focused research that I was planning; thus, I decided to develop my own framework.

5. A New Conceptual Framework

Development of the framework

To help interpret the findings in paper 1 and being unable to find a suitable conceptual framework in the literature, I proposed a new framework (Figure 1 depicts the current configuration), centred around two of my original propositions: population health outcomes have multiple predictors, many of which relate to the characteristics of those populations, and healthcare can modify these predictive effects by targeting population characteristics as well as the diseases themselves. Figure 2 summarises the timeline of the framework's development. An earlier version of the framework informed selection of explanatory variables and interpretation of findings in another paper I co-authored (Baker, 2012).

Description of the framework

The new framework is named the Leicester SEARCH (**S**ystematic **E**xploration and **A**nalysis of **R**elationships **C**onnecting **H**ealth variables in populations) conceptual framework. It has two components:

1. An illness pathway consisting of three groups of variables, starting with *illness determinants*, which generate *health needs*, which then predict *health outcomes* in populations, and

2. Modifiers of the illness pathway, consisting of two groups of variables, *context* (factors that are not directly involved in the generation of illness but describe the settings in which populations live) and *interventions*.

The framework should include variables based on their health-related importance. A variable may belong to more than one group, depending upon its effects in different situations. Each large group of variables is subdivided into smaller groups.

Illness determinants variables are classified as either *person-related* or *disease-related*. Person-related variables describe the susceptibility of a group of individuals to develop illness. Disease-related variables refer to the characteristics of the illnesses affecting these populations.

Within the illness pathway, interactions between person-related and disease-related variables generate the next group of variables: the health needs of a population, divided into two subgroups:
1. *Manifestations of disease*, which relate to the prevalence of morbidity and of clinical features
2. *Disruptions to functioning* in those with disease (with respect to either physical, psychological or socio-economic functioning).

Health outcomes variables are divided into *significant events*, *altered health status* (levels), and *resolution*. The rates of these outcomes in populations may be determined by numerous factors, including disease mechanisms, population characteristics, and the efficacy of interventions.

Modifiers of the illness pathway may act on either alterable health determinants that generate health needs or health needs themselves; thus, influencing the onset of health outcomes. In this component of SEARCH, the two large groups of variables are:
1. *Context* variables, classified as either *physical* or *socio-economic*
2. I*ntervention* variables classified as either *structures* or *processes*. Structure variables describe the organisation of healthcare systems. Process variables describe the actions undertaken by these systems.

Applications

SEARCH has both research and service utility. It recognises the importance of prevention, where modifying risk factors in affected populations may delay the onset and reduce the effects of illness.

Research applications

SEARCH exemplifies the type of conceptual framework needed to support population health research (Dzau, 2018), as illustrated by the observational studies discussed in this thesis. Fuller understanding of complex problems arises from co-ordinating diverse sets of knowledge, undertaking appropriate robust analyses, and interpreting findings meaningfully.

Service applications

By organising often-complex ideas in order to depict the 'real world', conceptual frameworks can facilitate planning, implementation and monitoring of effective healthcare. Clinical Commissioning Groups (CCGs) and Local Authorities (LAs) need to collaborate, developing clear and sensible priorities for local health and social care, but consistent with national policies. For example:

- Reducing avoidable admissions and accelerating appropriate discharges should lead to more cost-effective hospital bed occupancy.
- Taking a more proactive approach to screening and managing risk factors, such as obesity and hypertension, may reduce morbidity and demands on services.

By identifying and organising relevant factors and their relationships, a framework can help organisations to develop better policies, tailored to local needs, and then to manage interventions more effectively.

SEARCH can inform evaluations of cost-effectiveness. In deciding whether to implement interventions, the resources required need to be balanced against their effectiveness in reducing health needs and in improving outcomes. Such calculations should consider relationships and interactions between variables, and differences in variables' levels and functioning, especially between population cohorts.

Limitations

SEARCH may continue to evolve as a result of further theoretical developments and/or empirical studies. I recognise that it has gaps and limitations:

- *Level of sample* – Although SEARCH was developed in conjunction with population level studies, it should be applicable at other sample levels, e.g. individual. However, it cannot be assumed that the sets of variables and their interactions and the allocation of variables to groups or subgroups will be identical at different levels.
- *Temporal variations* – I have used SEARCH in both cross-sectional and longitudinal observational studies. The arrows between the variable groups (in Figure 1) represent the directions of potential relationships between the groups, but do not indicate how these might vary over time, which may need to be reflected in some longitudinal analyses.
- *'Omitted' variables* – SEARCH must be able to accommodate additional variables not previously considered or whose data were unavailable (such as reorganised or new variable groups and subgroups, or different interactions).
- *Amount of detail* - An ideal balance needs to be maintained between sufficient simplicity for clarity and sufficient complexity to give a more comprehensive representation of reality: a risk in all frameworks.

SEARCH's design may need to be modified when addressing the above to remain useful in future research (e.g. individual level studies, randomised control trials).

6. Other Research

Current projects

SEARCH has helped in two further observational practice population level analyses, both presented as abstracts at academic conferences in 2018:

1. Following up paper 5, I undertook a longitudinal analysis of the predictive effect of general practice deprivation scores on variations in slopes of practices' NHS payments, using a random intercepts and random slopes model. After adjusting for confounders, increasing deprivation scores predicted very weakly greater increases in payments over time, and payments increased at all deprivation levels. The (cross-sectional) correlation between payments and deprivation was very weakly negative in all years (Levene, 2018). The paper has been accepted by the British Journal of General Practice.

2. I examined the associations between satisfactory glycaemic control (HbA1c < 64mmol/mol or <7.5%) in patients with diabetes and three explanatory variables (deprivation, Black ethnicity and South Asian ethnicity) to assess whether the negative correlations reported during the first five years after the introduction of the new GP contract in 2003 (Alshamsan, 2012; James, 2012) have persisted. In four successive years (2013-14 to 2016-2017) there were statistically significant, but very weakly negative, partial correlations between the percentage of diabetic patients with HbA1c <64mmol/mol and the three variables, after adjusting for 11 organisational and population confounders. This needs further work to be expanded into a paper.

Future research

Recently Professor Kamlesh Khunti at the Leicester Diabetes Centre invited me to collaborate with his team in future studies. I am the principal investigator (PI) for a study that is being funded by CLARHC (Collaboration for Leadership in Applied Health Research and Care) East Midlands. The study will use patient

level data from the Clinical Practice Research Datalinks (CPRD) database to analyse the predictive effects of detection and management of an important risk factor, hypertension, on hard outcomes, i.e. death and unscheduled hospital admissions due to cardiovascular events, comparing cohorts that have cardio-metabolic morbidity with controls. I used SEARCH to generate a hypothesis and to guide variable selection in the analysis. CPRD is about to allow us access to the data.

7. Conclusions

Answering the research questions

I hope to have demonstrated how a population health conceptual framework has helped to generate testable hypotheses, establish useful sets of relevant variables for inclusion in analyses, and describe relationships between these variables.

The contribution to knowledge

These publications have contributed to knowledge by:

1. Describing how both non-disease variables and clinical performance variables predict variations in mortality rates between defined populations,
2. Demonstrating that the current allocations of practice funding may inadequately support general practices serving very deprived populations with greater health needs
3. Describing the pervasive decline of relationship continuity of care, reflecting that practices are struggling more to provide adequate access
4. Providing a new comprehensive conceptual framework to aid population health research.

The relevance of this research

My findings are consistent with some other research. Improved access (e.g. continuity of care) and risk factor management (e.g. detection and control of hypertension) are two of Starfield's six mechanisms by which primary care benefits population health (Starfield, 2005).

The papers are relevant to current debates about two important challenges faced by the NHS, which must operate within the limits of financial and human resources in a tough economic climate:

1. Health inequalities, e.g. disparities in mortality rates between populations, linked to levels of socioeconomic deprivation, persist despite an overall decline in mortality (papers 1-3). Also, in this decade improvements to life expectancy

have slowed more in the United Kingdom than in many other countries (ONS, 2017; ONS, 2018).
2. Access to primary healthcare has worsened, one manifestation being the pervasive steady decline in continuity of care (paper 6).

The current levels and allocation of NHS general practice payments are unlikely to help practices tackle these challenges. Practices serving populations with greater health needs, as predicted by higher deprivation scores, often receive insufficient additional funding to cope with their greater workloads. The current formula needs to be updated (paper 5).

Effective decisions about the future roles and configuration of healthcare require a correct understanding of what determines population health outcomes and how healthcare might best improve these. Conceptual frameworks such as SEARCH can contribute to further research and to the design and implementation of effective policies by identifying and organising relevant factors and by describing their relationships (paper 7).

Smarter management and further analyses of the huge amount of data already collected and published by the NHS has the potential to improve the quality of policy making and performance (paper 4).

My suitability for a research degree by published work qualification

I am the lead author for all the papers. I undertook all of the work myself, with supervision from Professor Richard Baker, Professor Kamlesh Khunti and Dr John Bankart. I wish to acknowledge their and others' contributions to my research:

- Dr Bankart and Professor Baker provided frequent constructive feedback at all stages to each study and to the framework's development.
- Dr Bankart undertook the statistical analyses in papers 1-3 and double-checked my analyses in papers 5-6.

- Professors Khunti and Andrew Wilson, and Drs Nicola Walker, Kambiz Boomla and Christopher Williams contributed ideas and feedback to the studies in which they were collaborators.

I believe that I have demonstrated my suitability to undertake research by:

- Taking the lead role in initiating and completing projects
- Acquiring familiarity with population health literature through searches,
- Organising key ideas, generating hypotheses and developing focused research questions,
- Performing statistical analyses in two papers (5-6),
- Interpreting and describing research findings,
- Drafting papers accepted by leading peer-reviewed journals,
- Responding to reviewers and editors, and
- Disseminating my work through abstracts and posters, presentations at scientific meetings, and interviews on local radio and national television.

Final thoughts

Primary care can contribute to better population health outcomes by having a population perspective and by recognising how non-disease related factors contribute to health needs and outcomes. Dealing effectively with complex situations often requires considering multiple factors and understanding their relationships, and where univariable solutions to multivariable problems may be partially successful, but risk unforeseen or untoward consequences.

Figures

Figure 1: Configuration of the Leicester SEARCH (Systematic Exploration and Analysis of Relationships Connecting Health variables in populations) conceptual framework

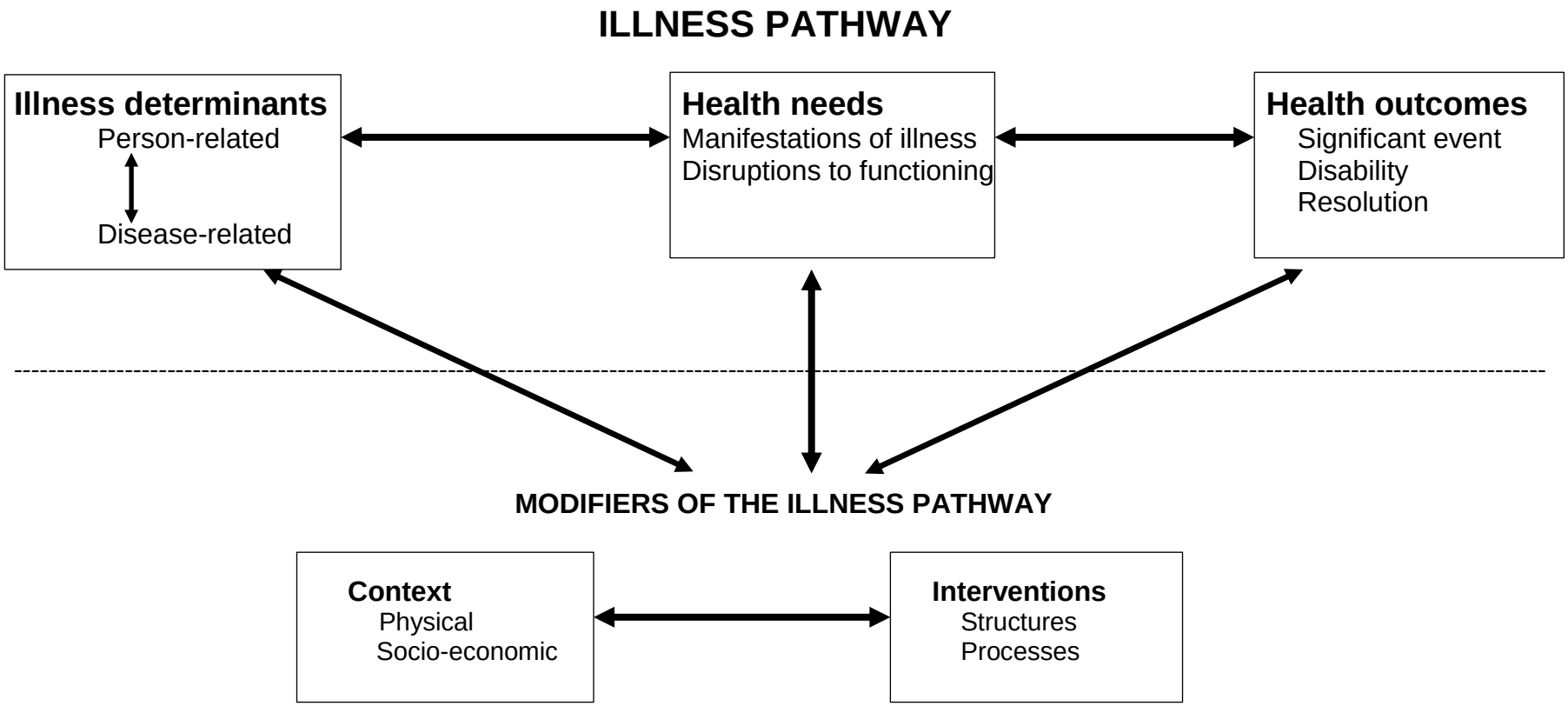

Figure 2: Timeline for development of the conceptual framework in conjunction with the observational studies

Sizeable cross-sectional variations in CHD mortality noted between PCT populations

Paper 1 (2010)
CHD mortality
PCT level

First version of framework: illness determinants predict an important health outcome in populations, modified by healthcare.

Paper 2 (2012)
4 types of mortality
PCT level

Framework tested using other outcomes, with more variables added.

Paper 3 (2015)
CHD mortality trends
PCT level

Framework needs to allow for cross-sectional variations between population groups and longitudinal changes in variables.

Paper 5 (2016)
NHS practice payments

Framework's configuration altered: modifying factors now divided into context and intervention variable groups, with associations between them. Both these groups also interact with an added intermediate group of variables in the illness pathway, named health needs.

Paper 6 (2018)
Continuity of care
Practice level

Framework is able to support longitudinal analysis. Final configuration of two modifying factor groups further defined, with exploration of the relationships between context and intervention variables and with health needs.

Bibliography

Alshamsan R, Tayu Lee J, Majeed A, Netuveli G, Millett C. (2012) Effect of a UK Pay-for-Performance Program on Ethnic Disparities in Diabetes Outcomes: Interrupted Time Series Analysis. *Ann Fam Med*,10, pp. 228-34. **DOI**:10.1370/afm.1335

Baker R, Honeyford K, Levene LS, et al. (2016) Population characteristics, mechanisms of primary care and premature mortality in England: a cross-sectional study. *Br Med J Open*, 6, e009981. **DOI:**10.1136/bmjopen-2015-009981

Barker I, Steventon A, Deeny SR. (2017) Association between continuity of care in general practice and hospital admissions for ambulatory care sensitive conditions: cross sectional study of routinely collected, person level data. *Br Med J*, 356, j84. **DOI:** https://doi.org/10.1136/bmj.j84

Berenson RA, Hammons T, Gans DN, Zuckerman S, Merrell K, Underwood WS, Williams AF. (2008) A house is not a home: keeping patients at the center of practice redesign. *Health Aff (Millwood)*, 27(5), pp.1219-30. **DOI:** https://doi.org/10.1377/hlthaff.27.5.1219

Bodenheimer T, Wagner EH, Grumbach K. (2002) Improving primary care for patients with chronic illness. *JAMA,* 288(14), pp. 1775-1779. **DOI:**10.1001/jama.288.14.1775

Bodenheimer T, Ghorob A, Willard-Grace R, Grumbach K. (2014) The 10 building blocks of high-performing primary care. *Ann Fam Med*, 12(2), pp. 166-171. **DOI:**10.1370/afm.1616

BMA. (2018) Focus on the global sum allocation formula (Carr-Hill formula). Updated: 15 March 2018. Available at: https://www.bma.org.uk/advice/employment/contracts/general-practice-funding/focus-on-global-sum-allocation-formula (Accessed: 13 September 2018)

Brown AF, Ettner SL, Piette J, Weinberger M, Gregg E, Shapiro MF, et al. (2004) Socioeconomic position and health among persons with diabetes

mellitus: a conceptual framework and review of the literature. *Epidemiol Rev*, 26, pp. 63–77. **DOI:** https://doi.org/10.1093/epirev/mxh002

Carr-Hill, R. (2004) *GMS Global Sum Formula: Annexe D resource allocation formula.* Available from: http://www.nhsemployers.org/~/media/Employers/Documents/Primary%20care%20contracts/QOF/QOF%202004/Annex%20D%20-%20Carr-Hill%20resource%20allocation%20formula.pdf (Accessed: 23 October 2018)

Davis N. (2018) 'Keeping the same doctor reduces death risk, study finds', *The Guardian*, 29 June, p.1. Available at: https://www.theguardian.com/science/2018/jun/29/keeping-the-same-doctor-reduces-death-risk-study-finds?CMP=twt_gu (Accessed: 15 October 2018)

Dzau VJ, Balatbat CA. (2018) Reimagining population health as convergence science. *Lancet*, 392(10145), pp.367-368. **DOI:** https://doi.org/10.1016/S0140-6736(18)31372-2

Farooqi AM, Levene LS. (2005) 'Diabetes Mellitus', in Lakhani, M and Charlton, R (eds.) *'Recent Advances in Primary Care'*. London: Royal College of General Practitioners, pp. 127-154.

Felber JP, Zermatten A, Dick J, Levene LS. (1975) Dietary modification of a specific hormonal system of the duodenal mucosa controlling the endocrine and exocrine pancreatic secretions. *Swiss Med Weekly*, 105(11), pp. 338-340.

Freemantle N, Wood J, Griffin C, Calvert MJ, Shankar A, MacArthur C. (2009) What factors predict differences in infant and perinatal mortality in primary care trusts in England? A prognostic model. *Br Med J*, 339, b2892. **DOI:** https://doi.org/10.1136/bmj.b2892

Graham H, Kelly MP. (2004) *Health Development Agency Briefing Paper:* '*Health inequalities: concepts, frameworks and policy'.* Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.607.3686&rep=rep1&type=pdf (Accessed: 15 October 2018)

James GD, Baker P, Badrick E, Mathur R, Hull S, Robson J. (2012) Ethnic and social disparity in glycaemic control in type 2 diabetes; cohort study in general

practice 2004–9. *J Roy Soc Med*, 105(7), pp. 300-308. https://doi.org/10.1258/jrsm.2012.110289

Kindig, DA, Stoddart G. (2003) What is population health? *Am J Pub Health*, 93, pp. 366-369.

Kindig DA. (2007) Understanding Population Health Terminology. *Milbank Q*, 85(1), pp. 139-161.

Kringos DS, Boerma WGW, Hutchinson A, et al. (eds) (2015) *Building primary care in a changing Europe.* Copenhagen: European Observatory on Health Systems and Policies.

Levene LS, Donaldson LJ, Brandon S. (1985) How likely is it that a district health authority can close its large mental hospitals? *Br J Psychiatry*, 147, pp. 150-5.

Levene LS. (1997) A protocol for the management of patients with diabetes mellitus in our practice. *Update*, 54(4), pp. 238-43

Levene LS. (2003) *Management of Type 2 Diabetes Mellitus in Primary Care: A Practical Guide.* Edinburgh: Butterworth Heinemann.

Levene LS, Donnelly R. (2008) *Management of Type 2 Diabetes Mellitus in Primary Care: A Practical Guide.* 2nd edn. Edinburgh: Butterworth Heinemann Elsevier.

Levene LS, Farooqi AM. (2010) *Recent Advances in Diabetes Mellitus for Primary Care.* Dartford: National Services for Health Improvement.

Levene LS, Baker R, Bankart MJG, Khunti K. (2010) Association of features of primary health care with coronary heart disease mortality. *JAMA*, 304(18), pp. 2028-2034. **DOI:**10.1001/jama.2010.1636

Levene LS, Bankart J, Khunti K, Baker R. (2012) Association of primary care characteristics with variations in mortality rates in England: An observational study. *PLOS ONE*, 7(10), e47800. **DOI:**10.1371/journal.pone.0047800

Levene LS, Baker R, Khunti K, Bankart MJG. (2015) Variations in coronary mortality rates between English primary care trusts: observational study 1993–2010. *J Pub Health*, 38(4), e455-e463. **DOI:** https://doi.org/10.1093/pubmed/fdv162.

Levene LS, Walker N, Baker R, Wilson A, Honeyford CE. (2016) Debate and Analysis - Rationalising data use for general practice: a missed opportunity. *Br J Gen Pract*, 66 (649), e603-e605. **DOI:** https://doi.org/10.3399/bjgp16X686485

Levene LS, Baker R, Wilson A, Walker N, Boomla K, Bankart MJG. (2016) Population health needs as predictors of variations in NHS practice payments: a cross-sectional study of English general practices in 2013–2014 and 2014–2015. *Br J Gen Pract*, 67 (654), e10-e19. **DOI:** https://doi.org/10.3399/bjgp16X688345

Levene LS, Baker R, Walker N, Wilson A, Williams C, Bankart MJG. (2018) Predicting declines in perceived relationship continuity using practice deprivation scores: a longitudinal study in primary. *Br J Gen Pract*, 68 (671), e420-e426. **DOI:** https://doi.org/10.3399/bjgp18X696209

Levene LS, Baker R, Bankart MJG, Walker N, Williams C, Wilson A. (2018) Practice funding and socioeconomic deprivation in English general practices: a longitudinal study 2013–2017. *Br J Gen Pract*, 68 (suppl 1), bjgp18X697397. **DOI:** https://doi.org/10.3399/bjgp18X697397

Levene LS, Bankart MJG, Walker N, Wilson A, Baker R. (2018) How healthcare may modify the effects of illness determinants on population outcomes: the Leicester SEARCH conceptual framework for primary care. *Br J Gen Pract Open,* bjgpopen18X101603. **DOI:** https://doi.org/10.3399/bjgpopen18X101603

Maxwell JA (2005). *Qualitative research design: An interactive approach* (2nd Ed.). Thousand Oaks, CA: SAGE Publications, p. 41.

Miles MB, Huberman A M (1994). *Qualitative Data Analysis: An Expanded Sourcebook*. Thousand Oaks, CA: Sage Publications, p.18.

Mold JW, Lienke RI, Brew B. (undated) *How Primary Care Produces Better Outcomes: A Logic Model.* Available at: http://www.napcrg.org/Portals/51/Documents/CASFM%20Products/Primary%20Care_2014_07_14-2.pdf (Accessed: 15 October 2018)

NHS Employers. (2010) *Global sum.* Available at: http://www.nhsemployers.org/your-workforce/primary-care-contacts/general-medical-services/gms-finance/global-sum-formula (Accessed: 23 October 2018)

NHS Employers. (2014) *GMS contract changes 2003/04*. Available at: http://www.nhsemployers.org/your-workforce/primary-care-contacts/general-medical-services/gms-contract-changes/contract-changes-2003-04 (Accessed: 15 October 2018)

NHS Employers. (2015) *2015/16 General Medical Services (GMS) contract: guidance for GMS contract 2015/16*. Available at: http://www.nhsemployers.org/~/media/Employers/Documents/Primary%20care%20contracts/GMS/GMS%20guidance%202010-present/2015-16/201516%20GMS%20Guidance.pdf (Accessed: 30 September 2018)

Office for National Statistics. (2017) *Dataset: Mortality rates (qx), principal projection, England and Wales.* Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies/datasets/mortalityratesqxprincipalprojectionenglandandwales (Accessed: 15 October 2018)

Office for National Statistics. (2018) *Article: Changing trends in mortality: an international comparison: 2000 to 2016. Analysis of period life expectancies and age-standardised mortality rates in selected countries globally from 2000 to 2016.* Available at: https://www.gov.uk/government/statistics/changing-trends-in-mortality-an-international-comparison-2000-to-2016 (Accessed: 15 October 2018)

Pereira Gray DJ, Sidaway-Lee K, White E, Thorne A, Evans PH. (2018) Continuity of care with doctors—a matter of life and death? A systematic review of continuity of care and mortality. *Br Med J Open*, 8**,** e021161. **DOI:** http://dx.doi.org/10.1136/bmjopen-2017-021161

Public Health Policy & Strategy Unit/NHS Commissioning Unit. (2013) *Living Well for Longer: A call to action to reduce avoidable premature mortality.* London: Department of Health. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/181103/Living_well_for_longer.pdf (Accessed 15 October 2018)

Rasanathan K, Montesinos EV, Matheson D, Etienne C, Evans T. (2009) Primary health care and the social determinants of health: essential and complimentary approaches for reducing inequities in health. *J Epidemiol Community Health*, 65(8), pp. 66-660. **DOI:** http://dx.doi.org/10.1136/jech.2009.093914

Rodman H. Are Conceptual Frameworks Necessary for Theory Building? The Case of Family Sociology. (1980) *Sociol Q*, 21(3), pp. 429-441. **DOI:** http://www.jstor.org/stable/4106304

Rose G. (2001) Sick individuals and sick populations. *Int J Epidemiol*, 30(3), pp. 427-432. **DOI**:10.1093/ije/30.3.427

Shields P, Rangarjan, N. (2013) *A Playbook for Research Methods: Integrating Conceptual Frameworks and Project Management*. Stillwater, OK: New Forums Press.

Singer M, Bulled N, Ostrach B, Mendenhall E. (2017) Syndemics and the biosocial conception of health. *Lancet*, 389(10072), pp. 941–950. **DOI:** https://doi.org/10.1016/S0140-6736(17)30003-X

Solar O, Irwin A. (2010) *A conceptual framework for action on the social determinants of health. Social Determinants of Health Discussion. Paper 2 (Policy and Practice).* Geneva: World Health Organization. Available at: http://apps.who.int/iris/bitstream/10665/44489/1/9789241500852_eng.pdf (Accessed: 15 October 2018)

Starfield B, Shi L, Macinko J. (2005) Contribution of Primary Care to Health Systems and Health. *Milbank Q*, 83(3), pp. 457–502. Available at: www.jhsph.edu/sebin/k/a/2005_mq_starfield.pdf (Accessed: 15 October 2018)

'Syndemics: health in context' (Editorial) (2017) *Lancet*, 389(10072), p. 881. **DOI:** https://doi.org/10.1016/S0140-6736(17)30640-2

University of Leicester. (2018) *News: Seeing your preferred GP is getting more difficult*. Available at: https://www2.le.ac.uk/news/blog/2018-archive/may/seeing-your-preferred-gp-is-getting-more-difficult (Accessed: 23 October 2018)

Victoria CG, Huttly SR, Fuchs SC, Olinto MTA. (1997) The Role of Conceptual Frameworks in Epidemiological Analysis: A Hierarchical Approach. *Int J Epidemiol,* 26(1), pp. 224-227.

Wade DT, Halligan PW. (2004) Do biomedical models of illness make for good healthcare systems? *Br Med J*, 329(7479), pp.1398–1401. **DOI:** https://doi.org/10.1136/bmj.329.7479.1398

Walker RJ, Gebregziabher M, Martin-Harris B, Egede LE. (2014) Relationship between social determinants of health and processes and outcomes in adults with type 2 diabetes: validation of a conceptual framework. *BMC Endocr Disord*, 14, e82. https://doi.org/10.1186/1472-6823-14-82

Watson DE, Broemeling A-M, Reid RJ, Black C. (2004) *A results-based logic model for primary health care: laying an evidence-based foundation to guide performance measurement, monitoring and evaluation.* Vancouver: Centre for Health Services and Policy Research, University of British Columbia, Available at: https://circle.ubc.ca/bitstream/handle/2429/50215/Watson_D_et_al_Logic_model.pdf?sequence=1 (Accessed: 15 October 2018)