What do tomorrow's doctors need to learn about ecosystems? A systematic review

Dr Sarah C Walpole, sarah.walpole@hyms.ac.uk, Academic Clinical Fellow, Hull York Medical School/ National Institute for Health Research

Dr David Pearson, david.pearson@hyms.ac.uk, Deputy Dean, Hull York Medical School

Dr Jonathan Coad, jonathan.coad@nhs.net, Academic Foundation doctor, Hull & East Yorkshire NHS Trust

Catriona Kemp, Catriona.Kemp@hyms.ac.uk, HYMS Librarian, York University

Prof Anthony McMichael, tony.mcmichael@anu.edu.au, Professor of Population Health, Australian National University College of Medicine, Biology and Environment

Stefi Barna, s.barna@uea.ac.uk, Lecturer in Public Health

Prof Ian Roberts, Ian.Roberts@lshtm.ac.uk, Professor of Epidemiology, London School of Hygiene and Tropical Medicine

Background to the topic

Ecosystems are a major determinant of human health and influence on public health. In a forward to the World Health Organisation (WHO)'s synthesis on ecosystems and health, Jong-Wook Lee reminds us that "*nature's goods and services are the ultimate foundations of life and health*". (Corvalan, Hales, & McMichael, 2005) As ecosystems provide services that we need to maintain health, it follows that disruption of ecosystems constitutes a threat to health. The WHO states that ecosystem disruption due to human activities is a major cause of morbidity and mortality worldwide. Lang and Rayner (2012) propose that ecosystems thinking should be central to our conception of public health, emphasising that "*human health ultimately depends on the health of ecosystems*".

WHO defines an ecosystem as follows:

> "*An ecosystem is a naturally occurring community of organisms, such as plants and animals, together with their environment, functioning as a unit. Disruption of ecosystems – whether as a result of human activities or natural phenomena – can have severe and unpredictable effects on human health.*" (WHO, 2013)

We are currently in a decade (2005-2014) for Education for Sustainable Development (ESD) announced by the United Nations General assembly. (UNESCO, 2013) In the UK, the Higher Education Academy has a work stream on ESD, and in all major UK universities ESD exists as a cross-faculty initiative. (HEA, 2013)

The Global Consensus on Social Accountability (2010) recognises the role of medical schools in providing a service to both local and global communities. It is increasingly recognised that the role of the doctor goes beyond being a medical expert and treating disease in individuals into being a health advocate and manager of healthcare services, as, for example, in the CanMEDS framework for doctors. (Frank, 2005) In 2012, the World Organisation of National Colleges, Academies and Academic Associations of General Practitioners/ Family Physicians (WONCA) upgraded their special interest group on the Environment to Working group status. The aim of this international working group is to promote "*healthy ecosystems on a healthy planet*", and an objective is promotion of training in environmental health in health systems and medical schools. (WONCA, 2013) This systematic review will help to identify in which areas, and to what extent, doctors need to learn about theory and practice of ecosystems thinking.

Since 2008, members of the UK's Sustainable Healthcare Education network (SHE) have been working to develop, deliver and evaluate teaching for students in a number of medical schools. (Centre for Sustainable Healthcare, 2013) In January 2013, SHE launched a national consultation, requested by the General Medical Council (GMC), to identify priority learning outcomes for medical students relating to sustainability. This systematic review will support ongoing investigations into appropriate learning outcomes for medical students and doctors in relation to ecosystems and sustainability.

Many medical schools aim to equip graduates with a sense of their responsibility to local and global communities and a perspective on the social determinants of health. (Boelen, 2010) This will be the first systematic review on ecosystems in medical education. It will both contribute to the international medical education evidence base and provide information for UK medical curriculum advancement.

Review questions, objectives and key words

This is a systematic review, with a definitional component, with the following aims, objectives and process:

Aims

1. To determine the nature of discussions around ecosystems in educational, medical and medical education literature

2. To establish the nature and quality of the arguments for inclusion of ecosystems in medical education

Objectives:

Objective 1: To identify the terms and context used to discuss ecosystems in relation to medicine and medical education, by carrying out systematic searches to identify literature discussing ecosystems in relation to medical education

Objective 2: To establish in what curricular context learning about ecosystems is discussed, by examining literature which argues for or against the inclusion of ecosystems in medical education

Objective 3: To determine the explanations that are given to support arguments to include / exclude ecosystems as a topic in medical curricula and their quality, by using a systematic framework and a quality appraisal guide to compare the literature findings with established medical curricula topics

Objective 4: To develop recommendations for educational practice in light of the findings from the literature synthesis

Process:

1. Develop a search protocol
2. Screen search findings
3. Abstract and organise findings, using a systematic framework
4. Identify the quality of arguments made and identify connections between findings - where sources conflict, substantiate or develop findings from other sources
5. Submit synthesis for publication and disseminate findings to facilitate peer review

Keywords:

Medical education, medicine, medical student, medical school, health, healthcare, health professional ecosystem, ecology, environment, biodiversity, environmental sustainability, climate change

Why focus on 'ecosystems'?

There are a number of related concepts and terms which could have been chosen as the focus of this review, and the following section will outline the reasons for choosing to focus on the concept of 'ecosystems'.

Ecosystems are balanced systems of interacting parts, which exist at local and global levels. All natural materials, and by extension all synthetic materials, that humans use are taken from ecosystems. This includes resources for activities of daily living and for healthcare, such as paper, plastics and medications. Similarly, all waste that we produce in daily living and in providing healthcare are returned to the ecosystem, and an important service that ecosystems provide is waste recycling (such as decomposition by microbes and uptake of carbon dioxide by plants).

Human beings are not only members of ecosystems, but also fundamentally reliant on ecosystems for goods and services, from fresh air and clean water to food, fuel and medicines. This is an important reason why, as the WHO state, ecosystem disruption can have major negative impacts on human health. Meanwhile, humans are having unprecedented effects on ecosystems, causing global ecosystem change such as ocean acidification and climate change.

The ecosystems in which we live are often referred to as 'our environment' or 'the environment'. This is a human-centric perspective, which suggests that nature and ecosystems are only relevant to the extent that they interact with and support human life. Given that there are multiple interactions within an ecosystem that do not involve humans, yet are relevant to the services that we draw upon, it may be relevant for tomorrow's doctors to learn about the ecological system rather than a more two-dimensional concept of human interactions with their environment. While this argument is related to certain values which may not be universally held, there is another important reason for referring to 'ecosystems' rather than 'the environment'. 'Environment' is a term that has a great range of meanings depending on the context in which it is used. 'Environment' does not always refer to the natural environment or even the physical environment, for example, 'food environment' can refer to the context in which individuals gain access to food, or 'business environment' may refer to institutions, cultures, norms or economics which provide a backdrop for business. Furthermore, the term 'environmental health', has a specific and narrower meaning than the topic which will be reviewed in this study.

Another term that is often used when describing matters relating to ecosystems is 'sustainability', but, again, the concept has a range of meanings, depending on the context in which it is used. Taken literally, this term refers to the ability of something to continue existing. 'Sustainable development' was famously described by the Brundtland Commission (UN, 1987) as: "*development which meets the needs of the present without compromising the ability of future generations to meet their own needs*". Critics of the goal of 'sustainability' or 'sustainable development' would argue that enabling current infrastructures, practices and systems to continue existing is not a worthy goal. Furthermore, sustainability and sustainable development are often described as having three main dimensions: economic, social and environmental, not all of which will be addressed in this review.

The final term which has been considered is 'nature'. As with 'environment' and 'sustainability', 'nature' can have alternative meanings and refers to a nebulous concept. It has been argued that there is no clear line between that which is human and that which is natural.

A major challenge that this review faces is delimiting the topic of 'ecosystems'. An important sub-question for this research will be to identify if and how 'ecosystem' is defined in the literature. While the WHO provides a definition of an ecosystem on their website, a number of major organisations and reports on this topic do not define the concept about which they communicate. For example, the Millennium Ecosystems report on health and website (Millenium Ecosystem Assessment Board, 2003) do not provide a definition of the term ecosystem.

For the purposes of this review, an ecosystem is defined as per WHO as "*a naturally occurring community of organisms, such as plants and animals, together with their environment, functioning as a unit*". (WHO, 2013) This concept is taken to include climate, air, water, land and soil, plants and animals (biodiversity), and refer to the "community" or systems of interactions between these living and non-living parts. Learning about ecosystems in medical education would entail thinking beyond the human body (physiology) and human populations (public health), and considering local and global (planetary) ecological systems. Learning in this domain may be labelled as learning about 'environment', 'sustainability', 'climate change' or 'biodiversity', and therefore these search terms will be used in the literature search.

For the purpose of this study, there is a need to define those topics that should not be included in learning "*about ecosystems*". A biocentric perspective argues that humans are not part of an ecosystem and only impact upon ecosystems, (Taylor, 1986) while in extreme opposition to this view, others argue that even synthetic or human-made products are non-living factors that are part of the environment and thus part of ecosystems. For the purpose of this review, literature will be excluded if it is not focused on learning about either interactions between a community of organisms (more than 2 species) or the environment in which communities of organisms live. For example, papers discussing human-made organisations, products, structures or systems without reference to relational ecological factors will be excluded. By extension of the above, learning focused exclusively on the human species, for example on human physiology, will be excluded. An important sub question for this review is: *How are ecosystems discussed in the medical education, medical, science and education literature?*

Why consider 'what' tomorrow's doctors need to learn?

This review works from the assumption that tomorrow's doctors need to learn about ecosystems. Supporting this assumption are statements from the WONCA (2013), the Higher Education Funding Council for England (2009), the Higher Education Academy (Sterling, 2012) and the UK's Royal College of Physicians (RCP,

2013). These statements are based on the recognition that the environment is an important determinant of health, that health services have significant resource requirements and environmental impacts, and that protecting the health of the public is among the duties of a doctor. This review therefore begins from the standpoint that there *are* clear reasons why tomorrow's doctors need to learn about ecosystems - and this study will not primarily attempt to answer the question '*why* do tomorrow's doctors need to learn about ecosystems?' It will be informative in the literature analysis phase of this review to consider why individuals or organisations put forward the suggestions that they do about what tomorrow's doctors need to learn; that is to examine the motivations and perspectives of researchers and research subjects. A question for this review will be: *What reasoning is given for any educational need identified? (e.g. educational, professional or societal reasons)*

What is educational need?

'Educational need' can be defined in relation to personal, professional or public domains. For the purpose of this study, learning needs of tomorrow's doctors are described as that which a medical student or doctor requires to be a good student and a good doctor and fulfil his or her professional duties to patients or the public; including being able to develop their own knowledge and skills, treat patients appropriately, act as a manager and leader in the health service, and look after their own health and wellbeing. The GMC's "Good Medical Practice" highlights that a doctor has a professional duty to "protect and promote the health of patients and the public". (GMC, 2006) The CanMEDS framework (Frank, 2005) argues that fulfilling the professional duty to protect the health of the public includes playing an advocacy role, and a recent BEME systematic review highlights that understanding on how best to integrate professionalism across the curriculum is still evolving (Birden et al., 2013).

This study discusses learning, rather than teaching, because the focus of the study is on the needs of current students (tomorrow's doctors). There may be multiple mechanisms through which students learn, and not all mechanisms involve directed teaching.

The search will aim to find literature that highlights what the learning needs of tomorrow's doctors are, but it is also important to consider what tomorrow's doctors do not need to learn and how this may be represented in the literature. Firstly, there may be consensus statements or opinion pieces arguing against the inclusion of certain topics in learning, or research finding that students, educators or other stakeholders (such as the public or government) do not feel that such topics are needed. Secondly, if any literature evaluation of learning that showed no benefit or negative impact in terms of knowledge, skills, attitudes, behaviours, patient outcomes or learning in other areas would be suggestive that this learning is not something which tomorrow's doctors need.
It is expected, however that there will be a 'publication bias' towards literature arguing for the inclusion of this topic in medical education, as more advocates of learning on ecosystems are expected to aim to publish on this area. It may be that there are educators and researchers who oppose incorporating ecosystems as a topic in medical education, but it is expected, especially because this is a relatively new discourse in medical education, that literature highlighting disadvantages of or the lack of need for learning on ecosystems will be less prevalent. The difficulty of identifying a "lack of need" is an issue that will be borne in mind in the analysis of the results and taken up again in the discussion section of this thesis.

Why focus on 'tomorrow's doctors'?

The phrase "tomorrow's doctors" is used by the GMC (2009) in their core document on medical curricula, to refer to today's medical students. It is a useful phase as could be taken to include today's medical students and the majority of doctors (as all but those on the brink of stopping work will still be practising in the future ('*tomorrow*')). Aware of the changing context in which doctors are practising and that the majority of doctors have had little opportunity to learn about ecosystems in relation to their profession, this review aims to identify the learning needs of undergraduate and postgraduate doctors (both junior doctors and consultants in continuing professional development (CPD)). Doctors are defined as those holding a degree in Medicine from any country, and practising medicine (including surgery), healthcare or public health in any country or setting. This review will not aim to identify or discriminate based on whether a doctor is registered with a professional body, such as the GMC.

This study focuses on medical practitioners, because it is beyond the scope of the review to examine learning needs of all healthcare practitioners. This study does not assume that all healthcare practitioners have the same set of learning needs. The researchers are medical practitioners, have most experience in educating medical students, and are particularly interested in medical education of undergraduate and postgraduate doctors. Time

constraints will not allow this study to extend beyond the learning needs of doctors. The search will, however, look for and include in the analysis studies that discuss the learning needs of any health practitioners or students, as the supposition is that there may be information, ideas or evidence to be gained that will inform our understanding of the learning needs of tomorrow's doctors. It is envisaged that the methodological approach, lessons learnt in carrying out the study and findings of this study may support further research and inform curriculum development for other healthcare professionals.

In many other disciplines, learning about ecosystems as relevant to graduates is at a more developed stage. Generic 'sustainability competencies' have been proposed, for example by UNESCO as part of their Education for Sustainable Development workstream (UNESCO, 2005) and by Sterling in an HEA report on sustainability in higher education. (Sterling, 2012) Although there is great potential for medical education to learn from the competencies and learning practices on this topic that have been developed in other disciplines, this study will not include literature relating to learning outside of health professions. Key papers from other disciplines will, however, be reviewed, and compared with the findings of this study will form part of the discussion.

Why a systematic review is appropriate to answer this question

A systematic review is an appropriate approach for this study, because it will identify and synthesis all of the best evidence relevant to the question from the peer-reviewed and grey literature. Systematic searches are ranked highly in the 'hierarchy' of evidence (Harden, Grant, Buckley, & Hart, 1999; NICE, 2004) and similarly can be carried out in diverse sources; from medicine to education, and from published literature to theses and expert opinion. By drawing out all of the available evidence in this newly emerging field of medical education, it will highlight tensions between different perspectives on the relevant curriculum content for tomorrow's doctors. This is a time when key decision makers in the field of medical education, including the GMC and medical school leaders are considering if and in what way to incorporate learning on ecosystems in curricula and teaching, and making the evidence available in this way will facilitate their processes.

Although a number of reviews have been carried out on this topic, no existing systematic reviews have been identified following the author's involvement in this field over six years, consultation with experts in the fields of medical education and sustainable healthcare, and searches in databases of journal literature, systematic reviews and trial protocols.[1] A systematic review has been chosen over primary research, to garner an understanding of the existing evidence. A two-part consultation is currently being carried out in the UK, therefore it is more appropriate to carry out a systematic review than to duplicate this primary research before having an overview of the current state of the evidence base. This research project will help to fill a gap in our understanding of the learning needs of tomorrow's doctors in relation to ecosystems. Given that this is a new area of study in medical education, it is not expected that a high volume of high quality studies will be identified, and the research will highlight priorities for future research.

Search sources and strategies

While recognising the statements of CanMEDS and GMC on the roles of a doctor, this review will not limit inclusion according to outcome measure or a perception of what educational need is. This research will include any literature that states or implies what tomorrow's doctors need to learn; subsequently the analysis and synthesis will aim to identify and take into account motivations and underlying assumptions of the authors which contribute to their findings and conclusions.

The search, screening, extraction and analysis of data will look for evidence from or about learning in any setting, for example including clinical as well as non-clinical settings.

Searches will be carried out in major medical, public health, nursing, and allied health professional databases: Medline, CINAHL, BNI, Lilacs and Psycinfo. In order to avoid a Western-centric perspective and to identify literature from continents apart from Europe and North America, searches will be carried out in two smaller databases: Iran Medex and Korea Med. Lilacs also references literature from South America. Due to language barrier and resource constraints, it will not be possible to carry out searches in other foreign databases, such as the large Chinese databases. The major education databases ERIC, AEI and BEI will be searched using search

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[1] PROSPERO

terms to limit results to those related to health. To ensure inclusion of environment, ecology and conservation journals, Science Direct, ZETOC and Index to Thesis will be searched.

Apart from in journals, useful literature may include policy documents, medical school documents, conference presentations and theses, all of which may be found in the grey literature. Therefore, ZETOC conference proceedings, Index to Thesis and Open grey will be searched.

It will not be necessary to hand search journals, instead quality checks will be carried out to ensuring that key papers from journals coded by each database appear in the search results. Medical education journals such as "medical teacher" are coded by Medline.

Study selection criteria

Wherever possible, results will be downloaded to Mendeley for deduplication. Results in Mendeley will be screened first, and results that cannot not be deduplicated will be screened separately. The following inclusion/exclusion criteria will be used by two reviewers (SW and JC), to screen the papers blinded to the other reviewer's screening. Where there are disagreements between the two reviewers, consensus will be reached between three researchers (SW, JC, DP).

Population

Population - Inclusion:
- *doctors at any stage in their career, including those working in public health, clinical pathology, clinical microbiology*
- *undergraduate or postgraduate medical students at any stage in their training,*
- *nurses and allied health professionals, including physiotherapists, OTs*
- *nursing or allied health professional students*
- *dentists*
- *regulated complementary healthcare practitioners, including chiropracters, osteopaths, acupuncturists*

Population - Exclusion:
- *social workers – different training, different professional duties*
- *health care assistants and community healthcare workers – different training, different professional duties, not regulated by a professional body*
- *complementary therapists not registered with a professional body, for example flower remedy providers, shamans, !!..*
- *vets – not primarily working with human populations, different professional duties*
- *healthcare managers – not direct care providers, different training, different professional duties*
- *policymakers, apart from public health doctors – different training and professional duties to the majority of doctors*
- *students and professionals from disciplines other than health and healthcare, for example lawyers*

Intervention[2]

Intervention - Inclusion:

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[2] We have used the word intervention to mean the type of intervention that is being explored in papers – facilitation of learning. The review is looking at learning requirements, so studies included will not tend to observe this intervention; instead, included studies will comment on how this intervention should be carried out (i.e. what are learning requirements that should be met through this intervention).

- *education*
  - *intervention which aims to facilitate learning of knowledge, concepts, skills or behaviours and attitudes*
  - *development of learning outcomes or curriculums*
- *educational topic of ecosystems and environmental sustainability*
  - *interactions between a community of organisms (more than 2 species, one of which may be humans), or interactions between organisms and the natural environment, for example rivers, woodland, parks*
  - *local ecosystems and environmental change, including human and healthcare influences on ecosystems, for example reforestation, pollution*
  - *global environmental change and the global ecosystem, including human and healthcare influences on ecosystems, for example biodiversity loss, ocean acidification and climate change*
  - *environmental sustainability and the preservation of natural capital (conservation of natural resources , "strong" environmental sustainability (Hanley et al)), and sustainability of supply of healthcare resources*
  - *the linkages to health may or may not be explicitly addressed*

Intervention - Exclusion:
- *Education*
  - *interventions in the educational environment which are not primarily aiming to enhance learning, for example measures to improve the student experience, improve admissions procedures, save costs or increase environmental sustainability (if not supported by educational intervention)*
  - *studies about pedagogy rather than content (studies that discuss how teaching should be delivered and do not discuss what or why)*
  - *interventions which are aimed to enhance learning on all topics, and not specifically on the topic of ecosystems, for example, improvement to facilities and equipment for contact teaching, provision of supporting resources through a virtual learning environment, improved timetabling*
- *educational topic of ecosystems and environmental sustainability*
  - *exclusively about the human species (for example, with a focus on human physiology)*
  - *interactions of communities of organisms as the microscopic level, including bacterial infections, viral infections and clinical infection control*
  - *human-made organisations, products, structures or systems, without discussion impacts on or the influence of the wider ecosystem (other species or the natural environment)*
  - *management of adverse weather events and disaster preparedness.*
  - *disease vector and parasite control*

Study design - *Inclusion:*
- *systematic reviews; meta-analyses;*
- *expert consensus; policy documents;*
- *qualitative or quantitative studies exploring learning needs, including trials or observational studies;*

Study design - Exclusion:
- *comments; opinion pieces; letters and literature reviews, unless bringing to light new evidence or reporting on recent consensus, such as a conference or working group (in which case reference of the original document/ report will be sought through citation searching)*
- *case studies of teaching approaches, curriculum, development or delivery, unless demonstrating evidence of benefit of learning on topic of ecosystems/ environmental sustainability*

There will be no exclusion based on language – abstract or full text of studies will be translated where required.

Any questions that arise during screening and cannot be addressed using the above screening criteria will be noted. If the criteria are not comprehensive enough to inform a decision about inclusion/exclusion, DP, JC and SW will together review the criteria and extend them as required. This will be important as the criteria will also be required at the data abstraction stage.

Any papers meeting the inclusion criteria at the abstract stage will enter a further stage of screening. Full text will be requested and studies will be screened for quality.

Quality appraisal

Quality appraisal will be carried out by 2 reviewers (JC and SW). All data for inclusion will be assessed using CASP quality criteria. CASP criteria for different types of study are found at http://www.casp-uk.net/#!casp-tools-checklists/c18f8

Procedure for abstracting data

Data will be abstracted according to the above inclusion criteria and where it may provide information to answer the review questions.

The SHE framework (figure 1) will be used to organise findings by the context and content of learning. Findings will be abstracted from studies sequentially, beginning with the oldest publication date and working forward. Findings will be abstracted by highlighting and coding all relevant text, and assigning it within the framework. There may be findings that do not sit comfortably within any of the three main categories in the SHE framework, and these findings will be coded under a separate category initially. Two reviewers (JC and SW) will independently abstract data from included studies. The two reviewers will then compare findings and where there is disagreement, consensus will be reached with support from a third reviewer (DP).

At a later stage in the review the framework may be reinterpreted to best fit the findings identified.
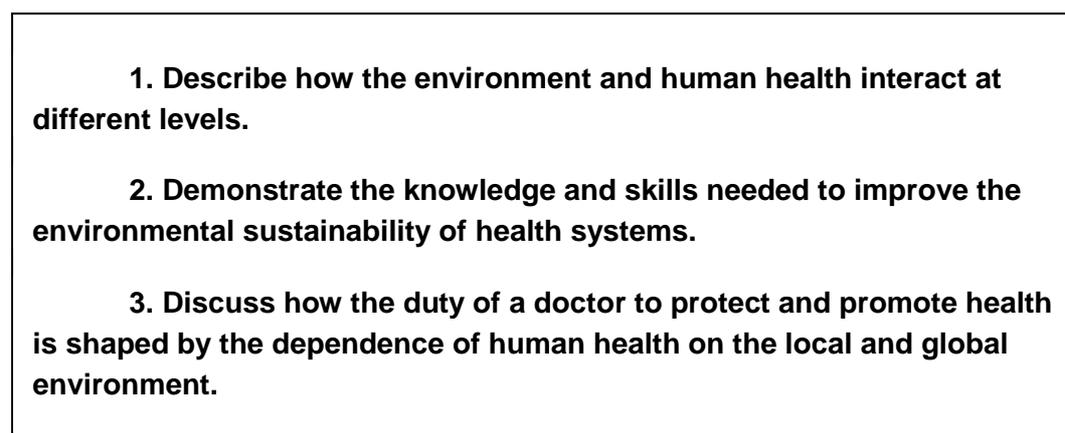
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1. Describe how the environment and human health interact at different levels.

2. Demonstrate the knowledge and skills needed to improve the environmental sustainability of health systems.

3. Discuss how the duty of a doctor to protect and promote health is shaped by the dependence of human health on the local and global environment.

Figure 1: SHE framework for Sustainable Healthcare Learning outcomes (Centre for Sustainable Healthcare, 2013)

Synthesis of extracted evidence

A narrative synthesis approach will be used for this review. Narrative synthesis is recommended for initial synthesis of data from a wide range of sources and to identify if further analysis is required. (CRD, 2009)It is expected that the range of data identified in this review will be too diverse to allow for more specialist synthesis.

Narrative synthesis is appropriate because this systematic review is likely to deal with diverse types of study design, primarily (if not exclusively) containing qualitative data. Guidance from ESRC (Popay et al., 2006) will be followed, including four main steps:

1. **Developing a theoretical model**
   The SHE framework provides a theoretical model which will be used initially to inform data extraction and organisation.
2. **Developing a preliminary synthesis**
   In the preliminary synthesis, the initial framework may be reinterpreted depending on findings. There may be findings that do not fit within the framework, or which suggest a different context or framework for the results.
3. **Exploring relationships in the data**
   Important relationships to review are, firstly, relationships between each study's characteristics and its findings, and, secondly, the relationships between findings of different studies. This section will

explore whether different literature support or refute each other's findings, considering how and why authors have come to the conclusions that they present in the literature and the credibility and transferability of these conclusions.

4. Assessing the robustness of the synthesis product
This will include assessing the credibility of the findings in the synthesis, as well as the quality of the synthesis itself, such as the extent to which the protocol was followed.

Narrative synthesis involves interpreting and synthesising findings through analysis of words and text, rather than statistical data. There is a risk of bias in using a narrative synthesis approach, due to the absence of strict criteria. To minimise the risk of bias in this systematic review process, the following actions will be taken:

- Following ESRC guidance on conduct of narrative synthesis
- Setting out clear objectives and inclusion/exclusion criteria and publishing these before beginning the search and screening processes
- Carrying out extensive searches in a range of databases and carrying out quality checks on systematic searches
- Using pre-defined inclusion and exclusion criteria to screen papers and abstract data
- Using systematic approach and two reviewers working blindly to ensure extraction of all relevant data
- Keeping an audit trail of all paper and data excluded as well as those included
- Disseminating the report for external review after publication

Project timetable

Initial searches – Jan- Dec 2013
Focussed searching – Jan - May 2014
Screening papers to determine inclusion or exclusion –Jun 2014
Review included papers and abstract findings – Jul 2014
Synthesise findings through narrative process – Aug 2014
Evaluation, review and dissemination – Sep -Dec 2014

Conflict of interest statement
DP and SW are members of the Sustainable Healthcare Education network. No financial conflict of interest.

Plans for updating the review

SW plans to update/supervise a student to update the review in 2019 – four years on from completion.

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