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**Chris Cooper a,\* , Paul Levay b, Theo Lorenc c, Gillian M. Craig d (2014) A population search filter for hard-to-reach populations increased search efficiency for a systematic review. Journal of Clinical Epidemiology (in press)**

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## **ABSTRACT**

**Objective:** This paper discusses how hard-to-reach population groups were conceptualised into a search filter. The objectives of this paper are: 1) to discuss how the authors designed a multi-stranded population search filter and, 2) to retrospectively test the effectiveness of the search filter in capturing all relevant populations (e.g. homeless people, immigrants, substance misusers) in a public health systematic review.

**Study design and setting:** Systematic and retrospective analysis via case-study. Retrospective analysis of the search filter was conducted by comparing the MEDLINE search results retrieved without using the search filter against those retrieved with the search filter. 5465 additional results from the unfiltered search were screened to the same criteria as the filtered search.

**Results:** No additional populations were identified in the unfiltered sample. The search filter reduced the volume of MEDLINE hits to screen by 64% with no impact on inclusion of populations.

**Conclusion:** The results demonstrate the effectiveness of the filter in capturing all relevant UK populations for the review. This suggests that well planned search filters can be written for reviews which analyse imprecisely defined population groups. This filter could be used in topic areas of associated co-morbidities, for rapid clinical searches, or for investigating hard-to-reach populations.

**Key Words:** Tuberculosis, Hard-to-reach, Search Filter, Systematic Review Methodology, Literature searching, Information retrieval, Information Science.

## What is new?

### Key finding:

The development of a hard-to-reach population search filter tested by a MEDLINE case-study.

### What is known:

- Search filters can be used to improve the specificity of literature searches (1);
- The use of search filters is not common in searching for community-based interventions or in public health reviews; and
- There are presently no search filters for hard-to-reach populations.

### This paper adds:

- A case-study tested, population search filter for hard-to-reach groups; and
- Detail on a successful approach to writing an effective, multi-stranded, population search filter.

## **Introduction**

This case study originated in a systematic review of qualitative evidence on the barriers to tuberculosis screening (2). The review's purpose was to inform guidance on identifying and managing tuberculosis among hard-to-reach groups (3), which presented some challenges to the review team. Chiefly, how should a population group which, by its very nature, is hard-to-define, be turned into a concept which could be sensitively reviewed and, at the same time, not become so broad, as to become diffuse?

This paper will explore how the review team responded to this challenge, explaining why and how a multi-stranded population search filter was constructed. The paper will also demonstrate how this filter has been tested and validated, as well as analysing its strengths and weaknesses.

The population search filter (available in a supplementary file) discussed in this paper can be used either:

- a. in the form presented here (for example, as a filter for rapid clinical enquires on hard-to-reach populations) or in analogous topic areas (such as other infectious diseases associated with similar populations); or,
- b. as a basis for further research, where the remit of the search requires a detailed analysis of the population groups discussed here.

The review discussed in this paper was commissioned by the UK's National Institute for Health and Care Excellence (NICE) to inform the development of public health guidance in England (3). The searches, data extraction and other methods used to compile the review were conducted according to the second edition of the NICE public health methods manual (4).

## **Background**

**Definition: what does hard-to-reach mean?**

The definition of “hard-to-reach” was modified during the review process as the evidence was searched, quality appraised and synthesised. The completed review (2) used a more detailed definition than the original scope setting out the parameters of the review (5), reflecting the iterative nature of the process and the work which this search filter engendered. The published NICE guidance defined the hard-to-reach population in the UK as:

“adults, young people and children from any ethnic background, regardless of migration status. They are ‘hard-to-reach’ if their social circumstances, language, culture or lifestyle (or those of their parents or carers) make it difficult to: recognise the clinical onset of TB; access diagnostic and treatment services; self-administer treatment; or attend regular appointments for clinical follow-up”. “The main groups considered in this guidance were people who are homeless, substance misusers, prisoners and vulnerable migrants” (3).

Given that the review did not start from a precise definition of the population (5), the search strategy had to reflect the diversity of meanings attached to “hard-to-reach” and recognise that the population under review could be described as: underserved, or hidden, difficult to locate, and difficult to engage with and treat. These distinctions are important because they each have implications for the ways in which services are organised and delivered.

### **Definition: what are search filters?**

Search filters form part of a search strategy and they are designed to retrieve specific types of results, often those reporting on a certain study type or outcome (1). Search filters are commonly used for locating reports of randomised controlled trials (RCTs), where the concept of an RCT is well understood and a shared definition is held by those involved in the process (1). There are certain characteristics that always make up an RCT and a search filter can be designed to capture these essential and static components; such as the fact that the trial has to be randomised and controlled. This method of information retrieval requires the author to identify their article as an RCT, the database producer to

index it as an RCT and the searcher to know how to identify an RCT. The key is to match these three stages in the process and, where the concepts are well understood, this can be done with high levels of accuracy (1, 6).

The issue in reviewing population-level interventions, such as tuberculosis screening, is that the naming of, and characteristics associated with, the search terms are frequently changing. It is difficult for the literature searcher to translate fluid and difficult-to-define concepts into the strict controlled vocabulary of a database, and to conceptualise definitions which are ever-changing. For example, the phrase “community-based interventions,” whilst a popular phrase in the epidemiological literature, does not have a universally agreed or single point of understanding, and so it does not match any Medical Subject Headings (MeSH) in MEDLINE, or the controlled indexing vocabulary of other databases. The literature searcher has to use a variety of free-text terms and indexing vocabulary to capture all potential interpretations of this idea. Furthermore, evidence relating to “community-based interventions” could be drawn from a range of disciplines, including psychology, education and sociology (7), with each one using its own terminology and sources of information (8). It is because of these points that search filters are not commonly used in public health reviews, particularly when *a priori* definitions of concepts do not exist (9).

## **The structure of this paper**

This paper will now break into two parts. Part one details why this population filter was required and how a multi-stranded population search filter was written. Part two records an evaluation of the filter’s effectiveness and covers the methods used to test the filter and the results found. In discussion, the paper analyses the strengths and limitations of the filter.

### **Part 1**

#### **1. The hard-to-reach population search filter**

##### **1.1 Why use a filter?**

Initially, we had proposed running the search without recourse to any population search syntax. This would have allowed the reviewers to define the population during the title and abstract screening, as it emerged from the evidence. This was attractive as it meant a clean and open search syntax could be used: simply, a search strategy combining terms for tuberculosis and qualitative methods. No population of potential interest would have been excluded at the search stage, as the population was unspecified. The qualitative evidence was isolated by using another search filter, this time one for retrieving studies reporting the relevant outcomes. The filter was based on current research on qualitative search filters (10, 11) and its construction does not form part of the current study, as the initial testing suggested it worked adequately.

Testing this approach produced too many results to screen in the time available for the project and sampling of the 8549 results returned by MEDLINE produced poor returns. It became clear that something was required to manage the volume of false-positive literature from these test searches. As no current hard-to-reach population search filter was found, we wrote one.

## **1.2 Construction of the search filter**

### **Structure**

It became clear quickly that the population filter had to take a multi-stranded approach to the topic, an idea used by Glanville in Whiting et al. (2006) (12). The population filter would have to capture all of the population groups of potential interest and it would simultaneously have to cover them with adequate sensitivity. This dual purpose meant the filter was unusual in that it had to be sensitive both within and between the concepts. Once a relevant population group was identified (e.g. prisoners) it was essential to list the synonyms (e.g. convicts), the settings where they might be found (e.g. prisons) and also to take into account any inter-linked concepts (e.g. substance abuse). We also needed to assess how the concept was described in the literature from other relevant countries to the UK and the different terminology used in those other contexts (e.g. penitentiary). The search filter had to achieve adequate

sensitivity (both ensuring no populations were missed and adequately covering the groups it had found), while still retrieving a workable volume. There would be a point of diminishing returns where the search filter became so sensitive, and the results so numerous, that it would have been quicker to revert to the original plan of searching without any population filter at all.

The population filter was structured using four strands:

- 1) Drawing together the higher-level concepts surrounding the population (e.g. hard-to-reach, difficult-to-locate);
- 2) Systematically listing the groups that were known to be likely to face lifestyle or social issues associated with tuberculosis in the UK (e.g. homeless people);
- 3) Defining relevant synonyms pertaining to the known groups and their circumstances; and,
- 4) Analysing the social factors that could hinder access to tuberculosis services. The purpose of this being to draw in literature which was not specifically about named groups but which might include settings causally linked to the topic (e.g. poverty and poor housing).

### **Constructing the filter: iterative searching and scoping**

Intensive, iterative scoping searches were conducted with a view to locating likely population groups. Importantly, we operationalised these searches not on a topic level (i.e. by only looking at the tuberculosis literature) but across a broad subject base, taking a view on all associated co-morbidities in the biomedical field, where the hard-to-reach population might be referenced. The population content was more important than the subject context at this stage of the process.

This approach led to a variety of literatures and produced a broad list of terms, as well as suggesting various controlled indexing terms. Once identified, a new population group was tagged for follow-up and then searched as a term in its own right, until saturation had been achieved. Saturation in this case

being a subjective measure as to whether any further synonyms or variants of the new search term could be identified.

The wide range of sources outside the primary topic area was important to developing a comprehensive list of free-text terms, which not only included American and British variations in spelling but also differences in the way the topics were described (e.g. penitentiaries as well as prisons). Drawing from the controlled indexing thesauri of various databases beyond MEDLINE (e.g. National Criminal Justice Reference Service) was of particular use in capturing terminology that is not usually used in medical databases. Concepts taken from other sources were then tested in MEDLINE to ensure saturation of each concept.

### **Constructing the filter: snowballing**

The next step was to locate any papers that had actually used the term “hard-to-reach” and to examine how these had been handled by the indexers (e.g. (13)). This helped to compile a list of synonyms that was incorporated into the search filter in numerous combinations, for example “hard” and “difficult” were combined with “reach”, “locate”, “find”, “treat” and “engage”. Once a relevant paper had been identified, it was thoroughly examined to extract maximum benefit from it. The purpose of this exercise was not necessarily to identify papers relevant to the review but to find includable population groups, synonyms or associated themes relating to the population. For example, Flanagan (2010) (13) contains the target phrase “hard-to-reach” in its title and it was a productive source of information, even though it was not directly concerned with tuberculosis or infectious diseases. The MEDLINE record shows how the term “hard-to-reach” has been translated by the indexers into MeSH terms and we then searched for other papers with these subject headings. Similarly, Dixon-Woods (2006) mentions neither tuberculosis nor “hard-to-reach” but the paper deals with the central concept of our review (barriers to accessing healthcare services) and it was useful for identifying the MeSH term “vulnerable populations” (14). These papers were also subjected to backwards citation chasing (where we looked at the references

they cited) and forwards chasing (where we used *Web of Knowledge* to find later papers citing the ones we already knew were useful), which helped locate further terminology.

### **Constructing the filter: tuberculosis epidemiology**

It was important to draw on the evidence relating to tuberculosis itself. We undertook several scoping searches which identified social factors that could increase the risk of tuberculosis and then we were able to investigate free text and MeSH descriptors for them. We started with the broad patterns in the UK epidemiology (15) and followed this up by looking in more detail at specific groups (16, 17). From these studies we were able to identify a core set of risk factors, including homelessness, substance misuse and imprisonment (18).

### **Constructing the filter: contact with experts**

A multi-disciplinary team drawing on information specialists, systematic reviewers and experts in tuberculosis, designed, tested and quality assured the filter. The combination of searching expertise and subject-specific knowledge has been shown to be an effective approach to strategy development (19). The topic experts were invaluable at identifying issues within the tuberculosis field such as outmoded terms which had recently fallen from usage but were still required in the search given the date parameters of the review (1990-Current). The experts were also essential in identifying new terms which were emerging at conferences but which had not made it firmly into the literature. For example, the phrase “non-UK born” was a different way of describing migrant populations that was gaining currency before the search (20).

## **Part 2**

### **2. Testing the search filter**

The obvious concern with any literature search is missing includable papers and this search had the added concern of missing any includable populations. The filter was extensively piloted in MEDLINE

before being used in the original review to check it was retrieving papers potentially eligible for inclusion. The paper now moves to the retrospective analysis that was developed to verify that all includable populations had been captured. Did the filtered search miss any population groups that would have been identified by screening the unfiltered search results?

## **2.1 Methods**

The original, unfiltered search yielded 8549 results in MEDLINE (OVID interface). The population search filter reduced the number of results screened for the review (2) down to 3084, a difference of 5465. The purpose of this retrospective analysis was to investigate whether any relevant populations were missed by not screening these 5465 MEDLINE references.

The original MEDLINE strategy from the review was re-run both with and without the filter. The 5465 references were identified and entered into a new database, using Reference Manager software (Thomson Reuters: Version 12). This identified that 10 of the articles were duplicates, meaning that the analysis was conducted on a set of 5455 items. The articles were then screened according to the criteria that had been used in the review (2), with an additional question added at the end for the purpose of this case study, which asked, “does the study include data from any hard-to-reach group that has not already been included in the search filter?” (see supplementary file for full searches and criteria).

The first 100 articles were extracted and independently screened by two reviewers. There was 100% agreement on the final decision whether to include or exclude the paper ( $\kappa = 1$ ) and 79% agreement on the codes used to exclude articles. The discrepancies were discussed and a consensus reached on the coding decisions. This led to several minor amendments to the screening criteria, such as changing the order of the questions. A second batch of 100 articles was then chosen for double screening against the revised criteria and this time there was 100% agreement on the final decision

(kappa = 1) and 98% agreement on the coding used. The references were then split in half (one database of 2727 and one of 2728) and two reviewers single screened one of these each.

## 2.2 Results

**Table 1: Exclusion and inclusion of the 5455 papers**

Exclusion criteria	Percentage of 5455
1 Not in English	22.8%
2 Published before 1990	0%
3 Non-OECD country	18%
4 Non-qualitative study	57.86%
5 Not a tuberculosis service	0.44%
6 Not a hard-to-reach group	0.59%
7 Hard-to-reach group already in the filter	0.31%
Includable populations which should have been in the filter	0%

The screening did not identify any additional population groups that should have been included in the search filter.

The population filter achieved a 64% reduction in volume of studies to be screened for the review without missing any population groups which would have been includable in the review. In practice, this means that the review located the same relevant studies from screening 3084 as opposed to screening 8549 MEDLINE hits. Extrapolating the filter-less MEDLINE figure to the other 16 databases used in the review, suggests that the reviewers would have sifted approximately 27500 instead of the 9800 papers they actually screened. The reviewers who worked on the review were able to screen at a rate of about 500 articles a day. Screening the additional 17700 papers at this rate suggests the filter saved

approximately 35 days, or seven working weeks of time. The time and resources available for the project could not have accommodated this additional workload.

The sifting did identify a number of additional population groups, including funeral directors (21), farmworkers (22), Russian factory workers (23), air force dentists (24) and a church gospel choir (25). These rather eclectic groups did not meet the definition of “hard-to-reach” adopted in the final review and these papers would have been excluded by the reviewers. The search filter did not retrieve papers on every population mentioned in the tuberculosis literature but it did not need to be modified in order to incorporate these groups, as they were not relevant to the definition of hard-to-reach populations adopted for the UK context of the guidance development.

Calculating a precise sensitivity and specificity score to validate the search filter, as is often done with methodological filters, has not been done in this case, as it may be misleading. The aim of this study was to test whether any population groups had been missed by the filtered-search and so the sensitivity, in these terms, was 100% and precision was unaltered, as no new populations emerged.

### **3. Discussion**

#### **3.1 Strengths**

The strength of the filter was that it named the populations that were already known and simultaneously searched for those that had not yet been identified but which might have been of value to the review.

The reviewers were unable to give a fixed definition of “hard-to-reach” until they had reviewed the evidence and the search filter coped with this inherent fluidity. The definition of “hard-to-reach” became much more robust in the final review because it emerged from the evidence and the reviewers were not forced to list explicitly the populations that were, and were not, includable at the beginning of the project.

The filter facilitated this fluidity because it adopted a multi-stranded approach that incorporated themes and situations associated with lifestyle and culture (e.g. poverty), rather than conceptualising population merely as the names for specific groups of people (e.g. homeless people). Excluding themes such as poor quality housing (not being a population but being a risk factor for tuberculosis) would have weakened the semantic nature of the search and missed those populations of interest that had not yet been identified.

The reduction in the screening workload (which we have estimated to be up to 35 days) allowed time for further grey-literature searching and screening. Booth (2010) has suggested that searchers should conduct a preliminary mapping of a field, target their resources on the productive areas and make full use of non-database techniques, such as citation searching and snowballing (26). The search filter meant that the reviewers did not have to spend time sifting through 5455 MEDLINE search results, which, we have subsequently proven, did not contain any additional at-risk groups.

The time saved on screening MEDLINE results was available for other activities, such as contacting experts, which had a noticeable impact on the final review. The review (2) included 25 studies: 19 of these were journal articles, with 18 identified by MEDLINE and one by CINAHL. The remaining six studies were reports, a thesis and other pieces of grey literature that were not indexed on the bibliographic databases most often used in reviews. The time saved on MEDLINE searching was invested in other techniques, which in turn retrieved around a quarter of the studies included in the review. The need for optimal searching approaches is particularly important in topics where the range of databases and potential sources to be considered is much wider than those traditionally used in systematic reviews (8).

### **3.2 Limitations**

The retrospective case-study presented here has only considered the MEDLINE results and a fuller analysis would require unfiltered searches on all 16 of the other databases used in the review. No

funding was available to screen the 17700 papers this could have required. It is unlikely that a wider study would reach different conclusions given that MEDLINE retrieved 18 of the 19 journal articles included in the review. MEDLINE was felt to be a sufficiently robust benchmark to judge the impact of the filter.

Search filters should not be unquestioningly copied from one review to another, as they need to be suitable to the specific research questions being asked. The search filter discussed here was designed for the OVID interface to MEDLINE and it would require some amendments before being used in other interfaces, as search results have been shown to differ according to the database provider (27). The filter was deliberately constructed for English language databases and there is, naturally, the potential to explore terms in other languages. The review focussed on evidence relevant to producing guidance for England, as required by the NICE public health methods manual (4), and so articles on Hispanic Americans and aboriginal Canadians were excluded (28, 29), which suggests that the filter would have to be reviewed to check its appropriateness to the culture or country under investigation. The search filter should also be cross-checked against the epidemiology and other risk factors when applied in other disease areas, for example reviews on barriers to HIV or hepatitis testing would benefit from the filter but they might emphasise different aspects of lifestyle and culture.

This search filter will need to be reviewed over time, as new terminology is developed in the literature, MeSH headings are constantly under review and search interfaces change.

#### **4. Conclusion**

The retrospective analysis has shown that the decision to design a search filter was justified on the basis that it saw a 64% reduction in the number of MEDLINE results for screening, without any impact on the conclusions of the review. The time saved on screening had a demonstrable impact on the quality of the review, as it freed time to explore other sources of evidence and resulted in other literature being captured.

This study has demonstrated that it is possible to search for undefined and unknown populations. A search was constructed for “hard-to-reach” populations without knowing which groups were actually captured by that definition. The search approach enabled the definition of relevancy to emerge from the evidence, rather than demanding an *a priori* definition. The multi-stranded search approach combining named populations, settings and themes is recommended for uncovering any hidden or undefined populations.

The specific filter is offered and tested for populations relating to tuberculosis and its value is transferable to associated disease areas (such as blood-borne infections) where hard-to-reach populations are of interest.

## Abbreviations

MeSH Medical Subject Headings

NICE National Institute for Health and Care Excellence (formerly the National Institute for Health and Clinical Excellence), UK.

RCT Randomised controlled trial

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