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Advancing the science of health research capacity strengthening in low- and middle-income countries: A scoping review of the published literature, 2000-2016.

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Abstract

Objectives: Substantial development assistance and research funding are invested in health research capacity strengthening (HRCS) interventions in low- and middle-income countries, yet the effectiveness, impact and value for money of these investments are not well understood. A major constraint to evidence-informed HRCS intervention has been the disparate nature of the research effort to date. This review aims to map and critically analyse the existing HRCS effort to better understand the level, type, cohesion and conceptual sophistication of the current evidence base. The overall goal of this paper is to advance the development of a unified, implementation-focused HRCS science.

Methods: We utilised a scoping review methodology to identify peer-reviewed HRCS literature within the following databases: PubMed, Global Health, and Scopus. HRCS publications available in English between the period 2000-2016 were included. 1195 articles were retrieved of which 172 met the final inclusion criteria. A-priori thematic analysis of all included articles was completed. Content analysis of identified HRCS definitions was conducted.

Results: The number of HRCS publications increased exponentially between 2000 and 2016. Most publications during this period were perspective, opinion or commentary pieces; however, original research publications were the primary publication type since 2013. Twenty-five different definitions of research capacity strengthening were identified, of which three aligned with current HRCS guidelines.

Conclusions: The review findings indicate a HRCS research field with a focus on implementation science is emerging, although the conceptual and empirical bases are not yet sufficiently advanced to effectively inform HRCS programme planning. Consolidating a HRCS implementation science therefore presents as a viable option that may accelerate the development of a useful evidence-base to inform HRCS programme planning. Identifying an agreed operational definition of HRCS,

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3 standardising HRCS-related terminology, developing a needs-based HRCS-specific research agenda
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5 and synthesising currently available evidence may be useful first steps.
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9 **Strengths and Limitations of the Study**

- 11 • This scoping review brings together various studies and reviews focused on HRCS to provide
12 the impetus and direction for a dedicated HRCS implementation science to emerge and to
13 foster a common identity for HRCS researchers.
14
- 15 • This review critically analysed current definitions of HRCS to contribute toward the
16 identification of a consolidated, evidence based, operational definition of HRCS on which
17 future HRCS interventions and evaluations can be based.
18
- 19 • Some articles published in non-Anglophone journals, in non-health related journals, or in a
20 lexicon outside of the key word terms employed herein would not have been retrieved by
21 the search methodology.
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- 23 • Relevant work that remains unpublished, published outside of academic peer-reviewed
24 journals or published prior to 2000 would also have been omitted.
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- 26 • The review did not critically examine the quality of the research effort (in original research
27 publications) or analyse the output (findings) of the collective research effort.
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Introduction

Health research capacity in many low- and middle-income countries (LMICs) is poor¹⁻⁴, undermining LMIC ability to identify and respond to local health needs or to equitably participate in the international response to global health challenges. Numerous health research capacity strengthening (HRCS) interventions have been employed in LMICs ranging from simple training programmes to currently advocated 'systems' approaches that focus on developing the capacity of individual researchers, research institutions and the wider research environment⁵⁻⁷. The international research community has a dual role in LMIC HRCS. The first role is that of a HRCS *implementer* and centres on the transfer of expertise in specialist subject areas pertinent to LMIC health research priorities, typically from higher- to lower-capacitated individuals or organisations and may be facilitated through such mechanisms as scholarship schemes, technical assistance, research networks or research consortia. The second role is that of an HRCS *scientist* and centres on the creation of robust theory and evidence to inform optimal HRCS interventions. Here, the researcher is not an expert in the subject matter of a specific HRCS intervention (e.g. increasing capacity in operational research to support national malaria control programmes), but is concerned with providing the evidence-base to inform HRCS funders and implementing partners how their respective programme goals may best be achieved (e.g. what investments would produce the greatest, most sustainable gain in operational research capacity to support a national malaria control programme).

The extent to which the research community is fulfilling this latter role (i.e. HRCS scientist), as compared to the former role (i.e. HRCS implementer), is questionable at present. A recent paper described the existing HRCS evidence-base as 'confusing, controversial and poorly defined'⁸ despite a long recognised need to support HRCS in LMICs⁹. Fundamental questions remain largely unanswered such as; how to reliably assess existing capacities at different levels of a health research

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3 system; which interventions facilitate sustainable capacity gains in which circumstances; and which
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5 capacity term (building, strengthening or development) is the most nuanced and appropriate to
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7 reflect developmental discourse and baseline capacities¹⁰. The international research community is
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9 therefore in the awkward position of being a highly active participant in the transfer of scientific
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11 theory and method within the context of subject-specific HRCS interventions, yet largely inactive in
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13 rigorously applying scientific theory and method to the HRCS process.
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18 The paucity of evidence available to inform HRCS implementation reflects, in part, the difficulties in
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20 measuring an inherently multi-faceted, long-term, continuous process (i.e. HRCS) subject to a
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22 diverse range of influences and assumptions. A greater constraint has been the sparse and disparate
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24 nature of the HRCS-related research effort to date. HRCS-related research has involved multiple
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26 academic disciplines, employing diverse frameworks, concepts, methods and terminologies, working
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28 in isolation and publishing in different fields (e.g. medical education, communication, operational
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30 research and evaluation). A dedicated, multi-disciplinary, implementation-focused research
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32 approach is undoubtedly required to improve the effectiveness, impact and value for money of
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34 current and future HRCS implementation activities in LMICs. However, there is little evidence of a
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36 unified HRCS implementation science emerging to date.
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42 The overall goal of this paper is to advance the development of a unified, implementation-focused
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44 HRCS science. To achieve this goal, a scoping review of HRCS-related publications for the period
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46 2000-2016 was conducted and operational definitions of HRCS within this literature critically
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48 examined. The review findings are not presented as a definitive account of HRCS activity across this
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50 period as relevant material may be unpublished, may be found in the grey literature or may be
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52 published in a lexicon outside of the search terms employed herein. The review is better understood
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54 as an attempt to critically analyse the collective HRCS effort regarding the level, type, cohesion and
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56 conceptual sophistication of the current evidence base. The review may be considered an initial
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3 attempt to map the HRCS research effort, providing the impetus and direction for a dedicated HRCS
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5 implementation science to emerge and fostering a common identity for HRCS researchers.
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9 10 **Methods**

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15 This review was conducted according to stages 1-5 of the advanced 'scoping' methodology proposed
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17 by Levac et al ¹¹, based on the original framework of Arksey and O'Malley ¹². A scoping review was
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19 considered appropriate given the primary focus was on examining the extent, range and nature of
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21 an emerging peer-reviewed literature. The critical examination of operational definitions of HRCS
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23 falls outside of the 'scoping review' approach, yet is included as a means of 'revealing' (in part) the
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25 conceptual sophistication and cohesion of the reviewed literature.
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30 31 **Identification of Data Sources**

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36 The first two steps of the scoping review method include identifying a research question and
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38 relevant studies. To explore the breadth, concepts, definitions and methods currently prioritised in
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40 the HRCSpeer-reviewed literature, we searched for empirical and theoretical publications within the
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42 following databases: PubMed, Global Health, and Scopus. Search terms used were: ("capacity
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44 strengthening", OR "capacity development", OR "capacity building") combined with ("global health"
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46 OR, "international health" OR, "global public health", OR "health research" OR, "health
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48 development"). Additional search criteria included: papers published between 01/01/2000 and
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50 31/12/2016 and both abstract and full paper available in English. Searches began from the year 2000
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52 as a reflection of the stepwise change in the profile and investment in HRCS. Results were stored
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54 within an EndNote library.
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Selection of Data Sources

Study selection (step 3) was an iterative process in which selected abstracts and full texts were initially reviewed to identify and agree upon inclusion criteria, which were then subsequently 'tested' and refined through further review. All article titles, abstracts and key words were reviewed against the final inclusion criteria (Figure 1). Publications that met these criteria following abstract review were then subjected to a more intensive full text review. Publications in which a conclusive inclusion/exclusion decision could not be made on the basis of abstract review were also included for full text review. SG and JP independently screened publications included for full text review with LD providing a third review to determine inclusion/exclusion status in cases of disagreement.

Figure 1. Summary of search and selection process

Data Charting and Analysis

The variables extracted from each publication included in the final review were determined by an iterative 'data charting' process (step 4) SG & JP independently reviewed a selection of publications and identified potential variables to extract. Target variables were then agreed by consensus opinion. Target variables included publication 'typologies' (Box 1) and the wide range of programme-, author- and research-type data listed in Tables 1, 2 and S1-S7. Research quality was not formally assessed; however, some aspects such as study design, methods and analysis were considered where appropriate., Data extraction was conducted independently by at least two reviewers, with the third providing a deciding opinion in cases of disagreement. Following data extraction, each member of the review team was assigned a sub-set of publications for subsequent summary analysis (step 5). Final analysis and reporting of all data were agreed by mutual consent.

Box 1. HRCS Publication Typologies

Original Research: Publications in which a) a hypothesis, research question or study purpose was stated; b) research methods described; c) results reported; and d) the results and their possible implications discussed.

Perspectives, Opinion or Commentary: Publications expressing the authors' viewpoint on some aspect of HRCS based on anecdotal evidence, personal experience and/or (in a very few cases) original data that were not presented in an 'original research' format (i.e. did not include a formal description of the research aims, methods, results and discussion).

Systematic Review: Publications in which a) research objectives/questions were clearly stated; b) explicit and systematic methods were used; c) methods were limited to the systematic identification and analysis of some form of literature; and d) results were reported and discussed. Non-systematic reviews were included within the original research section.

During in-depth analysis of each publication any operational definition of (health) research capacity strengthening was extracted and analysed for content. To identify commonalities, definition content was independently coded by JP and SG per the a-priori content criteria identified in Table 3. Coding disagreements were resolved by the same process described above. A content score, defined as the number of domains (out of 10) present, was calculated for each definition to identify the most inclusive working definition of HRCS within the current evidence base.

Results

1195 papers were retrieved via the search methodology of which 172 (see S8 Table) met the final inclusion criteria. The number of HRCS publications identified increased over time, from 0 in the year 2000 to a maximum of 32 in 2016 (Fig 2).

Fig 2. Number of publications per year by publication type.

HRCS Publication Typologies

Overall, 51% of publications presented a perspective, opinion or commentary, 46% original research and 3% findings from a systematic review (Table 1). The first and/or last author was from an institute located in an LMIC in 58% of publications, 'capacity building' was the favoured term in 59% and 19% presented an operational definition of HRCS.

Table 1. Selected characteristics of reviewed publications

Publication Type	No.	LMIC Authorship ¹			Capacity Term ²				Defined HRCS ³
		First	Last	Either	CB	CD	CS	Oth.	
Original Research	79	31	32	41	38	18	24	0	17
Pers. Opin. Commentary	88	36	42	56	63	6	19	0	16
Systematic Review	5	3	1	3	1	1	2	0	0
Total	172	70	75	100	102	25	45	0	33

1 Based on location of listed organisational affiliation of first and last authors; 'either' = either first or last. 2

capacity term used in title and then keywords given priority. (CB=capacity building, CD=capacity development,

CS=capacity strengthening, Oth.=other). 3 Number of papers that provided an operational definition of HRCS.

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6 **Original Research**
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Original Research

The 79 publications that met 'original research' criteria were sub-categorised into research typologies including: learning and evaluation (from research initiatives), capacity assessment, HRCS methods for implementation, evidence synthesis for HRCS implementation and evaluation, and miscellaneous. Table 2 presents selected methodological characteristics of the original research publications both overall and by sub-category. Additional data, not all of which are described below, are included in S1-S7 Tables.

26 **Table 2. Selected methodological characteristics of original research publications**

Sub-Category	No.	Setting ¹							Design ²				Data Collection ^{3,4}				Data Analysis ^{4,5}		
		Af	Am	Se	Eu	Em	Wp	Gl	Quan	Qual	Mix	Sur	IDI	FGD	Rev	Oth	The	Des	Inf
Learning & Evaluation	36	14	1	4	0	1	4	14	8	9	19	20	18	5	16	10	28	18	1
Capacity Assessment	27	16	0	0	1	2	3	5	6	7	14	15	13	5	15	7	19	22	0
HRCS Methods	7	6	0	0	0	0	0	1	1	5	1	2	1	1	4	4	6	1	1
Evidence Synthesis	5	0	0	0	0	0	0	5	0	4	1	1	0	0	5	4	5	0	0
Miscellaneous	4	2	0	0	0	0	0	2	0	2	2	2	3	0	2	1	4	0	0
Total	79	38	1	4	1	3	7	27	15	27	37	40	35	11	42	26	62	41	2

27 1. WHO region where the study was located: African (Af), Americas (Am), South-East Asia (Se), European (Eu), Eastern Mediterranean (Em), Western Pacific (Wp) or Global
 28 (Gl)(defined as 3 or more WHO regions). 2. Quantitative (Quan.), qualitative (Qual.) or mixed methods (Mix.). 3. Survey (Sur.), in-depth interview (IDI), focus group
 29 discussion (FGD), literature/document review (Rev.) or other methodology (Other). 4. Categories are not mutually exclusive. 5. Thematic (Them.), descriptive (Desc.) or
 30 inferential (Infer.).

35 Learning & evaluation

36 This category included 36 publications that presented findings from a formal evaluation of an HRCS
37 initiative or described 'learnings' obtained from HRCS implementation (Table 2 and S1 Table). Sixty-
38 four percent were 'education' based HRCS programmes in which some form of training (inclusive of
39 postgraduate awards) was provided to strengthen individual capacity and, in some cases, was
40 inclusive of the development and transfer of a course curriculum at an institutional level e.g. ¹³.
41 Other HRCS programme types included collaborative research (n=12), time-limited work placement
42 (n=2), strengthening the broader health research system (n=2), infrastructure development (n=1) or
43 strengthening financial management (n=1). The respective HRCS programmes involved North-South
44 collaboration in 83% of cases. Seventy-five percent of programmes sought to strengthen research
45 capacity in a specific subject area, most commonly health systems (n=6).

47 Box 2. Learning and Evaluation Typologies

48 **Lessons Learned:** publications focused on broad, programme(s)-level experiences in setting up
49 and/or participating in an HRCS initiative and/or providing a largely qualitative account of
50 programme achievements.

51 **Programme Outputs:** publications focused on HRCS programme outputs, where outputs were
52 defined as a quantification of activities that occurred during the programme and/or related
53 professional activities that occurred after the programme (e.g. no. of publications).

54 **Programme Outcomes:** publications that focused on improvements in individual-, institutional- or
55 environmental-level health research capacity following an HRCS initiative and employed quantitative
56 measures designed to attribute improved performance to the respective HRCS intervention.

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58 The objective of each 'learning and/or evaluation' publication was coded per the typologies
59 presented in Box 2. Overall, 67% of the learning and evaluation publications were given a single code
60 and 33% were given 2 or more codes. 'Lessons learned' was allocated to 44% of publications,

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3 61 'programme outputs' to 33%, 'programme outcomes' to 28% and unique codes were allocated to
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5 62 33%. Quantitative outcome indicators varied among publications that employed them, although
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7 63 were generally: variants of some form of citation analysis to measure influence of research
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9 64 publication (that followed the HRCS intervention) on health policy ¹⁴⁻¹⁶; measures of knowledge
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11 65 change pre- and post-HRCS intervention or knowledge gained from an intervention ¹⁷⁻²⁰; some form
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13 66 of 'attributional' measure designed to assess the relationship between capacity improvement and
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15 67 the respective HRCS intervention ^{17 18 21 22}.

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20 69 Sixty-four percent of studies were retrospective, 64% were a type of (quasi-) formative evaluation,
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22 70 53% were mixed methods and 17% were authored by individuals independent of the organisation
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24 71 implementing the respective HRCS initiative (study design data not presented in Table 2 are shown
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26 72 in S1 Table). Sampling was primarily purposive (n=20).

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74 **Capacity Assessment**

75 This category included 27 original research publications that presented the outcome of some form of
76 health research capacity assessment (Table 2 and S2 Table). Capacity assessment focus varied; the
77 largest proportion (9/27) focused on assessing capacity to carry out research, often in a specific
78 subject area (18/27), most commonly health policy and systems research (6/27).

79 Capacity assessments were conducted within the context of a research institution(s), including
80 universities or research network in 59% of publications. Eleven percent focussed on the capacities of
81 ethics committees and one involved health care providers. The remaining 26% focused on national
82 and/or regional capacity in specific research and/or geographical areas through reviewing literature
83 and publication trends.

84 Thirty-seven percent (10/27) of capacity assessments were conducted as part of a consortium based
85 research programme, consisting of European and African partners.

86 **HRCS methods for implementation**

87 This category includes 7 articles that present a methodological approach to HRCS or evaluation of
88 HRCS (S3 Table). Two articles focus on HRCS within the frame of North-South partnerships and 4
89 prioritised general HRCS, often embedded in a specific subject area e.g. policy analysis. The
90 remaining article focused on the development and validation of a questionnaire for evaluation of
91 HRCS training activities.

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93 The numbers of steps in methodological approach varied; however, consistent phasing or process
94 can be identified. In all publications, the purpose of the HRCS activity was initially established
95 although this was only stated as an explicit methodological step in one paper²³. Three articles then
96 developed bespoke 'optimal health research' criteria or 'ideal partnership capacity' criteria through
97 a combination of literature searches and interactions with key stakeholders. The remaining 4
98 publications adapted an existing tool or framework that could be used as a common ideal for health
99 research or partnership capacity. Once developed, 3 papers described these measures as
100 'standardised'. The remaining 4 papers described these measures as 'semi-standardised' to allow for
101 flexibility in context. Two papers described this flexibility in approach as linked to theory of change
102 or quality assurance (QA) cycle methodology.

103
104 Papers then presented the methods used to conduct the capacity assessment. One described a fixed
105 point of quantitative measurement, and six described a phased or developmental approach to
106 identification of both health research capacity strengths and weaknesses, anticipating that as HRCS
107 methods were implemented, weaknesses may be identified and certain areas strengthened. One
108 partnership focused paper described this developmental approach to ensure equity within
109 partnership development. Two papers described assessments that were solely 'self-assessments'
110 (i.e. relied solely on internal institution staff). Four papers described assessments that involved
111 collaborative assessments between partners inside (usually LMIC) and outside (usually high income

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3 112 country (HIC) the institution. Four of the papers that took a developmental approach described the
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5 113 end of this process as the collaborative development of continuously evolving capacity
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7 114 strengthening plans which HRCS activities should be implemented against.
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11 116 **Evidence synthesis for HRCS implementation and evaluation**

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14 117 This category included 5 articles that focused on the synthesis of evidence to enhance learning for
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16 118 the implementation or evaluation of HRCS programmes (S4 Table). Four articles concentrated on
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18 119 understanding multi-programme experience to harmonise learning for HRCS evaluation. All 4 of
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20 120 these articles focus on the experience of funders of HRCS activities, with 3 extending their
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22 121 exploration to the views of HRCS experts, evaluators and/or implementers. The fifth article focused
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24 122 on understanding multi-programme experience to aid in more effective HRCS programme design
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26 123 and implementation for nurses. All articles had a global focus, with four prioritising LMICs.
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31 125 The nuanced nature of each article in this category made identification of core typologies
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33 126 challenging. The 4 articles focused on evidence harmonisation for HRCS²⁴⁻²⁷, argued that evaluations
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35 127 should be underpinned by theory, using logic or theory of change models. However, 3 articles
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37 128 reflected that these models are rarely employed in practice due to time constraints on the
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39 129 evaluation process^{24 25 27}. Furthermore, where potential frameworks for evaluation do exist, 2
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41 130 articles described these as being driven by the goal of the funder with limited stakeholder
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43 131 engagement^{26 27}. Two articles linked lack of stakeholder engagement in evaluation design to issues
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45 132 of equity^{24 26}, arguing that for HRCS activities to be equitable, members of the most marginalised
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47 133 populations should be involved in evaluation design and indicators should reflect equity issues.
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52 135 **Miscellaneous**

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3 136 Four original research articles could not be assigned to any sub-category (Table 2 and S5 Table). The
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5 137 first publication was a qualitative cross sectional study that investigated the challenges and benefits
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7 138 of research capacity strengthening through North-South research partnerships from a Ugandan
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9 139 perspective. The second publication was a qualitative case study of health research commissioning
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11 140 among different organisations in East Africa. The third, investigated researchers' (involved in
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13 141 collaborative networks across LMICs) experiences regarding science and ethics in global health
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15 142 research collaborations. The fourth publication discussed different experiences of mentoring health
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17 143 researchers across HICs and LMICs, as effective mentorship of researchers is crucial for research
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19 144 capacity strengthening.
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146 **Perspectives, Opinion or Commentary**

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29 148 The 88 'perspective' publications were coded based on the primary subject matter. Codes included
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31 149 the three previously described in Box 2 and the additional codes 'programme description' and
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33 150 'recommendations'. Publications were coded 'programme description' if they presented a
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35 151 description of a specific HRCS programme or activity. Publications were coded 'recommendations' if
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37 152 a primary purpose of the publication was to describe steps, processes, approaches and/or activities
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39 153 that, per the authors' views and experiences, would enhance capacity strengthening initiatives.
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41 154 There is significant overlap between the categories 'lessons learned' and 'recommendations'. The
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43 155 key point of difference is that the lessons or recommendations presented in publications coded
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45 156 'recommendations' are largely based on broad experience or reading of the literature rather than
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47 157 reference to a specific HRCS programme or programme type (in which case they would be coded
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49 158 'lessons learned').
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56 160 Overall, 73% of the perspective, opinion or commentary publications were given a single 'focus' code
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58 161 and 27% were given 2 or more codes. 'Lessons learned' was allocated to 49% of publications,
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3 162 'programme description' to 26%, 'recommendations' to 25%, 'programme outputs' to 19%,
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5 163 'programme outcomes' to 2% and unique codes were allocated to 8%. The quantitative outcome
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7 164 indicators included a measure of knowledge change pre- and post-HRCS intervention ²⁸ and an
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9 165 'attributional' measure designed to assess the relationship between capacity improvement and the
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11 166 respective HRCS intervention ²⁹.

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16 168 The content of the various perspective, opinion or commentary publications was derived from HRCS
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18 169 experience in 76% of publications, although in the majority commentary pertained to experience
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20 170 from a single HRCS programme (59/67). Content was also drawn from reviews of HRCS-related
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22 171 literature or documentation (12/88), HRCS-related workshops (5/88) and in 8 cases the basis of the
23
24 172 commentary was not stated. The HRCS programme or activity types varied widely, ranging from a
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26 173 broad emphasis on HRCS in LMICs to specific aspects of HRCS in specified countries.

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30 31 175 **Systematic Review**

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35 176 Five publications fitted this category (S7 Table). Two publications reviewed tools and approaches to
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37 177 assess capacity needs and monitor and evaluate capacity strengthening activities ^{30 31}. Three
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39 178 publications did not focus on specific HRCS activities, but used bibliometric and scientometric
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41 179 techniques to investigate health research capacity in specific subject areas focussing on publication
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43 180 trends, author affiliations, geographical areas of the study, study design and thematic focus ³²⁻³⁴.

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47 181 Two publications searched a single database, 2 searched 2 and 1 searched 3. Four publications
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49 182 searched PubMed as the main database. Four publications followed a single systematic search
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51 183 strategy, whereas 1 employed a systematic search and snowball-sampling to identify publications
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53 184 after considering inclusion and exclusion criteria. The number of papers included in each review
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55 185 varied from 14–690.

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188 **HRCS Definitions**

189 Nineteen percent (33/172) of publications presented an operational definition of 'capacity' (S9
190 Table). The definition specifically pertained to 'health research capacity' in 7 publications; in the
191 remaining publications' broader definitions of 'research capacity' (n=10), 'capacity' (n=6) or
192 'organisational capacity' (n=1) were presented and in 2 publications capacity was operationally
193 defined as 'progress'. Twenty-five separate definitions were presented of which 9 were original
194 (Table 3). Seven of the 25 definitions were cited by 2 (n=4), 3 (n=2) or 4 (n=1) publications. In all
195 other cases the definition was presented in a single publication. Three publications presented 2
196 definitions.

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198 Thirty-six percent of the definitions included explicit reference to all 3 levels of capacity
199 strengthening, 12% included explicit reference to all 3 aspects of the research process (defining
200 research questions, conducting research and communicating/applying research outcomes) and 28%
201 included explicit reference to at least 2 of the 4 'other' content domains assessed, the most common
202 of which included reference to HRCS as improving research quality or ability (n=11) or HRCS as a
203 process (n=9) (Table 3). Out of the 10 content domains assessed, the median number present across
204 all definitions was 4 (range 2-9). Variation in median 'content' score was evident across the
205 definition types: the median score for 'health research capacity' definitions was 3 (range 2-6), 5
206 (range 2-9) for 'research capacity' definitions, 4 (range 3-5) for 'capacity' definitions and 2 (range 2)
207 for the 'organisational capacity' and 'progress' definitions.

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212 Table 3. Content analysis of ‘capacity’ definitions¹

Subject Defined	Capacity Term	Content Domains ²									
		Ind.	Ins.	Env.	Def.	Car.	App.	Qua	Sus.	Pro.	Con
Health Research Capacity	Building [30], Strengthening [70]	x	x	x		x	x		x		
	Building [166], Strengthening [74, 126]		x		x	x				x	
	Strengthening [123]			x				x			
	Development [45]		x					x		x	
	Strengthening [48]					x	x				
	Building [139]	x	x					x		x	
	Building [97]	x	x					x			
Research Capacity	Building [164], Strengthening [29, 123, 159]	x	x	x	x	x	x			x	x
	Strengthening [16, 72]	x	x			x		x		x	
	Development [4], Strengthening [31, 74]	x	x	x	x	x	x	x	x	x	
	Building [132]					x	x				
	Building [91, 96]	x	x			x	x	x			
	Building [130]	x	x	x						x	x
	Strengthening [165]	x	x			x		x			

	Building [46]	x	x	x	x	x	x	x
	Strengthening [79]	x	x	x				
	Building [166]	x				x		x
Capacity	Building [25]	x	x	x				x
	Building [133]		x	x			x	x
	Strengthening [66]	x	x	x				x
	Strengthening [65]	x	x	x			x	x
	Building [150]		x	x				x
	Strengthening [47]	x				x		x
Organisational Capacity	Development [27]		x					x
Progress	Building [142], Development[143]					x	x	

1. Numbered citations pertain to the reference list in S8 Table. 2. The content of each definition was independently coded according to the following criteria: explicit reference to individual (ind.), institutional (Ins.) or environmental (Env.) level capacity strengthening; explicit reference to strengthening capacity in terms of defining research questions or identifying research priorities (Def.), conducting research or applying research methods (Car.) or communicating and applying research outcomes (App.); explicit reference to facilitating an improvement in research abilities/quality (Qua.) sustainability (Sus.), reference to HRCS as a process (Pro.) and/or HRCS as a continuous activity (Con.).

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3 220 Variation between a capacity definition and favoured capacity 'term' (i.e. building, strengthening or
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5 221 development) was evident where a definition had been cited by more than 1 paper. For example,
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7 222 "an ability of individuals, organisations or systems to perform and utilise health research effectively,
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9 223 efficiently and sustainably"³⁵ was variously presented as a definition of health research capacity
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11 224 'strengthening'³⁵ and health research capacity 'building'¹⁶.

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16 226 An additional content analysis was conducted to examine the possible relationship between
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18 227 favoured capacity term and choice of capacity definition (S10 Table). Of the definitions used in the
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20 228 14 publications that favoured the term 'capacity building', the median content score was 4 (range 2-
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22 229 8), 36% (5/14) included a specific reference to all 3 levels of capacity strengthening, 14% (2/14)
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24 230 included explicit reference to all 3 aspects of the research process and 21% (3/14) included explicit
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26 231 reference to at least 2 of the 4 'other' content domains assessed. Comparative results for the 12
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28 232 publications that favoured the term 'capacity strengthening' were: 4 (2-9), 50% (6/12), 17% (2/12)
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30 233 and 33% (4/12) and 2.5 (range 2-9), 25% (1/4), 25% (1/4), 25% (1/4) for the 4 publications that
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32 234 favoured the term 'capacity development'.

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236 Discussion

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238 The purpose of this scoping review was to map the current HRCS research effort since the year 2000
239 and to critically examine how HRCS has been defined within the peer-reviewed literature. With
240 regards to the level and type of HRCS-related publication, the study revealed that the number of
241 HRCS publications has increased exponentially between 2000 and 2016. Most publications during
242 this period have been perspective, opinion or commentary pieces. Publications presenting original
243 research findings also increased over this period and have been the primary publication type since
244 2013, indicating an emerging field of predominantly implementation-focused HRCS science. Almost

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3 245 half of the original research papers pertained to the African region as did a large proportion of
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5 246 commentary papers (S6 Table). An Afrocentric evidence base may reflect current HRCS funding
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7 247 priorities³⁶ and need; however, such Afrocentrism renders it difficult to generalise the collective
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9 248 findings to LMIC settings in other geographical regions.

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13 250 The findings and recommendations presented in this paper should be considered alongside
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15 251 limitations in the review methodology. HRCS research, reviews and commentaries published in non-
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17 252 Anglophone journals, in non-health related journals or in a lexicon outside of the key word terms
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19 253 employed herein would not have been retrieved by the search methodology. Relevant work that
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21 254 remains unpublished, published outside of academic peer-reviewed journals or published prior to
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23 255 2000 would also have been omitted. Thus, the reported findings should not be considered a
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25 256 comprehensive representation of the existing literature pertaining to HRCS in LMICs. The analysis of
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27 257 retrieved publications was limited to identifying the typologies within, and key characteristics of, the
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29 258 collective peer-reviewed literature as well as the frequency and type of operational HRCS definitions.
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31 259 The review did not critically examine the quality of the research effort (in original research
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33 260 publications) or analyse the output (findings) of the collective research effort. These tasks were
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35 261 outside the scope of this review, but warrant future attention to inform a fuller assessment of the
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37 262 'value' of published HRCS research. All authors on this publication have considerable experience
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39 263 working in and/or with health research institutions in LMICs. However, all authors originate from,
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41 264 were educated in and are currently based in a high-income country context. Interpretation of the
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43 265 reported findings may reflect this reality.

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47 267 Our findings suggest conceptual representations of HRCS within the published literature are
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49 268 inconsistent and infrequently applied. Capacity was rarely defined across the publications and the
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51 269 definitions that were presented varied widely in content and scope. Broader definitions of 'research
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53 270 capacity' or 'capacity', rather than specific 'health research capacity' definitions, were most

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3 271 commonly employed and no 'one' specific definition of health research capacity was consistently
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5 272 applied. There appeared to be no relationship between a favoured capacity term, such as 'building'
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7 273 or 'strengthening', and the type of capacity definition used or the content of that definition. There
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9 274 was no apparent difference between operational definitions of (health) research capacity building,
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11 275 strengthening or development even though distinctions between these terms and the concepts they
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13 276 represent have previously been drawn ^{8 10 37}. The content analysis identified a divide between many
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15 277 of the capacity definitions presented and current conceptualisations of a multi-level 'systems'
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17 278 approach to HRCS ^{5 6}. For example, only 36% of the proffered definitions made explicit reference to
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19 279 individual, institutional and environmental level capacity strengthening and only 12% explicitly
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21 280 applied the definition to all stages of the research process from conception to subsequent uptake.
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29 282 There was little sign of cohesion or 'connectedness' across the HRCS-related peer-reviewed
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31 283 literature. Greater use of theory of change or logic models in HRCS programme and evaluation
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33 284 design was advocated ³¹⁻³⁴ and evident among the sub-set of articles focusing on HRCS methods for
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35 285 implementation ^{27 28 30 32}. However, systematic reviews or syntheses of available evidence were
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37 286 uncommon, despite the relatively narrow focus of the collective literature, and the available
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39 287 conceptual models and methodologies were rarely applied in practice. For example, learning and
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41 288 evaluation studies were typically retrospective and capacity assessments limited to a single 'fixed'
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43 289 time point, in contrast to the prospective, phased approaches deemed necessary to advance our
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45 290 understanding of what works well in HRCS implementation ^{28 32}. Furthermore, while multi-level,
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47 291 systems wide HRCS interventions are increasingly advocated ⁵⁻⁷, learning and evaluation studies
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49 292 commonly centred on individual-level education-based activities. This may reflect intervention or
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51 293 evaluation design, but either way highlights the absence of a widely accepted overarching (H)RCS
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53 294 framework to promote prevailing theories and concepts or to link the increasingly active HRCS
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55 295 research community.

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3 297 Collectively, findings suggest the existing (published) evidence-base is not yet sufficiently developed
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5 298 to reliably inform HRCS interventions in LMICs. The disjointed research effort is exacerbated by the
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7 299 absence of a recognisable HRCS research 'field' and the lack of a defined, needs-based HRCS-specific
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9 300 research agenda. Published research primarily consists of anecdotal, qualitative or descriptive
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11 301 accounts of single interventions not readily generalizable across different types of HRCS or to regions
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13 302 outside of Africa. While research quality was not formally assessed in the context of this review, the
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15 303 body of evidence needs further development when considered against relevant standards such as
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17 304 the Medical Research Council's guidance for developing and evaluating complex interventions³⁸ or
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19 305 against common hierarchies of evidence³⁹, inclusive of hierarchies specifically for assessing
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21 306 qualitative health research⁴⁰. Good research practice would further suggest that no new 'learning'
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23 307 studies should be completed without first reviewing the existing evidence of 'what works' or 'lessons
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25 308 learned' from previous investments or interventions⁴¹.

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31 310 Three comprehensive definitions that explicitly align with current HRCS guidelines were evident
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33 311 across the reviewed publications, although all three pertain to the broader notion of 'research
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35 312 capacity' strengthening. These included: "the ongoing process of empowering individuals,
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37 313 institutions, organisations, and nations to: define and prioritise problems systematically; develop
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39 314 and scientifically evaluate appropriate solutions; and share and apply the knowledge generated"⁴²;
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41 315 "the process by which individuals, organisations, and societies develop abilities (individually and
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43 316 collectively) to perform functions effectively, efficiently and in a sustainable manner to define
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45 317 problems, set objectives and priorities, build sustainable institutions and bring solutions to key
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47 318 national problems"⁴³; and "strengthening the abilities of individuals, institutions, and countries to
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49 319 perform research functions, defining national problems and priorities, solving national problems,
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51 320 utilizing the results of research in policy making and programme delivery"⁴⁴.

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3 322 In our opinion, the RCS definition presented by Lansang and Dennis ⁴² is the best among those
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5 323 presented in this review. This definition not only reflects current HRCS 'best practice' (i.e.
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7 324 encompasses all three levels of research capacity and spans the research process from conception to
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9 325 uptake) but also positions RCS as an 'ongoing process' and places few parameters on the focus of the
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11 326 research to be supported (beyond defining and prioritising 'problems' systematically). Alternative
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13 327 definitions, such as those provided by the Global Forum for Health Research ⁴³ or the United Nations
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15 328 Development Program ⁴⁴, limit the HRCS focus to '(key) national problems'. Whilst a focus on
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17 329 national problems is undoubtedly important, these definitions suggest restrictions on what types of
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19 330 research capacity should be strengthened. The more comprehensive, and more frequently used,
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21 331 'research capacity' definitions further raise the possibility that a health-specific RCS definition may
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23 332 not be needed. Arguably, a comprehensive, rather than sector-specific, RCS definition would
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25 333 suitably reflect contemporary HRCS approaches and illuminate the potential for health-specific RCS
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27 334 interventions to enhance capacity for all/additional (i.e. non-health) research areas within a target
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29 335 institution or environment (where applicable). Whilst discipline specific nuance may sometimes be
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31 336 required, promoting this kind of inter-sectoral, systems level thinking and discouraging vertical,
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33 337 parallel processes that can arise from topic-specific interventions, is increasingly advocated in the
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35 338 health sector ^{45 46} and is equally applicable in the context of a national research system.
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42 340 Determining a needs-based HRCS-specific research agenda would ideally involve input from
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44 341 influential HRCS funders, implementers and researchers from multiple disciplines. Technical working
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46 342 groups, specialist meetings and the creation of networking and resource sharing platforms would be
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48 343 required to establish and promote the research agenda and a common HRCS implementation
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50 344 science. Specialist meetings and HRCS research networks would also serve to raise the profile of
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52 345 HRCS science, increasing its standing and recognition as a legitimate field of scientific investigation
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54 346 and attracting greater involvement from the broader health research community. Funding to
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56 347 support these activities for strengthening research systems could be modelled on existing
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3 348 mechanisms operating for strengthening health systems, where it is recommended that global
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5 349 development partners involved in health systems strengthening dedicate 5-10% of programme funds
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7 350 to data collection, monitoring and evaluation and implementation research ⁴⁷. Without an agreed
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9 351 definition and understanding of HRCS, it is difficult to calculate annual investment in HRCS in LMICs,
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11 352 but the sum is likely to be substantial. For example, the United Kingdom's 'Global Challenges
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13 353 Research Fund' totals 1.5 billion pounds over a five-year period to support cutting edge research
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15 354 addressing challenges faced by developing countries, a significant proportion of which is allocated
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17 355 for strengthening capacity for research and innovation within LMICs
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19 356 (<http://www.rcuk.ac.uk/funding/gcrf/>). Thus, a 5% investment in (H)RCS implementation science
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21 357 could support a substantial research effort and rapidly accelerate learning about how to do HRCS
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23 358 more effectively.
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29 360 Crucially, given the aim of the HRCS research endeavour, ensuring equitable participation by LMIC
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31 361 partners in the development of an HRCS implementation science is essential. Metrics that better
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33 362 account for LMIC contribution may assist this. Despite promising findings, such as relatively high
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35 363 levels of LMIC authorship, questions can be raised as to what extent such indicators reliably reflect
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37 364 equitable contribution in HRCS implementation and research ⁴⁸. Relatively few studies examined
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39 365 North-South HRCS partnerships (a dominant form of HRCS implementation) from an exclusively
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41 366 southern perspective, or contrasted North-South models with South-South variants, suggesting an
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43 367 absence of critical reflection on the experiences and realities of those for whom HRCS interventions
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45 368 are intended. Such 'silencing' in intervention design and development should be rectified if
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47 369 ownership (an essential element of sustainability for HRCS interventions) ⁴⁹⁻⁵¹ is to be promoted.
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49 370 Conversely, it is widely acknowledged that equitable and effective partnerships should be of mutual
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51 371 benefit to all parties ⁵², yet benefits to the more strongly capacitated partners in HRCS
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53 372 implementation (e.g. those in HIC) were rarely discussed. Consideration of such issues will likely
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55 373 afford deeper insights into how power and politics influence equity in the design and development
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3 374 of HRCS theory and implementation, as well as allowing more rigorous examination as to which
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5 375 models of implementation provide the most equitable, efficient and sustainable gains for HRCS.
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10 11 12 378 **Conclusions & Recommendations**

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17 380 The review findings indicate a HRCS research field with a focus on implementation science is
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19 381 emerging, although the conceptual and empirical bases are not yet sufficiently advanced to
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21 382 effectively inform HRCS programme planning. The constituent parts for a coherent and conceptually
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23 383 driven research effort are present (if somewhat embryonic), but are not yet aligned under a
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25 384 recognisable 'HRCS implementation science' framework. Consolidating a HRCS implementation
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27 385 science therefore presents as a viable option that may accelerate the development of a useful
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29 386 evidence-base to inform HRCS programme planning. Identifying an agreed operational definition of
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31 387 HRCS, standardising HRCS-related terminology, developing a needs-based HRCS-specific research
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33 388 agenda and synthesising currently available evidence may be useful first steps. Crucially, given the
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35 389 aim of the HRCS research endeavour, ensuring equitable participation by LMIC partners in the
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37 390 development of an HRCS implementation science is essential. Advancing a dedicated HRCS
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39 391 implementation science will require specialist meetings (e.g. technical working groups, research
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41 392 priority setting forums) with representation from influential HRCS researchers, key LMIC partners,
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43 393 funders and implementers as well as the creation and maintenance of networking and resource
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45 394 sharing fora. The continued, substantial investment in HRCS in LMICs suggests apportioning a
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47 395 fraction of the various research and development budgets to support HRCS implementation science
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49 396 would represent a good 'buy'.
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7 540

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548 **Competing Interests**

549 We have read and understood BMJ policy on declaration of interests and declare that we have no
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551

552 **Authors Contributions**

553 LD, SG and JP were all involved in the search, screening and analysis of research articles. IB provided
554 technical oversight and expertise throughout the screening processes. All authors contributed to the
555 content, drafting, review and revisions to the manuscript.

556 **Data Sharing Statement**

557 Supplementary files as listed in the main manuscript are available to the reader. There is no other
558 unpublished data that links to this research.

559 **Supporting Information**

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3 560 **S1 Table. Supplementary and detailed data for 'learning and evaluation' original research publications.**
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5 561 **S2 Table. Supplementary and detailed data for 'assessments' original research publications**
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8 562 **S3 Table. Supplementary and detailed data for 'HRCS methods for implementation' original research**
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10 563 **publications.**
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12 564 **S4 Table. Supplementary and detailed data for 'Evidence synthesis for RCS implementation and evaluation'**
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14 565 **original research publications.**
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17 566 **S5 Table. Supplementary and detailed data for 'miscellaneous' publications.**
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20 567 **S6 Table. Supplementary and detailed data for 'Perspective, Opinion & Commentary' publications.**
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23 568 **S7 Table. Supplementary and detailed data for 'systematic review' publications.**
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25 569 **S8 Table. List of publications included in the review by typology**
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28 570 **S9 Table. HRCS definitions, sources and citing papers¹.** 1. Numbered citations in italics pertain to the
29 571 reference list in Supplementary Table 1. Numbered citations in normal (non-italicised) font are listed below. 2.
30 572 Presented as a definition of 'Health Systems Research' capacity. 3. Presented as a definition of 'research
31 573 capacity' in citing publication, but included in the 'health research capacity' definition list as contains specific
32 574 reference to 'health research'. 4. Cited as definition of 'health' research capacity in [123]. 5. Presented as a
33 575 definition of 'capacity' in citing publication, but included in the 'research capacity' definition list as contains
34 576 specific reference to 'research'
35 577
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37 578 **S10 Table. Content analysis of capacity definitions by capacity term¹.** 1. Numbered citations pertain to the
38 579 reference list in Supplementary Table 1. 2. The content of each definition was independently coded according
39 580 to the following criteria: explicit reference to individual (ind.), institutional (Ins.) or environmental (Env.) level
40 581 capacity strengthening; explicit reference to strengthening capacity in terms of defining research questions or
41 582 identifying research priorities (Def.), conducting research or applying research methods (Car.) or
42 583 communicating and applying research outcomes (App.); explicit reference to facilitating an improvement in
43 584 research abilities/quality (Qua.) sustainability (Sus.), reference to HRCS as a process (Pro.) and/or HRCS as a
44 585 continuous activity (Con.).
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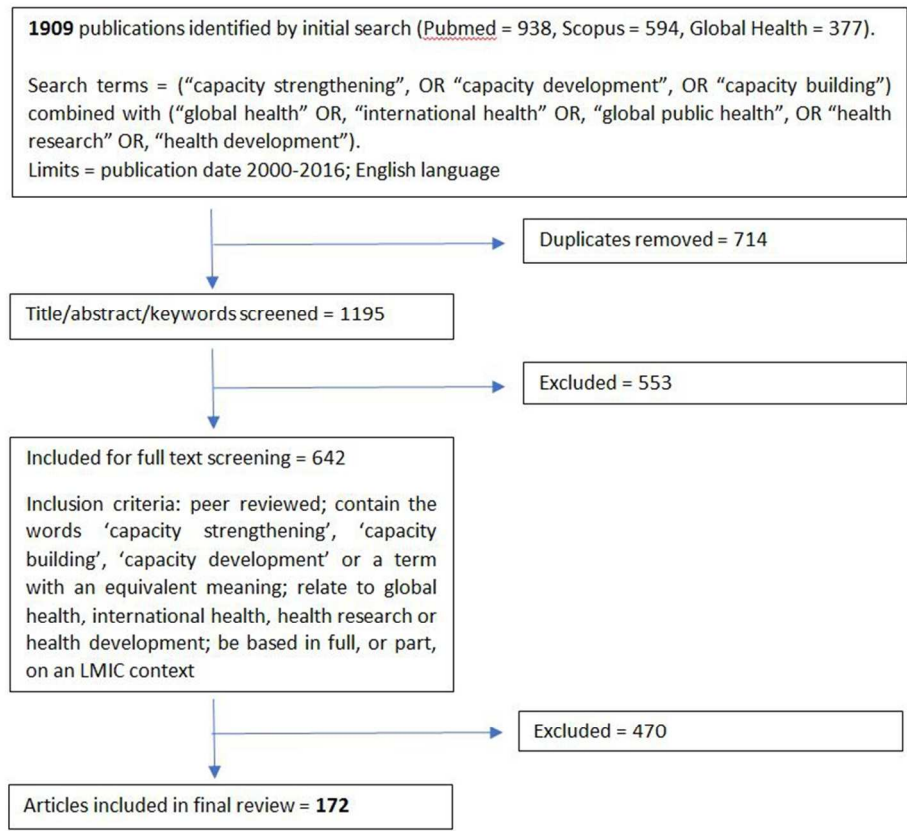


Figure 1. Summary of search and selection process

Figure One: Summary of search and selection process

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Figure 2. Number of publications per year by publication type

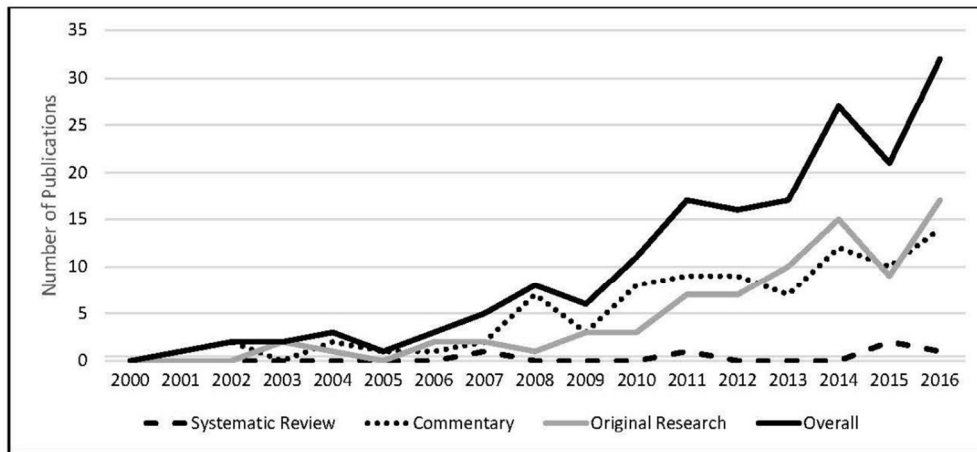


Figure Two: Number of publications per year by publication type

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Table S1. Supplementary and detailed data for 'learning and evaluation' (from research initiatives) original research publications

Publication		Publication Characteristics			Programme Characteristics			Global = 3+regions	
Author	Year	LMIC Authorship	Capacity Term	HRCS Definition	Name	Type	Focus	WHO Region	
Byrne et al	2016	Co-author	Capacity Development	Yes	Development and delivery of a Masters programme	Education	Nth-Sth	Community Systems Health Research	African
Aidam & Sombie	2016	First, last	Capacity Development	No	West African Health Organisation research development program	Health research system	Sth-Sth	Health research	African
Cole et al	2016	Co-author	Capacity Strengthening	No	Malawi's Health research Capacity Strengthening Initiative	health research system	National	Health research	African
Elmusharaf et al	2016	First. Co-author	Capacity Development	No	Connecting health research in Africa and Ireland Consortium	Education; collaborative research	Nth-Sth	Health systems strengthening	African
Kaser et al	2016	Nil	Capacity Strengthening	No	WHO/TDR Career Development Fellowship Programme	Placement	Nth-Sth	Clinical research	Global
Abawi et al	2016	Nil	Capacity Strengthening	No	E-learning for RCS	Education	Nth-Sth	Sexual and reproductive health	Global
Varshney et al	2016	First, last, co-author	Capacity Building	No	Asian Regional Capacity Development programme	Education; collaborative research	Nth-Sth	Social determinants of health	South-East Asia; Western Pacific
Thomson et al	2016	First, last, co-author	Capacity Building	No	Applied statistical training to strengthen HRC	Education	Nth-Sth	Statistical training	African
Atkins et al	2016	Co-author	Capacity Building	No	Africa/Asian Regional Capacity Development programme	Education; collaborative research	Nth-Sth	Health systems; Social determinants of health	Global
Protsiv & Atkins	2016	Co-author	Capacity Building	No	Africa/Asian Regional Capacity Development programme	Education; collaborative research	Nth-Sth	Health systems; Social determinants of health	Global
Farnman et al	2016	Co-author	Capacity Building	No	Africa/Asian Regional Capacity Development programme	Education; collaborative research	Nth-Sth	Health systems; Social determinants of health	Global
Protsiv et al	2016	Co-author	Capacity Building	No	Africa Regional Capacity Development programme	Education; collaborative research	Nth-Sth	Health systems; Social determinants of health	Global
Mahendradhata et al	2016	First, last	Capacity Building	No	Good Health Research Practice training programme	Education	Nth-Sth	Good health research practice	Global
Daniels et al	2015	Co-author	Capacity Building	No	AIDS International Training and Research Program	Education	Nth-Sth	HIV epidemiology and basic science	African
Heller et al	2015	Co-author	Capacity Building	No	People's Open Access Education Initiative, Peoples-uni	Education	Nth-Sth	Public health	Global

1										
2	Agar & Zarowsky	2015	Last	Capacity Strengthening	No	Multiple HRCS initiatives (*)	NA	NA	NA	African
3										
4	Dean et al	2015	Nil	Capacity Strengthening	Yes	RCS Award Scheme (un-named)	Collaborative Research	Nth-Sth	Life and physical sciences	African
5										
6	Ndebele et al	2014	First, co-author	Capacity Building	No	FIC research ethics capacity building initiatives (*)	Education	Nth-Sth	Research ethics	African
7										
8	Zachariah et al	2014	Co-author	Capacity Building	No	Structured Operational Research and Training Initiative	Education	Nth-Sth	Operational research	Global
9										
10	Saenz et al	2014	Co-author	Capacity Building	No	FIC bioethics training	Education	Nth-Sth	Research ethics	Americas
11										
12	Miuro et al	2013	First, co-author, last	Capacity Building	No	EDCTP Regional Networks of Excellence	Research collaboration	Nth-Sth	Clinical trials	African
13										
14	Vian et al	2013	Nil	Capacity Building	Yes	Pfizer Global Health Fellows Program	Placement	Nth-Sth	Global health	Global
15										
16	Wilson et al	2013	Nil	Capacity Building	No	Promoting Enhanced Research Capacity for Global Health	Education	Nth-Sth	Clinical research management	Global
17										
18	Bennett et al	2013	Last, co-author	Capacity Development	No	FIC research training programs(*)	Education	Nth-Sth	Health research	African
19										
20	Bennett et al	2013	Last, co-author	Capacity Development	No	FIC research training programs(*)	Education	Nth-Sth	Health research	African
21										
22	Marjanovic et al	2013	Nil	Capacity Building	No	Africa Institutions initiative	Collaborative Research	Nth-Sth	Health research	African
23										
24	Bennett et al	2012	Last, co-author	Capacity Development	Yes	Health policy analysis institutes (*)	NA	NA	NA	Global
25										
26	Redman-McLaren et al	2012	Co-author	Capacity Strengthening	Yes	Introduction to Health Research Workshop	Education	Nth-Sth	Operational research	Western Pacific
27										
28	Bissell et al	2012	Co-author	Capacity Building	No	Int. Union Against TB & Lung Disease & MSF OR training	Education	Nth-Sth	Operational research	Global
29										
30	Mahmood et al	2011	First, co-author, last	Capacity Building	Yes	Int. Centre for Diarrhoeal Disease Research, Bangladesh	Financial management	Institutional	Research funding & perform. monitoring	South East Asia
31										
32	Minja et al	2011	First	Capacity Strengthening	Yes	WHO/TDR Programmes (*)	Education; Infrastructure	Nth-Sth	Health research	Global
33										
34	Goto et al	2010	Last, co-author	Capacity Development	No	Epidemiology training course for physicians	Education	National	Epidemiology research	Western Pacific
35										
36	Mayhew et al	2008	Last, co-author	Capacity Strengthening	No	Health Economics & Financing Programme	Research collaboration	Nth-Sth	Health economics	African; South-East Asia
37										
38	Jonsson et al	2007	Co-author	Capacity Development	No	Health systems research training programmes	Collaborative Research	Nth-Sth	Health systems	Western Pacific
39										
40	Hyder et al	2003	First, co-author, last	Capacity Development	No	Doctoral trainings grants (*)	Education	Nth-Sth	Health research	Eastern Mediterranean
41										
42	Jentsch & Pilley	2003	Nil	Capacity Building	No	Multinational research project	Collaborative research	Nth-Sth	Maternal and Child Health	South East Asia
43										
44										
45										
46										
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Learning & Evaluation Characteristics						
Activities	Objective	Study Design	Data Collection	Sampling	Data Analysis	
Development and delivery of blended (largely web-based) Masters programme; teacher training (to support delivery)	Use of blended learning	Prospective; formative; mixed methods	Online surveys (n=17); IDIs (n=11)	Population	Thematic	
Research stewardship, financing, creating or sustaining resources, prod. Or using research & dev. partnerships	Programme outputs; lessons learned	Retrospective; formative; mixed methods	Document review; IDIs (n=180); consultation	Purposive	Thematic	
National priority setting, decision-making on funding, health research actor mobilisation	Lessons learned	Retrospective; formative; mixed methods; independent	Document review; IDIs (n=30)	Purposive; random	Thematic	
PhD scholarship; capacity assessment; project specific capacity building and/or research activities	Lessons learned	Prospective; summative; qualitative	Reflection; document review	Convenience	Thematic	
12-month placement at pharmaceutical company or PDP; administrative grant; networking	Programme outputs; outcomes; lessons learned	Retrospective; summative; mixed methods	Survey (n=33); IDIs	Population; purposive	Descriptive; thematic	
Online education	Programme outputs; outcomes	Retrospective; summative; quantitative	Online survey (n=175)	Population	Descriptive	
Short-term training; long-term training; joint research	Research partnerships	Prospective; formative; qualitative	IDIs (n=16)	Population	Thematic	
Short-term training	Programme outcomes	Prospective; summative; quantitative	Surveys (n=14-20)	Population	Descriptive	
Short-term training; long-term training; joint research	Use of blended learning	Prospective; summative; quantitative	Survey (n=82)	Population	Inferential	
Short-term training; long-term training; joint research	Use of blended learning	Prospective; formative; qualitative	IDIs (n=11)	Purposive	Thematic	
Short-term training; long-term training; joint research	Lessons learned	Prospective; formative; mixed methods	IDIs (n=16); document review	Population	Thematic	
Short-term training; long-term training; joint research	Use of blended learning	Prospective; formative; mixed methods	Group discussion (n=3); participant observation (n=11); survey (n=18); IDIs (n=?)	Population; purposive; convenience	Descriptive; thematic	
Short-term training	Lessons learned; programme outcomes	Prospective; formative; mixed methods	Course feedback (multiple methods; n=58); qualitative assessment	Population	Descriptive; thematic	
Short-term training; long-term training (MS, MPH, PhD)	Transfer of a health research training programme	Retrospective; formative; qualitative	IDIs (n=10)	Purposive	Thematic	
Distance learning MPH	Alumni collaboration	Retrospective; formative; mixed methods	Survey (n=68); online discussion forums	Population; convenience	Descriptive; thematic	

1						
2	NA	Lessons learned	Prospective; formative; qualitative	Document review; reflection; consultation (n=37)	Convenience	Thematic
3						
4	Funding to support delivery of a collaborative research project	Research partnerships	Retrospective; formative; mixed methods; independent	Online surveys (n=23); IDIs/FGDs (n=42)	purposive; convenience	Descriptive; thematic
5						
6	Training; mentorship; placements; web/electronic resources; public lectures, symposia; curriculum development	Lessons learned	Retrospective; formative; mixed methods	Survey (n=9); document review	Purposive	Thematic
7						
8	Workshop	Programme outputs; outcomes	Retrospective; summative; quantitative	Document review; survey (n=88)	Population	Descriptive
9						
10	Training (inclusive of certificate, diploma, masters) and fellowships	Programme outputs; lessons learned	Retrospective; formative; mixed methods	Document review; survey; consultation	Purposive	Thematic
11	Training; infrastructure development; research funding; research collaboration	Programme outputs; lessons learned	Retrospective; formative; mixed methods	Direct observation; document review	Convenience	Descriptive; thematic
12						
13	Training; technical assistance	Lessons learned	Retrospective; formative; qualitative; independent	Document review; IDIs (n = 9)	Purposive	Thematic
14						
15	Online continuing education course	Programme outputs; outcomes; lessons learned	Prospective; summative; quantitative	Surveys (x4, n= 21-166)	Population	Descriptive
16						
17	Training (Masters and PhD) and fellowships	Mentorship	Retrospective; formative; qualitative	IDIs/FGDs (n=72)	Purposive	Thematic
18						
19	Training (Masters and PhD) and fellowships	Programme outcomes	Retrospective; summative; mixed methods	IDIs/FGDs (n=52); survey, (n=29); document review	Purposive; random	Descriptive; thematic
20						
21	Funding to support delivery of a collaborative research project.	Lessons learned	Prospective; formative; mixed methods; independent	Document review; consultation; survey (n=51)	Purposive	Thematic
22	Funding to support advanced research training					
23	NA	Lessons learned	Retrospective; formative; mixed methods; independent	IDIs (n=80); document review	Purposive	Descriptive; thematic
24						
25	Workshop	Workshop participation dynamics	Retrospective; formative; qualitative	IDIs (n=5); written responses (n=5)	Purposive	Thematic
26						
27	Workshop	Programme outputs; lessons learned	Retrospective; summative; quantitative	Survey (n=12); document review	Population	Descriptive
28						
29	Implementation of a revised funding and performance monitoring framework	Programme outputs; outcomes	Retrospective; summative; mixed methods	KII; document review; survey	Purposive	Descriptive; thematic
30						
31	Research training grants; research re-entry grants; institution strengthening grants	Programme outcomes	Retrospective; summative; mixed methods	Survey (n=92); IDIs (n=10)	Population; purposive	Descriptive; thematic
32						
33	Workshop	Programme outputs; outcomes	Prospective; summative; quantitative	Surveys (x2, n = 8-70)	Population	Descriptive
34						
35	Joint research, publication & funding applications; staff exchanges/training; teaching & TA; small grants	Programme outputs; lessons learned	Retrospective; formative; mixed methods	Document review; IDIs (n=25)	Purposive	Descriptive; thematic
36	Training; funding to support delivery of a collaborative research project	Informing policy and practice	Retrospective; formative; mixed-methods	IDIs/FGDs (n=28); survey (n=56)	Purposive	Thematic
37						
38	Doctoral training	Programme outputs	Retrospective; summative; quantitative; independent	Survey (n=54)	Convenience	Descriptive
39						
40	Funding to support delivery of a collaborative research project	Research partnerships	Retrospective; formative; qualitative	IDIs (n=7)	purposive; convenience	Thematic
41						
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Table S2. Supplementary and detailed data for 'Capacity Assessment' original research publications

Publication	Publication Characteristics					
	Author	Year	LMIC Authorship	Capacity Term	HRCs Definition	Assessment of
Erasmus et al		2016	First, co-author, last	Capacity Strengthening	No	Postgraduate teaching capacity
Uzochukwu et al		2016	First, co-author, last	Capacity Building	No	Capacity needs for health systems policy and systems research and analysis
Motari et al		2015	First, co-author, last	Capacity Strengthening	No	Readiness of national ethics committees to respond to challenges posed by a globalised biomedical research system
Agyepong et al		2015	First, co-author, last	Capacity Strengthening	No	Capacity needs for health policy and systems research and analysis, conduct and teaching
Oliver et al		2015	Last	Capacity Strengthening	No	Capacity for conducting systematic reviews
Haafkens et al		2014	Nil	Capacity Building	No	Training needs of researchers to conduct research
Kilic et al		2014	First, co-author, last	Capacity Building	Yes	Research capacity and training needs
Kebede et al		2014	First, co-author	Capacity Development	Yes	Human capacity and staff movement

1					
2	Simba et al	2014 First, co-author, last	Capacity Strengthening	Yes	Human and financial resources
3					capacities, policies and
4					organisational support
5	Ekeroma et al	2014 Nil	Capacity Building	No	Clinical research activity and
6					audit
7					
8					
9					
10	Kanoute et al	2014 First, co-author	Capacity Strengthening	No	Current status of oral health
11					research
12	Franzen et al	2013 Co-author	Capacity Strengthening	No	Barriers and enablers to
13					investigator-initiated trials
14					
15					
16	Mirzoev et al	2014 Last, co-author	Capacity Strengthening	Yes	Capacity for health policy and
17					systems research and analysis
18					
19	Hofman et al	2013 First, co-author	Capacity Building	No	Current status of health equity
20					and Social Determinants of
21					Health training
22					
23	Nachega et al	2012 First, co-author, last	Capacity Building	No	Epidemiology and public health
24					capacity
25	Paulus et al	2012 Co-author	Capacity Development	No	Global training priorities, unmet
26					needs and potential cross-
27					cohort solutions
28					
29	Peykari et al	2012 First, co-author, last	Capacity Building	No	Health Systems Research –
30					ranking of institutions
31					
32	Magesa et al	2011 First, co-author, last	Capacity Building	No	Capacity building process of
33					Tanzanian National Institute for
34					Medical Research
35					
36	Mohammadi et al	2011 First, co-author, last	Capacity Building	No	Representation of different
37					nations in international public
38					health journals
39	Nakanjaro et al	2011 First, co-author, last	Capacity Building	No	Status and nature of mentoring
40					practices
41					
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Pepping	2010 Nil (1)	Capacity development	No	Training capacity in public health nutrition
Redman-MacLaren et al	2010 Co-author	Capacity Building	No	Public Health literature in Salomon Island
Nyika et al	2009 First, co-author, last	Capacity Building	No	Composition, training needs and independence of ethics committees
Malekafzali et al	2009 First, co-author, last	Capacity Building	No	Research activities in medical universities and their affiliated institutions
Moodley & Myer	2007 First, last (2)	Capacity Development	No	Composition, operations, and training needs of health research ethics committees
Singh	2006 First (1)	Capacity Development	No	Mental health research activities in LMICs
Cuboni et al	2004 First, co-author, last	Capacity Development	No	Participation of Fijians in health research publications

Focus	Name of programme	Region	Assessment location/level	Study Design	Data Collection	Data Analysis
Health systems policy and systems research and analysis	Consortium for Health Policy and Systems Analysis in Africa (CHEPSAA)	Africa	Multiple institutions involved in research (universities and research institutions)	Cross-sectional; mixed methods	Document review; surveys	Descriptive; thematic
Health systems policy and systems research and analysis	CHEPSAA	Africa	University	Cross-sectional; mixed methods	Document review; interviews (n=9); survey (n=123)	Thematic
Health research ethics	N.A.	Africa	Ethic committees (national level)	Cross-sectional; quantitative	Survey (n=33)	Descriptive
Health systems policy and systems research and analysis	N.A.	Africa	University	Cross-sectional; mixed methods	Document review; interview (n=1); focus group discussions (n=3); survey (n=67)	Descriptive; thematic
Systematic reviews	N.A.	Global	Multiple institutions involved in research (systematic review centres)	Rapid appraisal; mixed methods	Routine management data; document review; consultation of key informants; surveys (n=22)	Descriptive; thematic
Causes of health inequities	INDEPTH Network	Global	Multiple institutions involved in research (research network)	Qualitative	Online concept mapping (n=82)	Descriptive thematic
Non-Communicable Diseases research	RESCAP-Med	Europe	Multiple institutions involved in research	Mixed methods	Literature review; interviews (n=10); Survey (n=46)	Descriptive; thematic
National health research institutions	N.A.	Africa	Multiple institutions involved in research (health research institutions)	Quantitative	Surveys (n=847)	Descriptive

1							
2	Health systems research	Higher Education Alliance for Leadership Through Health (HEALTH)	Africa	Universities	Mixed methods	Document review; self-	Descriptive; thematic
3						assessment (n=123);	
4						interviews (n=73)	
5	Reproductive health	Building Reproductive	Western	Health care providers	Mixed methods	Interviews,	Descriptive; thematic
6	research	health Research and Audit	Pacific			questionnaires, focus	
7						group discussions;	
8		Capacity and Activity in the				online survey (n=28)	
9		Pacific Islands (BRRACAP)				Delphi survey (n=30);	Descriptive; thematic
10	Oral health research	N.A.	Africa	National and regional level	Mixed methods	literature review	
11							
12	Informing and directing	N.A.	Africa	Multiple institutions involved in	Qualitative	Interviews (n=7); focus	Thematic
13	capacity strengthening			research (research institute,		group discussions	
14	initiatives			university, NGO, hospital)		(n=3)	
15	Health systems policy and	CHEPSAA	Africa	Universities	Mixed methods	Document reviews;	Thematic
16	systems research and					interviews; surveys	
17	analysis						
18	Social Determinants of	INDEPTH Training and	Africa	Universities (Schools of Public	Qualitative	Document reviews;	Thematic
19	Health and health equity	research centres of		Health)		interviews (n=30),	
20		Excellence (INTREC)				online searches	
21	Training, research, funding,	N.A.	Africa	Regional level	Qualitative	Interviews (n=10);	Descriptive; thematic
22	human resources					literature review	
23	Cohort studies	World Cohort Integration	Global	Regional level	Mixed methods	Survey (n=42); FGDs	Descriptive; thematic
24		Workshop				(n=1)	
25							
26	Stewardship, capacity	N.A.	Eastern	Universities	Cross-sectional;	Survey	Descriptive
27	building, knowledge		Mediterra		quantitative		
28	production		nean				
29	Critical mass of	N.A.	Africa	Institute involved in research	Cross-sectional;	Document review;	Descriptive; thematic
30	multidisciplinary research				mixed-methods	interviews (n=78)	
31	scientists						
32	Equity in access to health	N.A.	Global	Regional level	Qualitative	Review of health	Descriptive
33	research capacity					journals (n=37)	
34	development						
35	Effective mentoring	N.A.	Africa	University	Qualitative	Survey (n=22)	Thematic
36							
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2	Public health nutrition	N.A.	Africa	Multiple institutions involved in research (research institutes and universities)	Mixed methods	Document review; survey (n=15); consultations; interviews; websites review	Descriptive; thematic
3							
4							
5							
6							
7							
8	Equitable research agenda	N.A.	Western Pacific	National level	Qualitative	Literature review (n=218); focus group (n=1)	Descriptive
9							
10							
11	Capacity building programmes for effective ethic review processes	African Malaria Network Trust (AMANET)	Africa	Ethic committees (national, institutional level)	Quantitative	Survey (n=312)	Descriptive
12							
13							
14	Capacity building programmes for effective ethic review processes	N.A.	Eastern Mediterranean	Multiple institutions involved in research (universities and research institutes)	Quantitative	Bibliometric assay	Descriptive
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16	Biomedical research	N.A.	Africa	Ethic committees (national level)	Mixed methods	Interviews; survey (n=12)	Descriptive; thematic
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21	Publication bias	N.A.	Global	Regional level	Quantitative	Number of manuscripts submitted to 8 journals	Descriptive
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26	Health priorities and research capacity in Fiji	N.A.	Western Pacific	Regional level	Mixed methods	Literature review (298 papers included); interviews	Descriptive; thematic
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Table S3. Supplementary and detailed data for 'HRCS methods for implementation' original research publications

Publication		Publication Characteristics			Programme Characteristics		
Author	Year	LMIC Authorship	Capacity Term	HRCS Definition	Focus	Region	Study Design
Murphy et al	2015	Co-author	Capacity Development	No	Partner assessment toolkit (PAT) to discuss partnership ethics and put accountability measures in place.	Global	Qualitative
Le et al	2014	Co-author	Capacity Strengthening	No	Strengthening capacity for health policy and systems research and analysis (HPSR+A) in Universities.	Africa	Mixed Methods
Huber et al	2014	Co-author	Capacity Strengthening	Yes	Training evaluation for training related to HRCS.	Africa	Quantitative

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7					Capacity assessment tool for	
8	Jessani et al	2014 Co-author	Capacity	No	schools of public health to	Africa
9			Development		reflect on institutional	Qualitative
10					strengths and weaknesses for	
11					health systems research.	
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19					Development of a practical	
20	Bates et al	2014 Nil	Capacity	Yes	approach for the design and	Africa
21			Strengthening		evaluation of health capacity	Qualitative
22					strengthening programmes.	
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30					North-South clinical nursing	
31	Birch et al	2013 Co-author	Capacity Building	No	partnership for CS.	Africa
32						Qualitative
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Bates et al	2006 Last	Capacity Building	Yes	Evidence based tool to determine infrastructural capabilities and design and evaluation of capacity building programmes in health research.	Africa	Qualitative
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Data Collection	Data Analysis	Steps in HRCS Process	Methods Used in Process
Stakeholder workshops situated around case studies and briefing papers	Thematic	<ol style="list-style-type: none"> 1. Common understanding of PAT components developed through workshops with sub-Saharan African partners. 2. PAT modified by expert team and circulated to partners in all country contexts for comment. 3. PAT finalised and tested in existing partnership. 	<p>Qualitative joint self-assessment. Phased/developmental approach.</p> <p>Standardised</p>
FGD, IDI, Stakeholder workshop, survey, document review	Thematic and Descriptive	<ol style="list-style-type: none"> 1. Develop shared understanding of capacity and CS across consortium. 2. Map contextual environment for HPSR+A, including desk review, and key informant interviews/discussions. 3. Self-assessment against core thematic areas identified. 4. Comparative synthesis by UK partner and cross-consortium comparison. 	<p>Mixed-method self-assessment by African partners and 'external' assessment by UK partner.</p> <p>Phased/developmental approach.</p> <p>'Semi-standardised' to allow for flexibility in context.</p>
Survey	Inferential	<ol style="list-style-type: none"> 1. Domains for evaluation selected based on existing framework. 2. Development of questionnaire. 3. Testing of questionnaire. 4. Validation of questionnaire. 	<p>Quantitative self-survey.</p> <p>Fixed-point.</p> <p>Standardised</p>

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Quantitative self-assessment.

Qualitative institutional profiling and priority identification.

Phased/developmental.

'Semi-standardised' to allow for flexibility in context.

Mixed-method joint assessment and priority identification.

Phased/developmental.

'Semi-standardised' to allow for flexibility in context.

Mixed-method self-assessment.

Phased/developmental.

Standardised.

- 1. Capacity assessment questions based on previous instruments but adapted for focus.
- 2. Meeting with capacity focal points at universities to be assessed to refine tool to context.
- 3. Implementation of tool.
- 4. Dissemination and reflection on findings to develop capacity strengthening plan in workshop.

- 1. Establish goal of capacity strengthening programme
- 2. Describing ideal capacity to achieve goal- synthesis of relevant evidence
- 3. Determination of existing capacity against 'ideal' identified in step 2.
- 4. Devise and implement an action plan to fill gaps.
- 5. Learn through doing and adapt the action plan regularly.

- 1. Systematic literature search for partnership measures.
- 2. Screening of partnership measures for applicability.
- 3. Selection and modification of existing appropriate measure.
- 4. Piloting of measure.

Stakeholder workshop Thematic

Review and case studies Thematic

Review Thematic

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Review	Thematic	<ol style="list-style-type: none"> 1. Literature search for existing tools and models 2. Using best practice examples to design the evaluation programme 3. Develop and adapt an evaluation tool (links to QA cycle): define institutional systems needed to support research; enumerate existing and missing resources; address identified gaps. 	<p>Qualitative self-assessment and priority identification.</p> <p>Phased/developmental</p> <p>'Semi-standardised' to allow for flexibility in context.</p>
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Table S4. Supplementary and detailed data for 'Evidence synthesis for RCS implementation and evaluation' original research publications

Publication		Publication Characteristics			Programme Characteristics
Author	Year	LMIC Authorship	Capacity Term	HRCS Definition	Focus
Bates et al	2015	Nil	Capacity Strengthening	No	Enhance understanding in difficulties of evaluating health research capacity strengthening and make recommendations for improvement
Cole et al	2014	Nil	Capacity Strengthening	Yes	Describe the design of health research capacity strengthening evaluations, indicators, outputs and outcomes.
Boyd et al	2013	Nil	Capacity Strengthening	No	Describe and compare key characteristics of existing health research capacity strengthening evaluation frameworks
Gadsby	2011	Nil	Capacity Strengthening	Yes	Understand the way in which research capacity strengthening is understood and approached through examination of methods for monitoring and evaluation of research capacity strengthening.
Edwards et al	2009	Co-author	Capacity Building	No	Identification of factors that have influenced research capacity development amongst nurses in LMICs.

Region	Study Design	Data Collection	Data Analysis	Participants/Target Group
Global	Qualitative	Informal discussion and review	Thematic	HRCS Funders, evaluators and implementers
Global	Qualitative	Review	Thematic	LMIC Health Research Funders
Global	Mixed methods	telephone discusison, stakeholder meetings, online survey, review	Thematic	HRCS Funders, evaluators and implementers
Global	Qualitative	Review, informal discussions, semi-structured interview	Thematic	Donor Organisations and Experts in HRCS
Global	Qualitative	Review, informal interviews/discussions	Thematic	Senior Nurse Leaders (HRCS Intervention Target Group)

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Table S5. Supplementary and detailed data for 'miscellaneous' publications

Publication		Publication Characteristics		
Author	Year	LMIC Authorship	Capacity Term	HRCS Definition
Cole et al	2016	Last, co-author	Capacity Strengthening	No
Parker & Kingori	2016	Nil	Capacity Building	No
Muldoon et al	2012	Co-author	Capacity Building	No
Nurse & Wight	2011	First	Capacity Strengthening	Yes

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Aim	Region	Study Design	Data Collection	Data Analysis
Mixed methods examination of mentorship experiences in Global Health	Global	Mixed methods	Document review; case	Thematic
Qualitative examination of researcher's views on good and bad international research collaborations	Global	Qualitative	Interviews (n=22)	Thematic
Documenting North-South research collaborations and provide insights into ongoing benefits and challenges of engaging in the research process from the Southern perspective	Africa	Mixed methods	Surveys (n=19), Interview	Thematic
Analysing the political economy of health research commissioning among bilateral, multilateral, non-governmental and philanthropic organisations	Africa	Qualitative	Document review; interview	Thematic

Table S6. Supplementary and detailed data for 'Perspective, Opinion & Commentary' publications

Publication		Publication Characteristics		
Author	Year	LMIC Authorship	Capacity Term	HRCS Definition
Airhihenbuwa et al	2016	Nil	Capacity Building	No
Bloomfield et al	2016	Last, co-author	Capacity Building	No
Hyder et al	2016	Last, co-author	Capacity Strengthening	No
Hawkes et al	2016	Co-author	Capacity Strengthening	No
Winchester et al	2016	Co-author	Capacity Building	No
Dossou et al	2016	First, co-author	Capacity Strengthening	No
Cubaka et al	2016	First, co-author	Capacity Building	No
Davies & Mullen	2016	Nil	Capacity Building	No
Bloomfield et al	2016	Nil	Capacity Building	No
Sturke et al	2016	Nil	Capacity Building	Yes
Atkins et al	2016	Last, co-author	Capacity Building	No
Osanjo et al	2016	First, co-author, last	Capacity Building	No
Atkins et al	2016	Co-author	Capacity Building	No
O'Connor et al	2016	Co-author	Capacity Building	No
Berman et al	2015	First, co-author, last	Capacity Building	No
Cash-Gibson et al	2015	Last, co-author	Capacity Building	Yes
Koso-Thomas et al	2015	Last	Capacity Building	No
MacLaren et al	2015	Co-author	Capacity Building	No
Langlois et al	2015	Co-author	Capacity Strengthening	No
Miranda et al	2015	First, co-author, last	Capacity Building	No
Adanu et al	2015	First, co-author	Capacity Strengthening	No
Cottler et al	2015	Co-author	Capacity Building	Yes
McGregor et al	2015	Nil	Capacity Building	No
Kombe	2015	First, co-author, last	Capacity Strengthening	No
Anderson et al	2014	Last, co-author	Capacity Building	No
Hanney & Gonzalez-Block	2014	Last (2)	Capacity Building	No
Cole et al	2014	Nil	Capacity Strengthening	No
Kabiru et al	2014	First, co-author, last	Capacity Building	No
Chu et al	2014	Last, co-author	Capacity Building	No
Sweetland et al	2014	Co-author	Capacity Building	No
Adedokun et al	2014	First, co-author, last	Capacity Building	No
Harries et al	2014	Co-author	Capacity Building	No
Carothers et al	2014	Nil	Capacity Building	No
Klinkenberg et al	2014	Last, co-author	Capacity Building	No
Mandala et al	2014	First, co-author, last	Capacity Strengthening	No

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2	Ramsay et al	2014	Co-author	Capacity Building	No
3	Pratt & Loff	2013	Nil	Capacity Strengthening	No
4	Noormahomed et al	2013	First, co-author, last	Capacity Strengthening	No
5	Sanchez et al	2013	Last, co-author	Capacity Strengthening	No
6	Sanchez et al	2013	Last, co-author	Capacity Strengthening	No
7	Shaji	2013	First (1)	Capacity Building	No
8	Ekeroma	2013	Nil	Capacity Building	No
9	Vasquez et al	2013	Last, co-author	Capacity Strengthening	Yes
10	Osei-Atweneboana et al	2012	First, co-author	Capacity Building	Yes
11	Ijsselmuiden et al	2012	First, co-author, last	Capacity Strengthening	Yes
12	Mckee et al	2012	Nil	Capacity Building	No
13	Nwaka et al	2012	First, co-author, last	Capacity Building	No
14	Kasonde & Campbell	2012	First	Capacity Building	No
15	Thornicroft et al	2012	Last, co-author	Capacity Building	Yes
16	Pratt & Loff	2012	Nil	Capacity Strengthening	No
17	de-graft Aikins et al	2012	First, co-author	Capacity Building	No
18	Greenwood et al	2012	Nil	Capacity Development	No
19	Airhihenbuwa et al	2011	Last, co-author	Capacity Building	Yes
20	Farquhar et al	2011	Last	Capacity Building	No
21	Forde et al	2011	Last, co-author	Capacity Development	No
22	Laabes et al	2011	First, co-author	Capacity Building	No
23	Kariuki et al	2011	First, co-author	Capacity Building	No
24	Pinto et al	2011	Co-author	Capacity Building	No
25	Wilson et al	2011	Last	Capacity Building	No
26	Manabe et al	2011	First, co-author, last	Capacity Building	Yes
27	Gezmu et al	2011	Co-author	Capacity Building	No
28	Brown et al	2010	First, co-author, last	Capacity Development	No
29	Kabiru et al	2010	First, co-author, last	Capacity Development	Yes
30	Ezeh et al	2010	First, co-author, last	Capacity Building	Yes
31	Lazarus et al	2010	Last	Capacity Development	No
32	Kutcher et al	2010	Last, co-author	Capacity Building	No
33	Maher et al	2010	First, co-author, last	Capacity Strengthening	No
34	Ntoumi	2010	First (1)	Capacity Building	No
35	Zumla et al	2010	First, co-author, last	Capacity Development	No
36	Kilama	2009	First (1)	Capacity Building	Yes
37	Kilama	2009	First (1)	Capacity Building	No
38	Coloma & Harris	2009	Nil	Capacity Building	No
39	Hussein	2008	First (1)	Capacity Building	No
40	Kumar et al	2008	First, co-author, last	Capacity Building	No
41	Malomo et al	2008	First, co-author, last	Capacity Building	No
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2	Sheikh	2008	First (1)	Capacity Building	No
3	Tindana & Boateng	2008	First, last (2)	Capacity Building	No
4	Upshar	2008	Nil (1)	Capacity Building	No
5	Whitworth et al	2008	Last, co-author	Capacity Strengthening	No
6	Schulz-Baldes et al	2007	Nil	Capacity Building	No
7	Nuyens	2007	Nil	Capacity Strengthening	Yes
8	Stillman et al	2006	Co-author	Capacity Building	No
9	Goto et al	2005	First, co-author, last	Capacity Building	No
10	Andruchow et al	2004	Nil	Capacity Building	No
11	Lansang & Dennis	2004	First,last (2)	Capacity Building	Yes
12	Reddy et al	2002	First, last	Capacity Building	Yes
13	Varkevisser et al	2001	Nil	Capacity Building	No
14	Nchinda	2002	Nil	Capacity Strengthening	Yes
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Commentary Content

HRCS Focus	Commentary Purpose	Commentary Informed By
HRCS leadership development	Recommendations	Experience
Global health centres of excellence training programme	Programme outputs; lessons learned	Experience (single programme)
Road traffic injuries research network	Programme description; programme outputs	Experience (single programme)
Capacity development for evidence uptake	Lessons learned	Experience; review
Development of a global health network	Programme description; lessons learned	Experience (single programme)
Implementing a sexual and reproductive health network in Africa	Programme description; lessons learned	Experience (single programme)
Twinning' model for PhD students	Programme description; lessons learned	Experience (single programme)
HRCS funding for Africa	Advocacy	Experience (single programme)
Capacity building in Global Health research	Lessons learned	Experience (single programme)
NIH International Tobacco and Health Research and Capacity Building Programme	Programme description; lessons learned	Experience (single programme)
Online journal clubs for student mentoring	Programme description; lessons learned	Experience (single programme)
Implementation science research training fellowship	programme description; programme outputs; lessons learned	Experience (single programme)
Africa/Asian Regional Capacity Development programme	Programme description; lessons learned	Experience (single programme)
capacity development in nursing informatics	Programme description; lessons learned	Experience (single programme)
Development of a knowledge translation platform	Lessons learned	Experience (single programme)
Sth-Nth-Sth research collaboration network	Lessons learned	Experience (single programme)
Global network for women and children's health research	Programme outputs; lessons learned	Experience (single programme)
Introduction to health research workshop	Lessons learned	Experience (single programme)
Health systems research synthesis in LMICs	Programme description	Experience (single programme)
Translational research in NCDs	Programme description	Experience (single programme)
HRCS in sexual and reproductive health in Africa	Recommendations	Workshops
HRCS for brain and nervous system disorders research	Recommendations	Experience; review
Bibliometric analysis of authorship HIV treatment/prevention publications	Analysis of LMIC authorship	Review
Field worker capacity strengthening in Africa	Recommendations	Workshops
Creating a charter of collaboration for HRCS partnerships	Process description	Experience (single programme)
Building health research systems	Situation analysis	Review
HRCS evaluation approaches	Recommendations	Review
African doctoral dissertation research fellowships	Programme outputs; lessons learned	Experience (single programme)
HRCS in Africa	Recommendations	Not stated
Mental health research capacity in Mozambique	Programme description	Experience (single programme)
Consortium for advanced research training in Africa	Programme outputs; lessons learned	Experience (single programme)
Mentorship for operational research capacity building	Lessons learned	Experience (single programme)
FIC clinical research scholars and fellows programme	Lessons learned	Experience (single programme)
Ethiopian operational research initiative	Programme outputs; lessons learned	Experience (single programme)
Southern Africa consortium for research excellence	Programme description	Experience (single programme)

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2	Operational research training initiative	Programme outputs; lessons learned	Experience (single programme)
3	Contribution of product development partnerships to RCS	Programme outputs	Review
4	Medical education partnership	Programme outputs; lessons learned	Experience (single programme)
5	Multi-faceted Nth-Sth HRCS project	Programme description	Experience (single programme)
6	Multi-faceted Nth-Sth HRCS project	Lessons learned	Experience (single programme)
7	HRCS in mental health research	Recommendations	Not stated
8	Building reproductive health research and audit capacity in the Pacific	Programme description	Experience (single programme)
9	HRCS	Recommendations	Experience (single programme); review
10	HRCS for helminthiasis control	Recommendations	Experience
11	Developing human resources for health research	Recommendations	Review
12	HRCS in LMICs	Recommendations	Review
13	Identification of centres of excellence in health innovation in Africa	Programme description	Experience (single programme)
14	Creating a knowledge translation platform in Zambia	Lessons learned	Experience (single programme)
15	HRCS in global mental health research	Recommendations	Experience
16	Promotion of justice in global health research	Recommendations	Not stated
17	Nth-Sth research partnership on chronic disease	Programme outputs; lessons learned	Experience (single programme)
18	Gates malaria partnership	Programme outputs; lessons learned	Experience (single programme)
19	Nth-Sth RCS partnership	Lessons learned	Experience (single programme)
20	Afya-Bora consortium	Programme description	Experience (single programme)
21	Nth-Sth multi-faceted research collaboration	Programme outputs; lessons learned	Experience (single programme)
22	HRCS for biomedical research	Recommendations	Not stated
23	HRCS for NTD control in Africa	Recommendations	Workshops
24	Development of international research partnerships	Lessons learned	Experience (single programme)
25	NTD collaborative teaching and learning	Programme description	Experience (single programme)
26	PhD training in Africa	Programme description	Experience (single programme)
27	Strengthening biostatistics resources in Africa	Deliberations	Workshops
28	Public health nutrition research and training capacity in Africa	Deliberations	Workshops
29	African doctoral dissertation research fellowships	Lessons learned	Experience (single programme)
30	Consortium for advanced research training in Africa	Programme description	Experience (single programme)
31	HRCS in Africa	Recommendations	Experience; review
32	Nth-Sth clinical research development project	Programme outputs; programme outcomes; lessons learned	Experience (single programme)
33	ALPHA network programme of HIV epidemiology workshops	Programme outputs; lessons learned	Experience (single programme)
34	HRCS in Africa	Programme description(s)	Experience
35	Nth-Sth research collaboration	Programme outputs; lessons learned	Experience (single programme)
36	Research translation	Recommendations	Not stated
37	HRCS in Africa	Situation analysis	Review
38	HRCS in LMICs	Programme description	Experience (single programme)
39	FIC sponsored bioethics MHSc	Lessons learned	Experience (single programme)
40	FIC sponsored bioethics MHSc	Lessons learned	Experience (single programme)
41	FIC sponsored bioethics MHSc	Lessons learned	Experience (single programme)
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2	FIC sponsored bioethics MHSc	Lessons learned	Experience (single programme)
3	FIC sponsored bioethics MHSc	Lessons learned	Experience (single programme)
4	FIC sponsored bioethics MHSc	Programme description	Experience (single programme)
5	HRCS in Africa	Recommendations	Not stated
6	Benefit sharing in international health research	Recommendations	Not stated
7	10 best resources for HRCS	Recommendations	Not stated
8	FIC tobacco HRCS programme	Lessons learned	Experience (single programme)
9	Reproductive health research in-service training course	Programme outputs; programme outcomes; lessons learned	Experience (single programme)
10	Cancer training and research collaboration	Lessons learned	Experience (single programme)
11	HRCS in LMICs	Recommendations	Review
12	Nth-Sth research collaboration	Lessons learned	Experience (single programme)
13	Nth-Sth joint health systems research project	Programme outputs; lessons learned	Experience (single programme)
14	HRCS in LMICs	Recommendations	Experience
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Table S7. Supplementary and detailed data for 'systematic review' publications

Publication	Publication Characteristics					
	Author	Year	LMIC Authorship	Capacity Term	HRCS Definition	Aim
Adedokun et al		2016	First	Capacity Building	No	Examine author affiliations of genomic epidemiology publications
Mugabo et al		2015	First, co-author, last	Capacity Strengthening	No	Describe different training approaches to research capacity strengthening
Huber et al		2015	Nil	Capacity Development	No	Support researchers and stakeholders in systemising future efforts in the HRDC field
Gonzalez-Block et al		2011	First, co-author	Capacity Strengthening	No	Assess the capacity of research collaborations and implementation research in strengthening networks and institutions in developing countries
San Sebastian & Hurtig		2006	Nil	Capacity Building	No	Review of health research on indigenous populations in Latin America between 1995-2004

Region	Searched databases	Search terms	Final no. of reviewed papers
Africa	Humane Genome Epidemiology (HuGE) Pub	Sub-Saharan Africa	508
Africa	PubMed	Capacity building; building capacity; capacity strengthening; strengthening capacity; capacity development; skills development; research; building research capacity; research training; operational research training; health; Africa	14
Global	PubMed; Google Scholar	Capacity development; research; health professuin fields; monitoting and evaluation; level of needs assessment, monitoring and evaluation	42
Global	PubMed; African Index Medicus; Literatura Latinoamericana y del Caribe En Ciencia de la Salud (LILACS)	Translational research; operations research; community based participatory research; process assessment; health plan implementation; government programmes; national health programmes; efficiency organisational; patient acceptance of health care; health service accessibility; reproductive health services; disease and health conditions; communicable diseases; malnutrition; malnutrition; maternal mortality	237
Americas	PubMed and LILACS	Indian; indigenous; aboriginal; native; amazon and all the different countries of Latin America	690

Supplementary Table 8. List of publications included in the review by typology

Original Research: Learning & Evaluation (from research initiatives)

1. Abawi K, Chandra-Mouli V, Toskin I, Festin MP, Gertiser L, Idris R, Hamamy H, Ali M, Bonventure AM, Temmerman M *et al*: **E-learning for research capacity strengthening in sexual and reproductive health: The experience of the Geneva Foundation for Medical Education and Research and the Department of Reproductive Health and Research, World Health Organization.** *Human resources for health* 2016, **14**(1).
2. Aidam J, Sombie I: **The West African Health Organization's experience in improving the health research environment in the ECOWAS region.** *Health research policy and systems* 2016, **14**:30.
3. Atkins S, Yan W, Meragia E, Mahomed H, Rosales-Klitz S, Skinner D, Zwarenstein M: **Student experiences of participating in five collaborative blended learning courses in Africa and Asia: a survey.** *Global health action* 2016, **9**:28145.
4. Byrne E, Donaldson L, Manda-Taylor L, Brugha R, Matthews A, MacDonald S, Mwapasa V, Petersen M, Walsh A: **The use of technology enhanced learning in health research capacity development: lessons from a cross country research partnership.** *Globalization and health* 2016, **12**(19):
5. Cole DC, Nyirenda LJ, Fazal N, Bates I: **Implementing a national health research for development platform in a low-income country - a review of Malawi's Health Research Capacity Strengthening Initiative.** *Health research policy and systems* 2016, **14**(24):
6. Elmusharaf K, Tahir H, D OD, Brugha R, Homeida M, Abbas AM, Byrne E: **From local to global: a qualitative review of the multi-leveled impact of a multi-country health research capacity development partnership on maternal health in Sudan.** *Globalization and health* 2016, **12**(1):20.
7. Farnman R, Diwan V, Zwarenstein M, Atkins S: **Successes and challenges of north-south partnerships - key lessons from the African/Asian Regional Capacity Development projects.** *Global health action* 2016, **9**:30522.
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Supplementary Table 9. HRCS definitions, sources and citing papers¹

Subject Defined	Capacity Term	Definition & Source	Cited In
Health	Building [30]	"an ability of individuals, organisations or systems to perform and utilise health research effectively, efficiently and sustainably" [70]	[30, 70]
Research Capacity	Strengthening [70]	"the ability to define problems, set objectives and priorities, build sustainable institutions and organisations, and identify solutions to key national health problems" [1]	[74, 126, 166]
	Building [166]	"a strategy that is implemented worldwide to improve the ability of developing countries to tackle the persistent and disproportionate burdens of disease they face" [2]	[123]
	Strengthening [74, 126]	"the process required for building capacity in health research would be define the institutional systems needed to support research, enumerate existing and missing resources and improve research support by addressing the identified gaps" [70]	[45]
	Strengthening	"the level of expertise and resources needed for the production of new knowledge and its application" [3] ²	[48]
	Building	"an approach to the development of sustainable skills, organisational structure, resources and commitment to health improvement...to multiply health gains many times over" [4] ³	[139]
	Building	"a systematic, purposeful and goal-oriented effort to strengthen human resources and infrastructure to enable local scientists and institutions to become independent and responsive to existing and emerging health needs and threats" [97] ²	[97]
	Research Capacity	Building [164]	"the ongoing process of empowering individuals, institutions, organisations, and nations to: define and prioritise problems systematically; develop and scientifically evaluate appropriate solutions; and share and apply the knowledge generated" [164] ⁴
Strengthening [29, 123, 159]		"process of individual and institutional development which leads to higher levels of skills and greater ability to perform useful research" [5]	[16, 72]
Strengthening [16, 72]		"the process by which individuals, organisations, and societies develop abilities (individually and collectively) to perform functions effectively, efficiently and in a sustainable manner to define problems, set objectives and priorities, build sustainable institutions and bring solutions to key national problems" [6]	[4, 31, 74]
Development [4]		"the ability to conduct, manage, disseminate, and apply research in policy and practice" [132]	[132]
Strengthening [31, 74]		"Includes any efforts to increase the ability of individuals and institutions to undertake high-quality research and to engage with the wider community of stakeholders" [7]	[91, 96]
Building		"a long-term process that requires a systematic and inter-sectoral approach to developing appropriate regulatory frameworks, building and maintaining physical infrastructure, and investing in human resources, equipment and training in an environment conducive to research commitment and institutional support" [8]	[130]

	Strengthening	“consists of two main closely inter-related and inter-dependent activities, which, together, form the basis of institutional development. The two parts are: improving, through appropriate training, the capabilities of scientists to undertake quality research; improving institutional support – equipment, supplies and other logistic support to the institution in which the trained scientists have to work” [165]	[165]
	Building	“strengthening the abilities of individuals, institutions, and countries to perform research functions, defining national problems and priorities, solving national problems, utilizing the results of research in policy making and programme delivery.” [9]	[46]
	Strengthening	“goes beyond facilitating or funding a research project to the broader objectives of nurturing the prerequisites of the research process, such as state and institutional support, specialized training, infrastructural development, networking opportunities, publications and career paths.” [79]	[79]
	Building	“a deliberate effort to augment health and social science research outputs as well as human capital, so as to favourably impact upon a research focus area” [166] ⁵	[166]
Capacity	Building	“a process that improves the ability of a person, group, organisation or system to meet its objectives or perform better” [10]	[25]
	Building	“the process of helping communities and organisations harness human, technical and financial resources, which allows them to respond adequately to health issues in ways that inform such policies” [11]	[133]
	Strengthening	“process through which people, organisations, and society as a whole are enabled to shape their own development and adapt it to changing conditions and frameworks” [12]	[66]
	Strengthening	“process of improving individual skills, processes, and structures at the organisational level and the networks and context in which the organisation functions” [65]	[65]
	Building	“helping recipient countries to invent, develop and maintain institutions and organisations which are capable of learning and bringing about their own transformation, so that they can play a dynamic role in supporting national development processes” [13]	[150]
	Strengthening	“the ability of individuals or groups to perform tasks in a sustainable manner” [47]	[47]
Organisational capacity	Development	“the capacity of research departments in universities, think tanks and so on to fund, manage and maintain themselves” [14]	[27]
Progress	Building [142] Development [143]	“ability to understand, interpret, select, adapt, use, transmit, diffuse, produce and commercialise scientific and technological knowledge in ways appropriate to culture, aspirations and level of development” [15]	[142, 143]

1. Numbered citations in italics pertain to the reference list in Supplementary Table 1. Numbered citations in normal (non-italicised) font are listed below. 2. Presented as a definition of ‘Health Systems Research’ capacity. 3. Presented as a definition of ‘research capacity’ in citing publication, but included in the ‘health research capacity’ definition list as contains specific reference to ‘health research’. 4. Cited as definition of ‘health’ research capacity in [123]. 5. Presented as a definition of ‘capacity’ in citing publication, but included in the ‘research capacity’ definition list as contains specific reference to ‘research’

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Supplementary Table 10. Content analysis of capacity definitions by capacity term¹

Subject Defined	Capacity Term	Content Domains ²									
		Ind.	Ins.	Env.	Def.	Car.	App.	Qua	Sus.	Pro.	Con
Health Research Capacity	Building [139]	x	x					x		x	
Health Research Capacity	Building [97]	x	x						x		
Research Capacity	Building [132]					x	x				
Research Capacity	Building [91, 96]	x	x			x	x	x			
Research Capacity	Building [130]	x	x	x						x	x
Research Capacity	Building [46]	x	x	x	x	x	x	x			
Research Capacity	Building [166]	x				x		x			
Capacity	Building [25]	x	x	x					x		x
Capacity	Building [133]		x	x				x			x
Capacity	Building [150]		x	x					x		
Progress	Building [142], Development [143]					x	x				
Health Research Capacity	Building [30], Strengthening [70]	x	x	x		x	x		x		
Health Research Capacity	Building [166], Strengthening [74, 126]		x		x	x			x		
Research Capacity	Building [164], Strengthening [29, 123, 159]	x	x	x	x	x	x			x	x
Health Research Capacity	Strengthening [123]			x					x		
Health Research Capacity	Strengthening [48]					x	x				
Research Capacity	Strengthening [16, 72]	x	x			x		x		x	
Research Capacity	Strengthening [165]	x	x			x		x			
Research Capacity	Strengthening [79]	x	x	x							
Capacity	Strengthening [66]	x	x	x						x	
Capacity	Strengthening [65]	x	x	x				x		x	
Capacity	Strengthening [47]	x				x			x		
Research Capacity	Development [4], Strengthening [31, 74]	x	x	x	x	x	x	x	x	x	
Health Research Capacity	Development [45]		x						x		x
Organisational Capacity	Development [27]		x							x	
Progress	Building [142], Development [143]					x	x				

1. Numbered citations pertain to the reference list in Supplementary Table 1. 2. The content of each definition was independently coded according to the following criteria: explicit reference to individual (ind.), institutional (Ins.) or environmental (Env.) level capacity strengthening; explicit reference to strengthening capacity in terms of defining research questions or identifying research priorities (Def.), conducting research or applying research methods (Car.) or communicating and applying research outcomes

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3 (App.); explicit reference to facilitating an improvement in research abilities/quality (Qua.) sustainability (Sus.), reference to HRCS as a process (Pro.) and/or HRCS as a
4 continuous activity (Con.).
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