

Collective health research assessment: Development of a tool to measure the impact of multi-stakeholder research initiatives

Anna-Aurora Kork (✉ anna.kork@tuni.fi)

Tampere University: Tampereen Yliopisto <https://orcid.org/0000-0002-2658-0918>

Carla Antonini

Universidad Autónoma de Madrid: Universidad Autonoma de Madrid

Nicolás García-Torea

Universidad de Burgos

Mercedes Luque-Vílchez

Universidad de Cordoba

Ericka Costa

University of Trento: Università degli Studi di Trento

Juliette Senn

Montpellier Business School

Carlos Larrinaga

Universidad de Burgos

Deborah Bertorello

FISM: Associazione Italiana Sclerosi Multipla

Giampaolo Brichetto

FISM: Associazione Italiana Sclerosi Multipla

Paola Zarin

FISM: Associazione Italiana Sclerosi Multipla

Michele Andreus

University of Trento: Università degli Studi di Trento

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Abstract

Background

The need for measuring the impact of health research more collaboratively and from multi-dimensional perspectives has been acknowledged. As part of a Collective Research Impact Framework (CRIF), a scorecard was developed that will engage stakeholders in measuring the impacts of health research and innovation. The purpose of this study is to describe the developmental process of the MULTI-ACT Master Scorecard and how it can be used as a practical tool for assessing future responsible research and innovation actions collectively.

Methods

Based on an extensive review of the health research impact literature and multi-stakeholder initiatives, a total of 1,556 impact indicators were collected into a database. The Master Scorecard was then co-created by engaging key stakeholders and conducting semi-structured interviews with experts in the field.

Results

The MULTI-ACT Master Scorecard consists of five accountability dimensions: the excellence, efficacy, economic, social and patient-reported dimensions. The tool includes 126 potential indicators classified into 52 measurement aspects that are considered the most relevant topics applicable to multi-stakeholder research and innovation initiatives in assessing their impact based on their mission and stakeholders' interests. The MULTI-ACT Master Scorecard allows the strategic management of multi-stakeholder research initiatives to demonstrate their research impact on people and society. The value of the tool is that it is comprehensive, customizable and easy to use.

Conclusions

The MULTI-ACT Master Scorecard is an example of how the views of society can be taken into account in assessing research impacts in a more sustainable and balanced way. The engagement of patients and other stakeholders is an integral part of the CRIF, facilitating collaborative decision-making in the design of policies and research agendas. In policy-making, the collective approach allows extending the evaluation perspective to the needs of society and toward responsible research and innovation. Multi-dimensionality fosters research and innovations to be more responsive to systemic challenges and developing more equitable and sustainable health services.

Background

Concerns have recently been raised about the social impact and ethical considerations of research. In health research, studies have identified a high level of dissatisfaction about how research is being assessed and how its effects are defined mostly in academic or economic terms [1–3]. In more detail, the traditional assessment of health research based on academic outputs is, arguably, linked with (i) a lack of translation of health research into healthcare policy and practice [4, 5] and (ii) an ineffective use of scarce resources in both research and health systems [6]. Therefore, measuring research impact beyond traditional measures is considered crucial [7, 8]. In the search for new measures, ethical issues [9] and the needs of patients and society [10] are given prominence.

Previous research has stated the need for a paradigm shift in measuring the impacts of health research toward more collaborative and multi-dimensional forms of assessment, such as engaging a wide array of stakeholders [11] and considering multi-cultural environments [12] to collectively define impact assessment systems [10, 13]. To this end, the European Commission [14] has proposed the “Responsible Research and Innovation” (RRI) approach to making research more inclusive, responsive and sustainable. The key aims are promoting public engagement, gender equality, ethics, science education and open access in research governance [15]. Overall, RRI means that a wide variety of stakeholders work together to align both research processes and outcomes with the values, needs and expectations of society [16–18].

This paper presents a framework with a tool that facilitates the operationalization of the RRI approach. The Collective Research Impact Framework (CRIF) was developed in the MULTI-ACT project in line with the European RRI action to go beyond the traditional forms of research assessment and to increase the impact of health research on patients and society. A specific focus was on brain diseases, which have been causing a high proportion of disabilities and deaths [19]. Therefore, the effects of brain diseases are significant for the healthcare system, increasing the heavy burden for society, the economy, patients and their families [20, 21]. The premise of MULTI-ACT lies in the observation that sustainable research needs a transformational mission and collective impact measurement [13]. Instead of single solutions provided by individual organizations, reaching an impact on patients and society requires collective action and a shared mission defined by all the relevant stakeholders. This innovative co-accountability strategy of MULTI-ACT calls for novel frameworks and impact measurement systems that respond to different demands of stakeholders and enable the alignment of a plurality of interests toward a shared mission (see [22]).

Despite the growing importance attached to RRI and creating innovations that can better address population health needs, there are currently no tools that can help to *evaluate* RRI requirements in the health sector. A considerable number of studies have focused on developing frameworks for *implementing* RRI (see e.g. [16, 23, 24]), but there is a lack of tools allowing the assessment of whether and how research and innovations are actually following the RRI approach, aligned with the needs of society or considering the patient as the core element of the impact measurement. Hence, to address these needs and challenges, the CRIF and a specific impact measurement system were developed to

assess the impacts of multi-stakeholder initiatives by emphasizing multi-dimensionality and patient engagement.

The CRIF is a responsive model that allows the participation of multiple stakeholders involved in health research and innovation. The framework takes into account the diversity of interests of stakeholders as well as reflecting the variety of measurement aspects related to health research impacts. Multi-dimensionality is based on a broad understanding of the return on investment aligned with the needs and values of different stakeholders, such as patients and their caregivers, rather than purely focused on short-term financial outcomes. In aligning divergent priorities of different stakeholders, the measurement system enables the co-accountability of all relevant stakeholders to progress toward the shared mission for the benefit the whole of society.

In a time of sustainability challenges that involve transformative missions such as those in the health field, the future RRI requires new multi-stakeholder and multi-disciplinary models of cooperation that guarantee a long-term return on investment, not only economic. One innovative feature of the CRIF versus existing frameworks is that it considers the mission-related dimension as one explicit driver for accountability. In doing so, it introduces the dimension of the efficacy of a research initiative interpreted and evaluated as to its capacity to fulfill the shared mission. Efficacy (along with the other impact dimensions detailed hereafter) acts as a pivotal element to promote research programs and projects having an impact on patients and society. Around this core revolves the development of high-quality health research (excellence), which has to be aligned with the mission success of health research (efficacy), the co-participation of all the stakeholders who are directly or indirectly participating in the field (social), while enabling financial sustainability (economic). The fifth dimension (patient-reported outcomes) is transversal, to be applied across the other four dimensions. It covers investigating the impacts on patients and people affected by a disease and highlighting the active engagement of stakeholders during the whole research process. Figure 1 shows the five accountability dimensions of the CRIF that reflect the interrelated perspectives of impact measurement: excellence, efficacy, economic, social, and patient-reported outcomes.

As an integral part of this framework, the MULTI-ACT Master Scorecard (MSC) was designed to foster the collective evaluation of impacts. So far, most of the conventional research measurement systems for assessing the impact on people or health have not been effective, as they lack shared impact measures or a supporting infrastructure to allow for the true alignment of efforts and accountability of results. This has discouraged the true commitment of the various stakeholders to be co-accountable and thus narrowed the impact measurement of health research. To overcome these issues, the MSC was developed as a practical tool that can be used for collaborative decision-making in assessing the return on investment that best reflects the mission, relevant claims and issues for each stakeholder, including benefits for patients and society. The MSC can be applied at the beginning or during the development of a research initiative to engage multiple stakeholders in collectively defining the impact indicators toward a given mission.

This study describes the development process of the MSC, which, consistently with RRI, was multi-stakeholder in nature, combining expertise in different fields with literature reviews, individual interviews and focus groups with experts, patient organizations and practitioners. The contribution of this paper is twofold. First, the study attends to the call of going beyond conventional metrics for assessing the impact of research [3, 10] and implementing RRI [16, 25–26]. Second, by doing this, the article presents the MSC with the multi-dimensional impact indicators to assist future multi-stakeholder initiatives in the field of health research to measure their impact, particularly their collaborative actions aligned with the RRI approach.

The remainder of the paper is organized as follows. The next section lays out the methods and the key developmental phases of the MSC. In section 3, the results of the analysis and thus the advanced MSC with its functionalities and multi-dimensional impact indicators are presented. The paper concludes with a discussion of the potential value and the usability of this kind of collaborative measurement tool for implementing and assessing the RRI actions of future multi-stakeholder initiatives.

Methods

To develop a formal tool to assess the impact of health research aligned with RRI, we utilized the key principles identified from the RRI literature that were applied in building the five dimensions of the CRIF. These criteria included participatory governance, effective and inclusive stakeholder engagement, shared mission and agenda and collective measurement for the bottom-up evaluation of health research impacts that advance collaboration between science and society and integrate scientific excellence with patients' needs and social responsibility.

The MULTI-ACT Scorecard was accomplished by drawing from lessons learned through the whole multi-stakeholder engagement process carried out by the MULTI-ACT project. First, an initial database of the health research impact indicators was built through a meta-review and systematic literature review to explore existing health research impact frameworks and indicators already being used in the health sector and multi-stakeholder organizations. Second, as the engagement of stakeholders lies at the core of the MULTI-ACT approach, key stakeholders were identified to adopt a multi-stakeholder engagement and co-creation approach to gather their perceptions to refine the selection of the most suitable indicators. The methods for the data collection and analysis are described below.

Initial collection of impact indicators: Meta-review and systematic literature reviews

The analysis of the academic and non-academic literature on health research impact and multi-stakeholder initiatives has informed the development of an initial database on health research impact indicators (Figure 2). This database formed the basis for the development of MSC.

A tentative meta-review was conducted on previous health research impact frameworks proposing indicators and measurement dimensions on health research assessment (e.g. [26–28]). These frameworks have some limitations concerning their suitability for assessing the impact of multi-stakeholder initiatives (e.g. lack of patient engagement and stakeholder participation in defining the indicators, limited coverage of multi-dimensional impacts or implementation of indicators in practice). Therefore, we also performed the literature review on academic and non-academic research (not limited to health research) impact studies focused on multi-stakeholder initiatives between 1992 and 2017. We identified 19 documents proposing specific indicators for measuring research impact for more detailed analysis. In particular, we collected proposed indicators from the payback model [29], the expected monetary value [30], the Research Impact Framework [31], the Research Excellence Framework [32], logic models [33, 34], the Canadian Academy of Health Sciences model [35], and the hybrid forms of these frameworks [36–48].

The selection of documents was combined with an additional systematic literature review in the Scopus database to gather other specific impact indicators used in practice in health sector organizations and the pharma industry. The following search phrases were used: (1) “health services” OR “health systems” OR “health research”; (2) “payback”; (3) “indicators” OR “measurement” OR “metrics.” For the pharma industry, the Scopus search included: (1) “pharmaceutical industry” OR “pharmaceutical sector” OR “pharmaceutical business” OR “pharmaceutical compan*” OR “pharmaceutical firm” OR “pharmaceutical corporation”; (2) “performance assessment” OR “performance measurement” OR “impact”; (3) “indicators” OR “metrics.” For the deeper analysis, we only included studies that provided multi-dimensional indicators. We also considered grey literature through a Google search to look for reports of non-academic initiatives that contained a specific list of indicators. The final sample consisted of 32 academic articles and 15 non-academic initiatives.

To identify the potential patient-reported outcomes (PRO) indicators for the patient-reported dimension (PRD), a literature review was performed on the current evidence of their usage for research and innovation assessment and a benchmark with relevant existing PRO initiatives such as PROMS, PROMOPRO-MS, iConquerMS™ [49]. In addition, building on the MULTI-ACT patient engagement guidelines and the related public consultation, a selection of indicators for assessing the performance and effectiveness of patient engagement directly from the patient’s perspective was identified and included under the PRD. The rationale and methodology of the PRD are detailed in the MULTI-ACT guidelines and reports (see [50, 51]).

Content analysis for building the indicator database

The indicators identified from all these reviews were analyzed and combined into a database that provided a long list of 1556 indicators used or suggested in measuring the impact of health research. The indicators were then classified according to the five CRIF dimensions: excellence, efficacy, economic, social and patient-reported outcomes. The payback model taxonomy [29] was chosen as a backbone for the indicator classification as it is a widely recognized framework for measuring health research impact [52, 53] and its categories were easily associated with the CRIF dimensions. Following an inductive

approach, we fine-tuned the initial categorization and further group the indicators into 52 measurement aspects based on the topics they represented within each CRIF dimension.

To filter down the number of indicators according to their robustness and serving for the multi-stakeholder research initiatives, at least one core indicator and one additional indicator were selected for each measurement aspect. The indicators were determined based on their appearance frequency in the literature and their relevance to the CRIF dimensions, grounded in the expertise and values espoused by MULTI-ACT. In line with the methodology applied to the other four dimensions, the PRD was developed with the identification of the most relevant aspects to the specific stakeholder category “patients” and selecting the indicators able to measure those identified aspects. All the indicators included under the PRD met the inclusion criteria to be reported by patients (and/or remotely collected) without the intervention of the clinician. The aspects and indicators for the PRD were integrated into the database with the other four dimensions. A shortlist included the final selection of the 126 most relevant indicators to measure the multi-dimensional impacts of health research.

Expert consultation and engagement: Semi-structured interviews and focus groups

Co-creation is an essential principle of the MULTI-ACT model. To collect the perceptions of stakeholders in the health research domain, interviews and focus groups were organized to engage stakeholders during the CRIF development process. Based on Concannon et al.'s [54] stakeholder taxonomy, the relevant stakeholder groups were identified: patient and patient organizations, research organizations and funders, policymakers, the pharma industry and healthcare providers. Stakeholders were then chosen according to their salience for constructing the CRIF. A preliminary mapping of 50 potential stakeholders was analyzed to select those to be invited to the Strategic Working Meeting, considering that they represented 1) a plurality of perspectives from social to economic, and 2) different interests and needs in the health research field, but also their 3) strategic importance for the project to achieve its mission, such as policymakers or patient organizations. The final selection of the most relevant stakeholders (n=12) was made considering deliberative and democratic principles [55] and stakeholders' attributes [56]. The Strategic Working Meeting was held to identify and understand the different interests of the stakeholders and the perspectives and dimensions of health research they consider important in the development of the CRIF.

We also interviewed eight members of the MULTI-ACT External Advisory Board representing the following stakeholder types: academia, patients & patients' organizations, pharma industry, healthcare organizations, health authorities, health innovation and neurodegenerative diseases. Using inductive, semi-structured interviews, we examined stakeholders' perceptions of the potential impact indicators as well as testing the CRIF dimensions. The interviews were held between December 2018 and February 2019, each interview taking approximately one hour. The interview protocol was flexible, giving the interviewer the possibility to adapt the questions according to the interviewee and the context. It contained 11 core questions with additional questions to guide the conversation when necessary. The

questions covered themes related to the suitability of the CRIF dimensions, as well as the aspects and indicators identified in the literature review.

The information and feedback received from the interviews and focus groups enabled the refinement of the selection and classification of the indicators identified from the literature reviews. As a result of the data content analysis, the MSC was finalized and its functionalities are presented in the next section.

Results

The MSC translates the philosophy and agenda of MULTI-ACT into action by providing a wide range of the most relevant indicators evaluating different applicable topics for multi-stakeholder initiatives. The MSC offers a catalogue of 126 indicators to evaluate the impact of health research. The indicators cover 52 significant measurement aspects related to the five CRIF dimensions: excellence, efficacy, economic, social and patient-reported outcomes. The core indicators (n=55) imply that they are the most-cited in the literature and thus principal for representing the aspect. The additional indicators (n=71) in turn characterize other relevant indicators based either on the literature or their value for enriching the CRIF dimension. Table 1 describes the distribution of indicators per dimension and measurement aspect (see Additional file 1 for details).

Table 1
The MULTI-ACT Master Scorecard and the distribution of indicators

Dimensions	Aspects	Indicators	Core indicators	Additional indicators
Excellence	20	57	20	37
Efficacy	9	22	9	13
Economic	9	20	9	11
Social	6	15	7	8
Patient-reported	8	12	10	2
Total	52	126	55	71

The MSC includes a description of each indicator, the method of measurement and examples and the type of information needed for each indicator (see Table 2). Along with the other elements of the MULTI-ACT model, the MSC is integrated into the MULTI-ACT Digital Toolbox (available at <https://toolbox.multiact.eu>). This online platform provides information on each indicator to help research initiatives in their production. In addition to specifying the dimension and aspect that an indicator covers, the MSC provides information on how to collect and report the data.

Table 2
Functionalities included in each indicator of the MULTI-ACT Master Scorecard

Information	Description
Dimension	The CRIF dimension to which the indicator relates (excellence, efficacy, economic, social and patient-reported outcomes).
Aspect to be measured	Key topic evaluated by the indicator within each dimension.
Type of indicator	Type of indicator within each aspect: core or additional.
Description	The content of the indicator.
Example	Example from the report or website of health organizations.
Associated terms	Definition of associated terms that are relevant for understanding the indicator.
Comments	Notes that clarify issues related to the computation or use of the indicator.
Data type	Overall classification of the type of data the indicator provides: quantitative or qualitative.
Expected frequency of data collection	How often data is expected to be collected.
Expected frequency of data dissemination	How often data is expected to be disseminated.
Indicator in use	Whether the indicator is currently being used: Yes/No.
Limitations	Issues that should be considered when using the indicator.
Links	Additional resources that could be helpful in computing and using the indicator.
Method of measurement	Description of how the indicator can be measured and reported.
Monitoring and evaluation framework	Research stage that the indicator evaluates: input, process, output, outcome, impact.
Preferred data sources	Data sources for gathering the data required for elaborating the indicator.
Rationale	Relevance of the indicator and advantages of using it.
Type of information to be reported	Classification of the information provided in the indicator (e.g. number in physical units, percentage, narrative description, etc.).
Unit of measure	If the indicator is quantitative, units in which the indicator is measured (e.g. number of articles).

One specific feature of the MSC is that the patient-reported dimension enables the science of patient input, i.e. when data from people with a disease are used (active and passive contribution) to evaluate the impact of research and innovation. The PRD includes indicators that are reported by patients, family

members and caregivers addressing functional or psychosocial reported aspects such as patient-reported outcomes and indicators to evaluate the return on engagement. PROs are investigated as indicators able to measure the outcomes that matter most to patients and keep patients and stakeholders engaged along the research and innovation continuum. PROs are outcomes evaluated directly by the patient and based on the patient's perception of a disease and its treatment [57]. These indicators can be a collection of responses to questionnaires and active or passive data collection without the intervention of clinicians (e.g. eHealth via applications or technological devices such as wearables or electronic bracelets).

In the MSC, the PRD reports the perspective of the patient and/or provides continued objective data (eHealth), therefore is not influenced by the clinician. The rationale is that the development of PROs as key indicators of impact is instrumental to enable a multi-stakeholder approach and effective patient engagement. PROs are scientifically validated measures reported by patients able to capture their needs as final beneficiaries of research, thus capturing the interest of all the health stakeholders.

To operationalize the MSC, multi-stakeholder research initiatives are recommended to select a minimum of one indicator per dimension and to a maximum of 12 indicators in total. This will guarantee that the initiatives take into account the different interests of their stakeholders and assess their progress based on a holistic, democratic and co-accountable approach. The materiality analysis allows the stakeholders to express their judgments on which measurement aspects and impact indicators of the Master Scorecard are the most (1) relevant for the initiative's mission and agenda and (2) otherwise considered as material in making decisions. The MSC was validated and tested in the real case study of the Multiple Sclerosis Care Unit. The most relevant indicators for them can be identified through conducting the collective materiality analysis in the MULTI-ACT Toolbox.

Discussion

Measuring the impact of multi-stakeholder health research and innovation initiatives in line with the RRI approach is still in its infancy. In this paper, we provided insights into the developmental process of one practical evaluation tool and how it can be used for assessing future RRI actions collectively to push the agenda forward. A review conducted on previous health research impact frameworks proposing indicators and measurement dimensions on health research assessment (e.g. [26–28]) revealed these frameworks contained some limitations concerning their suitability for assessing the impact of multi-stakeholder initiatives, for example, lack of patient engagement and stakeholder participation in defining the indicators, limited coverage of multi-dimensionality or responsiveness to multi-stakeholder claims. More particularly, different frameworks for implementing RRI have been developed [58], but the specific tools to assess RRI actions and their impact on patients and society have been largely missing. Although there have been some studies proposing evaluation frameworks or quality criteria and indicators for fostering RRI policies (see e.g. [16, 23, 24]), the practical tools for operationalizing the frameworks and measuring the impact of research in a holistic way remain largely unexplored.

In the MULTI-ACT model, the mission-related dimension, i.e. the efficacy of research, is considered a key element to achieving the shared mission and collective impact [3, 10, 25]. Therefore, the measurement system needs to be based on collective decision-making, respect the multiple interests and put the stakeholders and patient engagement at the core of the impact assessment process. The literature revealed that, where the broader research impact has been assessed, the vast majority of studies have relied on researchers' views or peer review to assess impacts, instead of discussing or involving other important stakeholders or end-users of research such as patients (see e.g. [1, 2, 11, 13]). This would seem to be a methodological weakness of previous frameworks, leaving the research impact assessment process incomplete. Against this background, in the MULTI-ACT model and MSC development process, multiple stakeholder groups related to research (including end-users) are identified and engaged from the beginning of the project activities as well as testing the idea of impact dimensions through strategic working meetings, interviews, public consultation and advisory boards.

For future multi-stakeholder initiatives, our study shows how the MSC can be applied and developed as part of the collective research impact framework. The main contribution of the study is to facilitate the evaluation of RRI actions and engaging multiple stakeholders in measuring the impacts of health research. The results indicate that making stakeholders co-accountable for the research actions is an essential element if we want to achieve broader social impact. To promote the inclusiveness and social responsibility of research, multiple stakeholders should be engaged in decision-making and have the opportunity to select the most material indicators for them. The MSC is a practical tool that helps to gather and respond to diverse stakeholders' demands. It demonstrates that it is possible to integrate perspectives and multiple measurement aspects. The MSC introduces a selection of potential indicators classified under different research impact dimensions such as excellence, efficacy, social, economic and patient-reported outcomes. In doing so, the chosen set of indicators is expected to facilitate reaching objectives according to the shared mission, enabling each stakeholder to be involved and receive a return on investment, whatever form that might take.

The practical implication of the study is that the MSC can be exploited in managing health research and innovation initiatives, identifying their research outcomes or controlling and improving their performance. Instead of providing a 'score' or 'ranking,' the MSC provides information for and feedback from all stakeholders. The MULTI-ACT digital toolbox is freely accessible and applicable online. The policy and managerial implication of the study is that the potential MSC users such as research organizations, institutions and research funders can apply it during different phases and to serve different purposes (see Table 3): for instance, at the beginning of the project for planning, during the project for monitoring and at the end for assessing the outcomes. The final output will help initiatives to evaluate RRI requirements and to understand thus the multiple impacts that their activities can produce.

Table 3
Possibilities to apply the MULTI-ACT Master Scorecard during different phases

Initiation	Planning: The CRIF dimensions and the potential indicators allow the research initiative to strategically design and evaluate (ex-ante) the expected impact of research, in line with its vision and agenda.
Execution	Monitoring: the MSC can serve to implement the shared mission of the initiative. It can be used as a monitoring tool to assess the RRI activities. It could be used iteratively during the execution of the initiative.
Evaluation and feedback	Assessment: the MSC can be applied at the end of the initiative to assess <i>how</i> the desired results were reached. If the MSC is applied from the beginning of the project, the impacts can be compared with the initial evaluation output. This can help to strategically orient also future initiatives.

Conclusions

Our study shows that the MSC is an example of how the views of society are a critical starting point in developing new indicators to assess research impact. Overall, this collective research impact approach allows the measurement perspective to be extended from the traditional performance evaluation and short-term financial return on investment to society at large and the demands of RRI. Multi-dimensionality may foster research and innovations to be more responsive to systemic challenges and developing more equitable and sustainable health services. From the policy development viewpoint, the presented framework is useful for multi-stakeholder initiatives aiming to facilitate collaborative decision-making in the design of policies, agendas, funding programs and evaluation procedures or to increase the impact of research on people and society.

Abbreviations

CRIF
Collective Research Impact Framework
MSC
MULTI-ACT Master Scorecard
PRD
Patient-Reported Dimension
PRO
Patient-Reported Outcomes
RRI
Responsible Research and Innovation

Declarations

Ethics approval and consent to participate: The MULTI-ACT project has been ruled directly through European Commission and Agency requirements. The need for ethical committee approval does not

apply to the project as it did not entail any health research activity (intervention, treatment, or testing) on human participants. Neither children nor adults unable to give informed consent were involved in the research. Representatives of patients' associations were consulted on the research activities, and contributed thus as specific advisory bodies of the project. Written informed consent for participation in the research was obtained from all people involved. All research processes were overseen by the ethical manager of the consortium and by the external ethical advisor as required by the EC, Ethics Requirement No.6 of the Ethics Summary Report (Ref. Ares (2017)5910822 – 03/12/2017).

Consent for publication: Not applicable. The research did not involve processing sensitive personal data. All data collection and processing were carried out in compliance with EU and national legislation, consent procedures, and EU General Data Protection Regulation (GDPR).

Availability of data and materials: The dataset supporting the results of this article is available in the MULTI-ACT repository, at <https://www.multiact.eu>. The presented framework and a scorecard are freely exploitable through the MULTI-ACT Digital Toolbox at <https://toolbox.multiact.eu/>

Competing interests: The authors were members of the MULTI-ACT consortium and claim to have no competing interests.

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Authors' contributions: Background: AK, CA, MLV, CL, PZ Methods: AK, NGT, EC, DB, GB, PZ, MA Results: AK, NGT, EC, DB, GB, PZ Discussion: AK, MLV, JS, DB, PZ Conclusions: AK, MLV, JS. All authors read and approved the final manuscript.

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Figures



Figure 1

Interrelated impact measurement dimensions in the Collective Research Impact Framework

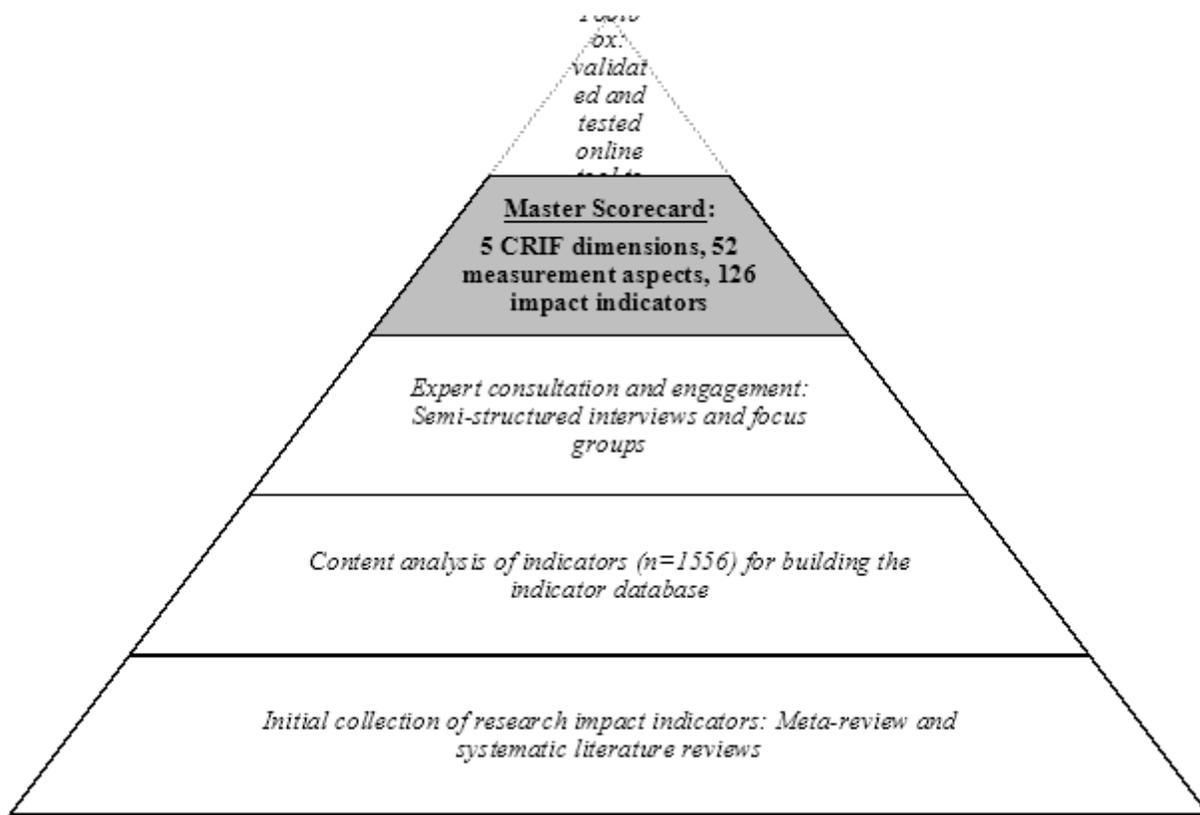


Figure 2

Key phases in the development process of the MULTI-ACT Master Scorecard

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