Biomedical researchers' perspectives on the reproducibility of research: a cross-sectional international survey

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Abstract

We conducted an international cross-sectional survey of biomedical researchers' perspectives on the reproducibility of research. This study builds on a widely cited 2016 survey on reproducibility, and provides a biomedical-specific and contemporary perspective on reproducibility. To sample the community, we randomly selected 400 journals indexed in MEDLINE, from which we extracted the author names and e-mails from all articles published between October 1, 2020 and October 1, 2021. We invited participants to complete an anonymous online survey which collected basic demographic information, perceptions about a reproducibility crisis, perceived causes of irreproducibility of research results, experience conducting replication studies, and knowledge of funding and training for research on reproducibility. A total of 1924 participants accessed our survey, of which 1630 provided useable responses (response rate 7% of 23,234). Key findings include that 72% of participants agreed there was a reproducibility crisis in biomedicine, with 27% of participants indicating the crisis was 'significant'. The leading perceived cause of irreproducibility was a 'pressure to publish' with 62% of participants indicating it 'always' or 'very often' contributes. About half of the participants (54%) had run a replication of their own previously published study while slightly more (57%) had run a replication of another researcher's study. Just 16% of participants indicated their institution had established procedures to enhance the reproducibility of biomedical research; and 67% felt their institution valued new research over replication studies. Participants also reported few opportunities to obtain funding to attempt to reproduce a study and 83% perceived it would be harder to do so than to get funding to do a novel study. Our results may be used to guide training and interventions to improve research reproducibility and to monitor rates of reproducibility over time. The findings are also relevant to policy makers and academic leadership looking to create incentives and research cultures that support reproducibility and value research quality.

Introduction

There is growing interest in both the reproducibility of research and around ways to enhance research transparency[1–4]. Terminology around reproducibility varies[5]; here we define reproducibility as re-doing a study using similar methods and obtaining findings consistent with the original study; and as irreproducible when the findings are not confirmed. This definition allows for variation in methods between the original study and the reproducibility study. Reproducibility of research is core to maintaining research trustworthiness and to fostering translation and progressive discovery. Despite the seemingly critical role of reproducibility of research and growing discussions surrounding reproducibility, the reality is that most studies, including pivotal studies within several disciplines, have never been formally subjected to a reproducibility effort. For example, in education research, an analysis of publications in the field's top 100 journals showed that just 0.13% publications (221 out of 164,589) described reproducibility projects[6]. In psychology, a study examining 250 articles published between 2014-2017 found that 5% described a replication[7], while a similar study examining replication rates in social sciences found that just 1% of articles sampled described a replication[8]. Across disciplines, our knowledge about the proportion of studies that are reproducible tends to be dominated by a small number of large-scale reproducibility projects. In psychology, for example, a study which estimated the replicability of 100 foundational studies in top journals in the field reported that only 36% had statistically significant results (one measure of replicability), compared to 97% of the original studies[9].

In 2016, *Nature* conducted a survey of more than 1,500 researchers about their perceptions of reproducibility. They found that 83% agreed there was a reproducibility crisis in science, with 52% indicating that they felt the crisis was 'significant'[10]. Survey studies like this play a powerful role in elucidating the determinants of reproducibility. Such information is essential to identify gaps in factors including training, research support, and incentives to ensure reproducible research. Given the global

nature of research, capturing global perspectives as was done in the *Nature* survey is crucial to obtaining broad understanding of issues across the research ecosystem.

In this study, we aim to build on the 2016 *Nature* survey on reproducibility by surveying researchers in the biomedical community specifically. There is immediate importance to ensuring biomedical research is reproducible: we know that in biomedicine, studies that were subsequently not reproducible may have led to patient harms[11,12]. By capturing a diverse and global group of biomedical researchers' perceptions of reproducibility within the field we hope to better understand how to ensure reproducibility in biomedicine. Our specific objectives were to: 1) explore biomedical researchers' perceptions of reproducibility and their perceptions of causes of irreproducibility; and 2) describe biomedical researchers' experiences conducting and publishing reproducibility projects. The study was descriptive, we have no formal hypotheses. To address our objectives, we used an adapted version of the 2016 *Nature* reproducibility survey; this allows for a comparison of results between the two cross-sectional studies.

Methods

Open science statement

This study received ethics approval from the Ottawa Health Sciences Research Ethics Board. This study protocol was registered a priori, and data and materials have been made available: https://osf.io/3ksvz/.[13]

Study design

We conducted an online cross-sectional closed survey of researchers who published a paper in a journal indexed in MEDLINE. The survey was anonymous.

Sampling framework

We downloaded the MEDLINE database of journals. From this list of approximately 30,000 journals we selected a random sample of 400 journals using the RAND() function in Excel. We then extracted the author names and e-mails from all articles published in those journals between 1 Oct 2020 to 1 Oct 2021. We included all authors whose names and emails were available and all article types/study designs. For full details on our semi-automated approach to extracting author emails please see our search strategy in S1.

Participant Recruitment

The survey was sent only to those researchers identified via our sampling procedure (i.e., a closed survey). Potential participants received an email containing a recruitment script which detailed the purpose of the study and invited them to review our informed consent form and complete our anonymous online survey. Participation in the survey served as implied consent; we did not require signed consent to maintain anonymity. To send emails to the sample of authors we used Mail Merge software. This tool allows for the personalization of emails without having to individually customize and send each out. In the case of non-response, we sent three reminder emails to potential participants at weekly intervals after the initial invitation. We closed the survey 4 weeks after the initial invitation. We did not provide any specific incentive to complete the survey.

Survey

The full survey is available in S2. The survey was administered using SurveyMonkey. The survey contained four demographic questions about the participants, including their gender, research role,

research area, and country of residence. Participants were asked to complete questions about their perceptions of reproducibility in biomedicine, questions about their experience with reproducibility, and questions about perceptions of barriers and facilitators to conducting reproducibility projects. The survey used adaptive formatting to present only certain items based on the participant's response to previous questions. Most questions were multiple choice, with two questions asking participants to expand on their responses using a free-text box. The survey was purpose-built for the study by the research team, building directly off the previously published *Nature* reproducibility survey[10]. We included several of the previous study's questions directly in this study, modified some slightly, and made some more specific to the biomedical research setting. This approach allows us to compare our results to the original study. We also introduced some novel questions on reproducibility. The survey was pilot tested by three researchers to ensure clarity and acceptability of format and we edited the survey to address their feedback. Participants were able to skip any question.

Data Management and Analysis

Data were exported from SurveyMonkey and analyzed using SPSS 28. We report descriptive statistics including count and percentages for all quantitative items. For the qualitative items, we conducted a thematic content analysis. To do so, two researchers individually read all text-based responses and assigned a code to summarize the content of the text. Codes were refined iteratively upon exposure to each text-based response read. After discussion to reach consensus on the codes used, we then grouped the agreed codes into themes for reporting in tables.

Results

Protocol amendments

In our original protocol we said we would take a random sample of 1000 journals from MEDLINE, and extract information from the first 20 authors. This approach required extensive manual extraction so we opted to restrict our random sample to 400 journals and semi-automate extraction of author information for an entire year's worth of publications. Our revised method meant that we obtained and used listed emails from all authors on an identified paper (i.e., we were not restricted to corresponding authors).

Demographics

A total of 24,614 emails were sent, but bounce backs were received from 1380, meaning 23,234 emails were sent successfully to potential participants. A total of 1924 participants accessed our survey, of whom 1630 participants provided a completed responses (response rate 7%; this frequency is slightly lower than the estimated 1,800 responses reported in our protocol). Most participants were Faculty Members/Primary Investigators (N=1151, 72%) and more than half of participants were male (N=943, 59%). Respondents were from more than 80 countries, with the USA (N=450, 28%) having the highest representation. About half of participants reported working in clinical research (N=819, 50%). Further demographic details by role, gender, country, and research area are provided in Table 1.

Perceptions of reproducibility

When asked whether there was a reproducibility crisis in biomedicine most researchers agreed (N=1168, 72%), with 27% (N=438) indicating the crisis was significant and 45% (N=703) indicating a slight crisis (we note that a 'slight crisis' is a bit of an oxymoron, but retained the wording from the original *Nature* survey for comparison purposes). Participants were then asked what percentage of papers in each of biomedical research overall, clinical biomedical research, in-vivo biomedical research, and in-vitro biomedical research they thought were reproducible. Only 5% (N=77) thought more than 80% of

biomedical research was reproducible). See Table 2 for complete results. We provide a breakdown of responses between genders, between researchers in different biomedical research areas, and by career rank in Table S3.

Compared to the previously published *Nature* study (N=819, 52%), fewer participants in our study felt there was a 'significant reproducibility crisis' (N=438, 27%). This difference was even larger when we restricted our data to the *Nature* study participants who indicated they worked in medicine (N=203, 60%); for complete results see Table 3.

Determinants of irreproducibility

When presented with various potential causes of irreproducibility, more than half of participants responded that each presented factor contributes to irreproducibility. The top factor participants noted as 'always contributing' to irreproducibility was pressure to publish (N=300, 19%). Factors deemed least likely to contribute to irreproducibility were fraud (N=320, 20%) and bad luck (N=568, 36%). See Table 4 for complete results.

A total of 97 participants provided a written response to elaborate on what they perceived were causes of irreproducibility. Responses were coded into 16 unique codes and then thematically grouped into seven categories: ethics, research methods, statistical issues, incentives, issues with journal and peer review, lack of resources, and other. For definitions and illustrative examples of the codes, see Table 5.

Experiences with reproducibility

Participants were asked about their experience conducting reproducibility projects. Nearly a quarter of participants indicated that they had previously tried to replicate one of their own published studies and

failed to do so (N=373, 23%); whereas 31% (N=501) indicated all such replications they had conducted had yielded the same result as the original; and slightly less than half of participants indicated that they had never tried to replicate any of their own published work (N=734, 46%). Among the 874 participants who indicated they had tried to replicate one of their own studies, when asked to consider their most recent replication effort, 313 (36%) indicated they had published the results. About a quarter of these participants (N=205, 25%), indicated they had no plans to publish their replication study.

Almost half of participants indicated that they had previously tried to replicate a published study conducted by another team and failed to do so (N=724, 47%); whereas 10% (N=156) indicated all replications they had conducted of the work of others had yielded the same result as the original, while 43% (N=666) indicated that they had never tried to replicate someone else's published research. Among those who had published their replication study, when asked to consider their most recent replication effort, 29% (N=224) indicated it took about the same amount of time to publish as a typical non-replication paper. A quarter (N=189; 25%) of participants who had attempted to replicate others' research indicated they had no plans to publish their replication study. Eighty-five percent of participants (N=1316) indicated they had never been contacted by another researcher who was unable to reproduce a finding they previously published. See Table 6 for complete results.

A total of 724 participants responded to the item about why they replicated their own research, of which 675 (93%) provided relevant text-based responses. Responses were coded into 17 unique codes and then grouped into seven themes: training, ensuring reproducibility, additional research, addressing concerns, joining/setting up a new lab, for publication or due to peer review, and other. For illustrative examples of the codes, see Table 7.

A total of 748 participants responded to the item about why they replicated someone else's research, of whom 700 (94%) provided relevant text-based response data. Responses were coded into 19 unique codes and then grouped into seven themes: trustworthiness, extending and improving research, application to new setting, new research, interest, training, and other. For illustrative examples of the codes, see Table 8.

Support for initiatives to enhance reproducibility

Few participants reported that their research institution has established procedures to enhance reproducibility of biomedical research (N=254, 16%), and almost half reported that their institutions did not provide training on how to enhance the reproducibility of research (N=731, 48%) with an additional 503 (33%) reporting they were unsure of whether such training existed. We asked participants to provide information and links to relevant reproducibility training at their institution, which resulted in information or (functioning) links to 24 unique training resources (see S4). Among these 24 sources, just 9 (38%) clearly described specific openly available (e.g., no paywall) training related to reproducibility. Most researchers responded that they perceived their institution would value them doing new biomedical research studies more than replication studies (N=1031, 67%). The majority also indicated that it would be harder to find funding to conduct a replication study than a new study (N=1258, 83%), with just 7% (N=112) indicating they were aware of funders providing specific calls for conducting reproducibility related research.

We asked participants to indicate how much they agreed with the statement "I feel I am more concerned about reproducibility than the average researcher in my field and at my career stage" as a way to indirectly address potential bias in self-selection to complete the survey. Participants responded on a 5-

point scale with endpoints, strongly disagree (1) and strongly agree (5). Participants reported a mean response of 3.2 (N=1402, SD=0.89) which corresponds to the mid-point of the scale 'neither agree nor disagree'. For full results see Table 9.

Discussion

We report the results of an international survey examining perceptions of reproducibility. Almost three quarters of participants reported that they felt there was a reproducibility crisis in biomedicine. The concern appears to apply to biomedicine overall, but also specifically to clinical research, in-vivo research, and in-vitro research (11% or fewer participants indicated that they think more than 80% of papers in each category were reproducible). Researchers agreed that a variety of factors contribute to irreproducibility; however, the chief cause that most participants indicated 'always contributes' to irreproducible research was a pressure to publish. Concerns about how the current system of academic rewards stresses quantity over quality have been expressed for decades[14,15] – a sentiment supported by this study's data, which suggest that researchers' performance is negatively impacted, in terms of producing reproducible research, by what the academic system incentivizes.

More than half of participants reported having tried to replicate their own work previously, with almost a quarter indicating that when they did so they failed, and many indicating that they do not intend to publish their findings. Similar findings were reported when asked about whether participants had tried to replicate another researcher's study, with 57% indicating they had done so, and 47% indicating the replication failed. The majority of participants had not been contacted by another researcher who was unable to reproduce their findings, which suggests that teams of researchers attempting to reproduce

studies don't typically communicate despite the potential value for this contact to enhance reproducibility[9,16].

The findings about institutions influence on reproducibility of research (Table 7) collectively suggest gaps in incentives and support to pursue reproducibility projects. While other stakeholders have taken actions to attempt to foster reproducibility, our results suggest that overall, researchers perceive that institutions are absent from efforts to support and reward research reproducibility[17]. The growth of 'Reproducibility Networks', national peer-led consortiums aiming to promote reproducibility and understand factors related to irreproducibility, are a promising opportunity to rectify this situation[18]. The structure of reproducibility networks allows for harmonization but also flexibility in approach. Obtaining a sustained funding mechanism will be critical to their growth and ongoing success.

This study is based on an extension of an earlier study of more than 1,500 researchers surveyed by Nature about reproducibility[10]. The current study differs in several important ways. Firstly, the focus is exclusively on biomedicine, since to our knowledge no large scale and representative survey of biomedical researchers has been conducted to date. Indeed, just 203 (13%) of the 1,576 researchers who completed the original study indicated 'medicine' as their main area of interest. Secondly, we randomly sampled researchers from publication lists, meaning we are able to report a response rate. This was not possible in the *Nature* survey, which was emailed to *Nature* readers and advertised on affiliated websites and social-media outlets, meaning that the number of individuals encountering the survey is unknown. While it is possible that among those invited to take part there is bias among participants who choose to complete the survey, our approach has been chosen to help minimize surveying those explicitly active in reproducibility projects or related initiatives. Indeed, the finding that overall participants report not to

differ from their belief of their peers regarding their level of concern about reproducibility provides some assurance that our sampling strategy was effective. We also find there isn't much difference between different groups responses (S3).

We find several key differences in our results and that of the original *Nature* paper. For example, in the original study, more than 70% of researchers indicated that they had tried and failed to reproduce another researcher's study, while we find that slightly fewer than 50% of researchers in our study had had this experience. While 52% of participants in the original study reported they felt there was a 'significant' reproducibility crisis, approximately 27% of our participants indicated a significant crisis. These differences may reflect sampling bias, temporal changes in the research ecosystem over time, different perceptions in biomedicine compared to research more broadly, or a combination of these factors.

Concerns about reproducibility are being widely recognized within research but also more broadly in the media[19]. The COVID-19 pandemic has shifted our thinking about research transparency[20] and highlighted issues with fraud in research, poor quality reporting, and poor-quality study design[21,22], all factors that can contribute to irreproducible research. As stakeholders work to introduce training and interventions to enhance reproducibility it will be critical to monitor the effectiveness of these interventions. This international survey provides a contemporary cross-section of the biomedical community; repeating this survey in the future would allow for a temporal comparison on how perceptions and behaviors shift over time. The outcomes of this survey also highlight perceived causes and constraints to producing reproducible research, these can be prioritized within the biomedical community and targeted to create improvement.

Funding: This work did not receive funding.

Author contributions: Conceptualization, Methodology, Validation: KDC; Data curation, Investigation, Formal analysis: KDC, SE, FA; Project administration, Writing- First draft: KDC; Writing-Review and editing: All authors.

Competing interests: The authors have declared that no competing interests exist.

Data Availability Statement: Data and material are available on the OSF or in the supplementary materials.

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Table 1. Participant Demographics

Item	Response options	N	%
Researcher role	Graduate student	88	6
	Postdoctoral fellow	129	8
	Faculty member/PI	1151	72
	Research support staff	54	3
	Scientist in industry	28	2
	Scientist in third sector	27	2
	Government scientist	54	3
	Other	73	5
	Missing data	26	-
Gender	Female	643	40
	Male	943	59
	Non-binary	3	0.2
	Prefer to self-describe	1	0.1
	Prefer not to say	13	1
	Missing data	27	-
Country of Employment (Top 5)	USA	450	28
	Canada	128	8
	UK	105	7
	India	93	6
	Missing data	32	-
Research Area	Clinical research	819	50
	Preclinical research – in vivo	191	12
	Preclinical research – in vitro	163	10
	Health systems research	147	9
	Methods research	81	5
	Other, please specify	227	14
	Missing data	2	-

Table 2. Participant perceptions of reproducibility

Item	Response options	N	%
In your view, is there a reproducibility crisis in biomedicine?	Yes, a significant crisis	438	27
	Yes, a slight crisis	730	45
	No, there is no crisis	237	15
	Don't know	221	14
	Missing data	4	-
What proportion of papers in biomedicine overall do you think are reproducible?	I don't know	264	17
	0-20%	97	6
	21-40%	268	17
	41-60%	491	31
	61-80%	394	25
	81-100%	77	5
	Missing data	39	-
What proportion of papers in clinical biomedical research do you think are reproducible?	I don't know	227	14
	0-20%	119	8
	21-40%	313	20
	41-60%	453	28
	61-80%	366	23
	81-100%	115	7
	Missing data	37	-
What proportion of papers in in-vivo biomedical research do you think are reproducible?	I don't know	364	23
	0-20%	125	8
	21-40%	303	19
	41-60%	361	23
	61-80%	334	21
	81-100%	99	6
	Missing data	44	-
What proportion of papers in in-vitro biomedical research do you think are reproducible?	I don't know	385	24
	0-20%	123	8
	21-40%	253	16
	41-60%	293	19
	61-80%	359	23
	81-100%	174	11
	Missing data	43	-

Table 3. Comparison of responses (in percentage) to the item asking about a reproducibility crisis between the original Nature paper and our findings, presented overall and by discipline.

Responses	Baker study (N= 1576, all responses)	Baker study (N=203, Medicine responses)	All responses (N=1626)	Clinical (N=816)	Preclinical- in vivo (N=190)	Preclinical- in vitro (N=163)	Health systems (N=147)	Methods research (N=81)	Other (N=227)
Yes, a significant crisis	52	60	27	27	29	29	22	27	26
Yes, a slight crisis	38	29	45	42	50	51	50	58	37
No, there is no crisis	3	4	15	15	13	13	10	9	20
Don't know	7	7	14	16	7	7	18	6	16

Responses	Baker study (N= 1576, all responses)		Baker study (N=203, Medicine responses)		All responses (N=1626)		Clinical (N=816)		Preclinical- in vivo (N=190)		Preclinical- in vitro (N=163)		Health systems (N=147)		Methods research (N=81)		Other (N=227)	
Yes, a significant crisis	819	52	121	60	438	27	221	27	55	29	47	29	33	22	22	27	60	26
Yes, a slight crisis	593	38	59	29	730	45	344	42	96	50	83	51	73	50	47	58	85	37
No, there is no crisis	47	3	8	4	237	15	124	15	25	13	21	13	14	10	7	9	46	20
Don't know	117	7	15	7	221	14	127	16	14	7	12	7	27	18	5	6	36	16

Table 4. Participant perceptions of the causes of irreproducibility

Cause	N (%)					
	Always contributes	**Very often Contributes**	**Sometimes Contributes**	**Does not Contribute**	**Unsure**	**Missing data**
Selective reporting of the published literature	131 (8)	638 (40)	714 (45)	43 (3)	73 (5)	31
Selective publication of entire studies	182 (11)	698 (44)	577 (36)	71 (4)	71 (4)	31
Pressure to publish	300 (19)	693 (43)	473 (30)	75 (5)	57 (4)	32
Low statistical power	185 (12)	706 (44)	579 (36)	76 (5)	48 (3)	36
Poor statistical analysis	197 (12)	615 (38)	649 (41)	99 (6)	44 (3)	26
Not enough internal replication (E.g., by the original lab/authors)	132 (8)	539 (34)	697 (44)	93 (6)	142 (9)	27
Insufficient study oversight	86 (5)	376 (24)	799 (50)	194 (12)	143 (9)	32
Lack of training in reproducibility	153 (10)	522 (33)	622 (39)	168 (11)	135 (8)	30
Failure to make materials openly available	141 (9)	449 (28)	722 (45)	191 (12)	99 (6)	28
Failure to make original study data openly available	137 (9)	476 (30)	685 (43)	205 (13)	94 (6)	33
Poor study design	208 (13)	584 (36)	678 (42)	96 (6)	38 (2)	26
Fraud	185 (12)	120 (8)	624 (40)	320 (20)	330 (21)	51
Poor quality peer review	140 (9)	437 (27)	755 (47)	192 (13)	72 (5)	34
Problems in the design of replication studies	103 (6)	406 (25)	809 (51)	162 (10)	123 (8)	27
Technical expertise required for replication	96 (6)	429 (27)	743 (46)	190 (12)	144 (9)	28

Variability of standard reagents	82 (5)	288 (18)	617 (39)	229 (14)	380 (24)	34
Bad luck	23 (1)	70 (4)	461 (29)	568 (36)	466 (29)	42

Table 5. Thematic analysis of perceived causes of irreproducibility

Themes	Codes	N (97)	%	Example
Ethics	Conflicts of interest	3	3	"Conflicts of interest, commerical interests, corporate interests"
	Fraud	2	2	"Sure sometimes there is fraud or poor study design or execution…"
Research methods	Complex research design or methods	2	2	"specialized or cutting edge techniques not adopted or fully appreciated by enough other labs"
	Heterogeneity in biology/environment	25	26	"heterogeneity of included subjects"
	Lack of standard methods	6	6	"lack of precise outcome measures for clinical studies"
	Poor study design or planning	8	8	"Poor design of original studies with increased Type 1 error due to multiple comparisons/endpoints"
Statistical issues	Discretion in statistical analysis	5	5	"Investigators conducting their own analyses"
	Overreliance on statistics	3	3	"over interpretation of statistics - 0.05 p value without thinking enough about methods behind it and meaning"
	sample size/power issues	4	4	"Small effects of biomedical phenomena"
Incentives	Lack of value for reproducibility studies	4	4	"no incentive to reproduce studies"
	Preference for novelty	10	10	"…They are so fixated on novelty they absolutely discourage replication and/or the publishing alternative findings."
	Pressure to publish	2	2	"I think it is the pressure to publish.."
	Researcher attitudes	2	2	"Preconceptions of investigators and reviewers.."
Issues with journals and peer review	Issues with journals and peer review	22	23	"Journals not accepting replication studies."
Lack of resources	Lack of resources	14	14	"Almost no funding for replication studies"
Other	Other	6	6	"Desire to have a convincing story, results"

Table 6. Participant experiences with reproducibility

Item	Response options	N	%
Have you ever tried to replicate a published study you previously conducted and failed?	Yes	373	23
	No- all replications I have completed of my own research have been successful	501	31
	No – I have never tried to replicate my own research	734	46
	Missing data	22	-
Did you publish your replication study results of your study?	Yes – but it took longer to publish than other papers you've published that were not replications	139	17
	Yes – and it took about the same amount of time to publish as other papers you've published that were not replications	152	19
	Yes – but it was quicker to publish than other papers you've published that were not replications	22	3
	No – I have submitted but not yet had the work accepted	29	4
	No – I have not yet submitted, but intend to do so	84	10
	No – I don't intend to attempt to publish this study	205	25
	No – Journals don't appear interested in publishing replications	117	14
	Other	75	91
	Missing data	51	-
Have you ever tried to replicate a published study conducted by another team of authors and failed?	Yes	724	47
	No- all replications I have completed have been successful	156	10
	No – I have never tried to replicate someone else's published research	666	43
	Missing	84	-
Did you publish your replication study results of the other researchers' study?	Yes – but it took longer to publish than other papers you've published that were not replications	139	18
	Yes – and it took about the same amount of time to publish as other papers you've published that were not replications	224	29

	Yes – but it was quicker to publish than other papers you've published that were not replications	14	2
	No – I have submitted but not yet had the work accepted	21	3
	No – I have not yet submitted, but intend to do so	79	10
	No – I don't intend to attempt to publish this study	189	25
	Don't appear interested in publishing replications	56	7
	Other	42	6
	Missing data	12	-
Have you ever been contacted by another researcher who was unable to reproduce a finding you published?	Yes	164	11
	No	1316	85
	I can't remember	53	3
	Unsure	16	1
	Missing data	81	

Table 7. Thematic analysis of reasons why participants replicated their own study

Theme	Code	N	%	Example
Training	Education purposes	15	2	"Used it for teaching purposes"
	New students/staff replicate former results	27	4	"To teach new batch of PhD students and ask them replicate senior students experiments"
Ensuring reproducibility	Could not reproduce a finding so studied why	15	2	"students reported difficulty replicating original methods"
	Findings were challenged	9	1	"Others have reported opposite findings so we wanted to verify our results."
	Interesting	8	1	"I was curious."
	Replication is part of research approach norms	22	3	"As a clinical researcher, we repeat some evaluations over time to detect modified trends."
	To confirm/validate the finding	309	46	"To check if finding were comparable over time"
	Public/community value	6	1	"This is very important for public acceptability."
Additional research	To use as controls	33	5	"As controls in a follow-up study."
	Novel research	17	3	"Test new ideas"
	Extension of study	232	34	"Replication and extension."
Address potential concerns with original study	To address limitations of the original study	30	4	"Confirmation with larger sample size after pilot proof of concept study"
	To address heterogeneity of biology/environment	35	5	"Search for minor variations in population and results"
	Improving quality	11	2	"Improve the research"
Joining/setting up a new lab	Joining/setting up a new lab	8	1	"Started independent lab"
For publication or due to peer review	For publication or due to peer review	11	2	"Journals request it"
Other	Other	30	4	"Scientific ethics"

Table 8. Thematic analysis of reasons why participants replicated someone else's study

Theme	Definition	Codes	N (874)	%
Trustworthiness	Expressing doubt and seeking to verify the trustworthiness of the original results	To verify the results	158	18
		Wary of the original result	59	7
		Obtained conflicting results	52	6
		To follow-up/challenge findings	12	1
Extending and Improving research	Intending to extend and improve the original study	To extend current research	129	15
		Ability to extend study with improved methods	48	6
		Interested in the same question	26	3
		To provide a more current replication	16	2
		Already running the same study	11	1
		Collaborating with original team	10	1
Application to new setting	Intending to apply the original study in a broader or new setting	Replication in a new setting/population	116	13
		To determine generalizability	8	1
New research	Utilizing the original study and/or studies method in new projects	Wanted to use the new studies method	73	8
		Reproduced research for new projects	30	3
		To use as baseline or control data	23	3
Interest	Replicating the original study out of personal interest and/or curiosity	Out of interest/curiosity	34	4
Training	Replicating the original study for the purpose of understanding and gaining new knowledge	To understand the methods better	17	2
		For educational purposes/to gain new knowledge	16	2
Other	Other	Other	36	4

Table 9. Participants perceived support for reproducibility

Item	Response options	N	%
Does your research institution have established procedures to enhance reproducibility of biomedical research?	Yes	254	16
	No	655	42
	I don't know	637	41
	Missing data	84	-
My institution would value me doing new biomedical studies more than me doing replication studies.	True	1031	67
	False	147	10
	I don't know	351	23
	Missing data	101	-
In my biomedical research setting it would be harder to find funding to conduct a replication study than it would be to find funding for a new study.	True	1258	83
	False	72	5
	Unsure	194	13
	Missing data	106	-
Are you aware of funders providing specific calls for conducting reproducibility related research?	Yes	112	7
	No	1417	93
	Missing data	101	-
Does your research institution provide training on how to enhance the reproducibility of research?	Yes, and I have taken it	184	12
	Yes, but I have not taken it	102	7
	No	731	48
	Unsure	503	33
	Missing data	110	-