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Challenges and opportunities of translating animal research into human trials in Ethiopia

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Abstract

Background and objectives Although the goal of translational research is to bring biomedical knowledge from the laboratory to clinical trial and therapeutic products for improving health, this goal has not been well achieved as often as desired because of many barriers documented in different countries. Therefore, the aim of this study was to investigate the challenges and opportunities of translating animal research into human trials in Ethiopia.

Methods A descriptive qualitative study, using in-depth interviews, was conducted in which preclinical and clinical trial researchers who have been involved in animal research or clinical trials as principal investigator were involved. Data were analyzed using inductive thematic process.

Results Six themes were emerged for challenges: lack of financial and human capacity, inadequate infrastructure, operational obstacles and poor research governance, lack of collaboration, lack of reproducibility of results and prolonged ethical and regulatory approval processes. Furthermore, three themes were synthesized for opportunities: growing infrastructure and resources, improved human capacity and better administrative processes and initiatives for collaboration.

Conclusion and recommendations The study found that the identified characteristics/features are of high importance either to hurdle or enable the practice of translating animal research into human trials. The study suggests that there should be adequate infrastructure and finance, human capacity building, good research governance, improved ethical and regulatory approval process, multidisciplinary collaboration, and incentives and recognition for researchers to overcome the identified challenges and allow translating of animal research into human trials to proceed more efficiently.

Keywords Animal research, Challenges, Ethiopia, Human trials, Opportunities, Translational research

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Background

From basic biology to translational research and clinical trials, animal models have been a useful tool for deducing human biological responses [1]. This is because most scientists agree that experiments involving the utilization of animals have abundant potential like facilitating innovation, developing platform technologies and usually providing a link with clinical trials. Furthermore, animal experimentation is valuable in exploring disease mechanisms, confirming and testing new targets for drug investigation and providing insights into drug toxicity and interactions [2].

Although enhancing health is the common goal of basic life science and biomedical research, this has not been well attained as usual as desired or required. One study found that less than 25% of highly promising biomedical discoveries resulted in a published randomized clinical trial and less than 10% were established in clinical practice within last 20 years [3]. There are two broad pathways to improve human health. The first is through public health initiatives designed and enacted on the basis of behavioral research through the application of current knowledge, public education, and policy change. The second pathway is scientific discoveries should be translated into practical applications and such discoveries usually begin at the bench with basic research where scientists study the disease at a molecular or cellular level for its development to the clinical level, or the patient's bedside. Translational research focuses on the improvement of human health by bridging the gap [4, 5] at two distinct levels: at the level of basic science research in the laboratory and in preclinical studies, translating it into new devices or treatments (from the bench to the bedside'); and at the level of clinical practice, transferring the new treatments into the daily routine [6, 7].

Much clinical research follows from animal research [8]. The practice of using animal models of human diseases for drug testing is common practice among biomedical researchers and scientists [9]. Recent attempts to improve translation within the animal research community include the "co-clinical trial" in which preclinical trials explicitly parallel ongoing human phase I and II trials [10] and the development of a scoring system to identify biomarkers that better predict therapeutic success [11]. Translational research has become an issue of increasing importance to scientists and governments around the world [6]. It has been estimated that 60–80% of animal experimentation used for pharmaceutical research and development are in the characterization of promising candidate drugs and about 5–15% are used in the discovery and selection process [9]. Of the one-third that enter into cancer clinical trials, as little as 8% of drugs pass Phase I successfully [12]. The majority of drug trials investigated in Ethiopia are on the use of already approved drugs to optimize treatment [13]. The animal studies for those clinical trials were conducted in other countries. In Ethiopia, there are many in vivo/preclinical studies conducted particularly on herbal medicines. However, none of them translated to human trials.

The academy of medical sciences in United Kingdom [14] reported that in the USA, UK and a number of other countries, the significant investment in the animal based biomedical study has led to substantial success in terms of scientific discoveries, however, it is failing to attain comparable advances in diagnosis, prevention and therapeutics with consequences for both the health of people and also the productiveness of country wide economies. This apparent gap between discovery and its transformation into profitable outputs has been clarified in terms of the poor predictiveness of animal models and a lack of scientific rigor that results in a lack of beneficial effect in subsequent clinical trials [3, 15]. The other barriers are regarded as the difficulties and time lags that often occur in the translation of laboratory-based research into new methods for diagnosis, therapy and prevention and their first testing in humans (Type 1 translation); and the time lags in the translation of results from clinical studies to their implementation in everyday practice (Type 2 translation) [16].

The entire translation continuum is a complex procedure and takes an average of 17 years for research evidence to reach clinical practice [17]. Regardless of the time and complexity of translating findings into care, there is a persistent need to promote the idea of translational medicine among clinicians, basic science researchers, biotechnologists, politicians, ethicists, sociologists and investors to further improve effectiveness of these translational processes [18]. Conversely, there are barriers, which hinder the translation of animal research to clinical medicine documented in different countries. These obstacles include: an absence of a 'culture of translation' within institutions [19], insufficient infrastructure, along with a lack of facilities to conduct clinical research [20]; and an inadequately skilled labor force and difficulties in holding those who do possess the essential competencies [21]. Although collaboration is proposed as a key requirement for translational research, it is inhibited by the compartmentalization of departments inside universities and hospitals, a cultural division between scientists and clinicians, and a university administrative system that rewards individual accomplishment instead of team work practices [19, 21]. In Ethiopia, several important barriers including low stewardship and governance capacity, limited funding allocation, weak regulatory and administrative systems, few learning opportunities, limited human and material capacity, poor incentive for conducting research, lack of local investigator initiated clinical trials, and lack of awareness, confidence and

motivation to undertake trials [22, 23] which limited the capacity to undergo clinical trials are recognized [24]. However, less is known about the challenges and opportunities of translating animal research into human trials in Ethiopia from the perspective of those largely held responsible for conducting translational research: basic and clinician scientists. Therefore, the aim of this study was to investigate the challenges, which hinder translation of animal research into human trials in Ethiopia, and to identify possible opportunities.

Methods

Study design and setting

Qualitative data were collected from November 2019 to June 2020. The data was collected from a study that was conducted in different research and academic institutions in Ethiopia including Armauer Hansen Research Institute (AHRI), Ethiopian Public Health Institute (EPHI), National Animal Health Diagnostic and Investigation Center (NAHDIC), National Veterinary Institution (NVI), and Addis Ababa University (Aklilu Lemma Institute of Pathology, College of Health Sciences and College of Veterinary Medicine and Agriculture). Most of animal researches and clinical trials that have been conducted so far in the country involved one or more of these institutes. All the five institutions have strongly contributed to health research in Ethiopia. AHRI is a center for clinical trial research, EPHI has been involved in preclinical studies related to animal and public health, NAHDIC and NVI are dedicated research institutions majorly on animal health related preclinical and clinical researches and sometimes involved in public research, and Addis Ababa University (AAU) has been involved in conducting both preclinical and clinical trial research.

A descriptive qualitative research approach was used to investigate the challenges and opportunities of translating animal research into human trials in Ethiopia from preclinical and clinical trial researchers' perspective.

Study participants

Study participants including basic and clinical trial scientists (researchers) at the study sites were contacted and interviewed. The interviews conducted were audio recorded and transcribed verbatim. Each interview took, on average, about 45–60 min.

Pre-clinical trial and clinical trial researchers with position of assistant professor and above from academic institution and assistant researcher and above from research institutions, and who have been involved in animal or clinical trial research as a principal investigator (PI) were included in the study.

Intensity purposive sampling technique was applied both in the selection of study participants as well as research institutes and academic institutions to get deeper information. The number of experts involved in the interviews were 17 (four from College of Health Sciences, two from AHRI, one from NVI, two from NAIDIC, three from Akililu Lemma Institute of Pathobiology, two College of Veterinary Medicine and Agriculture, and three from EPHI). As the study used an intensive purposive sampling, the printed version that describe our study's inclusion and exclusion criteria and the support letter from our College to each institution's directorate were first distributed and based on the staff profile there, each directorate suggested us who fit to our studies. The College of Health Sciences suggested 10 participants, but only four were contacted; out of the three participants suggested from AHRI only two were taken; out of the three participants suggested from NVI only one was taken; Akililu Lemma Institute of Pathobiology suggested three and all of them were taken; the College of Veterinary Medicine and Agriculture suggested two and both of them were taken; EPHI suggested three and three of them were taken. The remaining participants from some of the institutes were not interviewed because of information saturation. Participants were sampled following their willingness to participate. The sample size was determined based on information saturation.

Data collection methods and tools/ instruments

The data was collected using in-depth interview technique. For this purpose, semi- structured interview guide was designed and prepared in English with open-ended questions related to the objectives of the study that encouraged participants to describe their own understandings and opinions and allowed identification and exploration of themes and hypotheses that might not have been anticipated. The guide was used with flexibility; it included general questions about challenges, and opportunities in translating animal research into clinical trials. Interview questions did not target a specific trial but rather on participant`s basic research and trial experiences in general. The focus of the interview guide was to gather information on the respondent's socio-demographic characteristics, the challenges, and opportunities of translating animal research into human trials.

Participants were informed that the interviews were part of an MSc thesis project. There was no need for a translator as the interviewer (principal investigator) speaks both Amharic and English. The interviews took place in a private room/ office of each interviewee allowing confidentiality. Summaries and observations were written down in a field diary by the interviewer immediately after each interview and audio recording. These notes and audio records were useful during data analysis. Interviews continued until information saturation was reached. Saturation of information is considered to be reached when few or no new concepts were raised [25].

Data quality assurance

The investigator followed rigorous criteria using several strategies to maintain the trustworthiness of the study. The semi-structured interview guide was reviewed by two academic advisors and one postdoctoral scientist. The collected written and audio-recorded data were checked for completeness, accuracy, clarity, and consistency by the principal investigator on daily basis. To check the credibility of the study, some of the study participants were invited to review the findings and ideas whether they correctly represented their point of opinions. In addition, validity of the data was checked by theory triangulation and investigator triangulation (peer-debriefing) in which experts from different and same disciplines reviewed the finding, respectively, both during and after analysis. Moreover, a rich description was used to convey the findings of the study so as to help the reader to understand it easily.

Data management and analysis

All interviews were transcribed verbatim and reviewed based on the transcript and original recordings. Inductive emerging thematic analysis [37] was conducted using NVivo Plus version 12 qualitative data analysis software. English transcripts were analyzed in their original language. After repeated readings of the transcripts, data was grouped and sorted by question using auto coding, and coding was done by coding important features of the gathered data in a systematic manner. Codes were inductively developed. The coding frameworks were discussed amongst advisors before agreeing on a final version. After reading about 10% of the codes in the code book, themes were developed. The themes emerged from the data itself. The analysis was focused on challenges and opportunities in translation of animal research into human trials in the Ethiopian context. Notes (memos and codebook) were taken during the analysis to ensure that it is reflective. Similarities, differences, and patterns were identified across the interviews and sub-themes, which give structure to the over-arching themes before refining them. The data set was re-read to check for coherence of data within themes and for clear and identifiable distinctions between themes and sub-themes. Finally, revision was made on the data set to code any additional data that had been missed in previous coding stages. After discussions with advisors who are experts in various disciplines, decisions were made on final definition and naming of the themes and sub-themes.

Ethical considerations

Ethical approval was only sought from the Scientific and Ethics Review Committee of the Center for Innovative Drug Development and Therapeutic Trials for Africa (CDT-Africa), College of Health of Sciences, Addis Ababa University. The research project did not require access to private and sensitive information or health-related data or materials. Participants of the study were asked for verbal and written consent before participating in the study. Information sheet about the study, why study participants were selected, and what is expected from participants were given prior to the interviews. Participants were assured of confidentiality of information in the course of the study. They were briefed on the objective and background of the research project and the right to leave the study any time. Anonymity and confidentiality were guaranteed and thus no names of participants are disclosed in the thesis. All participants were asked for their agreement to be audio recorded during the interview, which averaged 45–60 min per study participant. This study was conducted with adherence to consolidated criteria for reporting qualitative research (COREQ) [26].

Results

Characteristics of study participants

A total of 17 researchers who have been involved either in preclinical studies or clinical trial or both participated in the in-depth interviews; eight were based at research centers, and nine at a university. Two to four interviews were conducted in each institution. Saturation of information was reached after the first 14 interviews. Ten participants had been involved in pre-clinical research, three in clinical trial, and four both in preclinical and clinical trials. The participants had experience in a diverse range of medical professional domains. Participants had between 5 and 30 years of working experience in preclinical and clinical research (Table 1). One participant have been involved in translating a study conducted on animal experiments using herbal medicine against helminth into human study up to phase-2 using a tablet formulated as a drug, but the drug was found to be inferior than the standard treatment. Another participant has been involved in the preclinical part of herbal medicinal plant against liver cancer and did not proceeded to the next step as the ethics committee didn't allow him. Moreover, a participant has been involved in preclinical studies using herbal medicine and formulated as ointment and now they are waiting for ethical approval to conduct phase-1 clinical trial in collaboration with other research institution in Ethiopia.

Challenges and opportunities for translating animal research into human trials

Using thematic analysis, six major themes were identified for challenges: lack of finance and human capacity, inadequate infrastructure, operational obstacles and poor research governance, lack of collaboration, lack of reproducibility of results and prolonged ethical and regulatory approval processes (Fig. 1). Moreover, three themes

Table 1 Characteristics of study participants

Terms	Categories		Number of participants
Area of expert	Pharmacology		5
	Clinical pharmacology		1
	Molecular microbiology		1
	Biotechnology and virology		1
	Infectious diseases		1
	Clinical pharmacy		1
	Microbiology		1
	Infectious disease epidemiology		1
	Pharmaceutical chemistry		1
	Pulmonary pediatrics and infectious diseases		1
	Epidemiology and biostatistics		1
	Zoonosis		1
	Trans-boundary diseases		1
Domain of experiences	Preclinical trials plus others		10
	Clinical trials plus others		3
	Both (preclinical and clinical trials) plus others		4
Years of research experiences	5–20 Years		12
	> 20 Years		5
Role as a PI in research	Preclinical	1–6 projects	10
		20–30 projects	3
	Clinical trial	1 project	4
		5 projects	2
Focus area in terms of diseases/ Pathogens/ Others	Studied in preclinical studies for both animal and human	African horse sickness, Anthrax, Antiinfertility, Anti-nflammation, Antipyretic, Antispasmodic, Asthma, Diabetic mellitus, E.coli, Fasciola hepatica, Fowl cholera, Pasteurellosis, Leish-mania, Schistosomiasis, Fowl typhoid, Haemonchus contortus, Helminthes, Hypertension, Leishmania, Liver related diseases, Malaria, New castle disease, Infectious bursal dis-ease, Histoplasma, Noncommunicable Neurodegenerative diseases, Phytogenics, Rabies, Relapsing fever, Rota virus, S.aureus, Salmonella, Trypanosomiasis, Tuberculosis	-
	Studied in clinical trial	Cervical cancer, Cholera, Diabetic mellitus, Helmin-thes, Hepatitis B, HIV, Malaria, Meningitis, Tuberculo-sis, Visceral leishmaniasis	-

Table 1 (continued)

Terms	Categories	Number of participants
Phase of study (Note: one person can conduct many studies at each phase)		**Number of studies**
	Phase 1	5, of them 1 waiting for approval
	Phase 2	3
	Phase 3	4,of them 1 waiting for approval
	Phase 4	1
	Not applicable (For preclinical research and vaccine trials)	11
Type of trial for clinical trial and pre-clinical studies	Drug	7
	Vaccine	7
	Diagnostic tools	2
	Pharmaceuticals dosage formulations on traditional medicinal plants	2
	Medicinal plants	8

were identified as opportunities: growing infrastructure and resources, improving human capacities and better administrative processes and initiatives for collaboration (Fig. 2). Representative quotes supporting each theme are presented, along with unique identification numbers of participants in brackets. The themes were prioritized based on the number (frequency) of interviewees who mentioned each theme as a challenge or opportunity (Table 2; Fig. 3), respectively.

Challenges for translating animal research into human trials

Lack of finance and human capacity

Nine of the participants mentioned that the major constraint for translating animal research into human trials is lack of funding. It was mentioned that translating animal research findings into human trials, particularly the clinical trial part requires a huge investment. Hence, if you do not have an adequate supply of fund from industries or other interested donors it is difficult to sustain translational research. Many brilliant Masters and PhD students who went abroad for education did not return because of that reason. Some who returned to the country after completing their education but who got the second chance to go abroad for their post docs in European and American universities did not come back because they learned that the research environment in Ethiopia was not attractive. Most academicians are frustrated to conduct thematic research projects related to translational research because of financial constraint and poor budget administration as mentioned by the study participants. The interviewees also stated that the government does not allocate enough money for translating animal research into human trials and there is a very little core research fund, which is less than five hundred thousand Ethiopian birr per annum. As reported by the participant:

"It is only the building that the government has provided. All the rest that we have managed to buy, among others, including vehicles, research laboratory equipment were secured from international funders on a very competitive basis. Some who are not able to get funding from foreign funders get frustrated and they…just compete for the local small grant which is less than five hundred thousand that can only use to cover…per diem, support MSc and PhD students work and buying simple reagents you can't even use it for fuel purchasing during field works. Unless there is core local research funding we should not expect any…real…development in the drug or diagnostic device or anything it could be used in clinical trial, we would end up in post clinical trial researches/approved drugs" (A1, clinical trial researcher*).*

On the other hand, two preclinical trial researchers stated that funding was not a problem; instead, it was a financial management problem.

Fig. 1 Concept map shows themes and sub-themes for challenges that hinder translating animal research into human trials

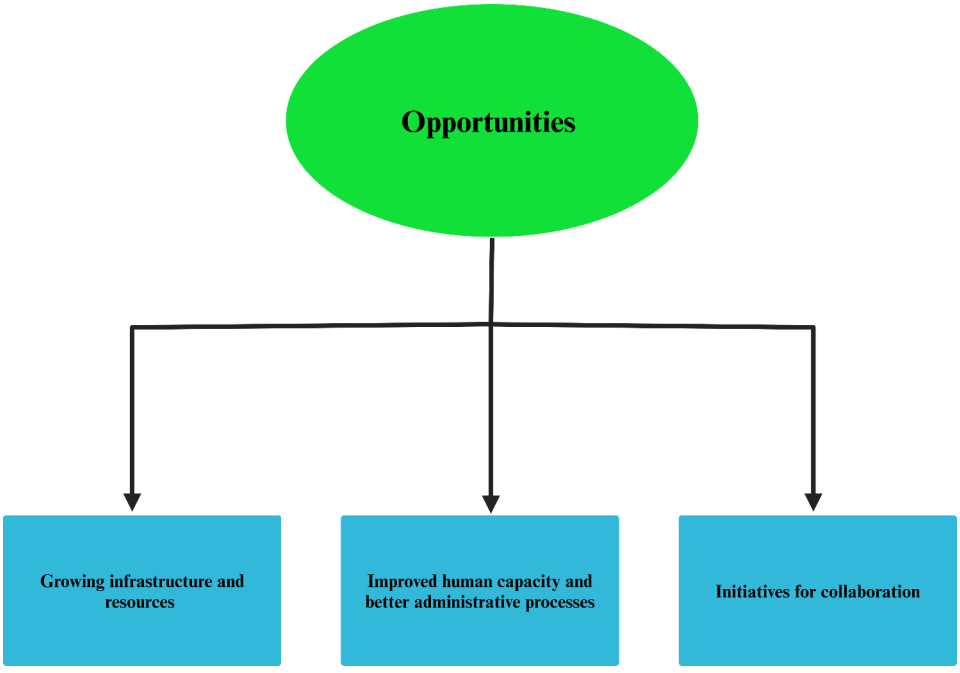

Fig. 2 Mind map that shows themes for the opportunities for translating animal research into human trials

Besides, eight participants felt that human capacity, be it from researchers' side or the ethics experts and regulators side, was the critical factor. Respondents stated that there were poorly qualified researchers in terms of knowledge, skill, training, and experience. There is minimum awareness and preparedness, attitude problems of the research community for such type of research. Moreover, there is a poor research literacy of researchers in clinical trials and low physicians' interest to conduct research on traditional medicine. As the study participant noted:

Table 2 Summary of themes emerged as challenges of translating animal research into human trials

Themes	Frequency	Sub- themes	Frequency
1. Lack of finance and human capacity	13	✓ Lack of funding	✓ 9
		✓ Limited capacity of researchers (knowledge, skill, experience, awareness and preparedness), attitudinal problems, lack of physicians' interest	✓ 16
		✓ Limited capacity of ethics committee and regulators in terms of knowledge, skill, experience	✓ 2
2. Inadequate infrastructure	11	✓ Poor facilities (e.g. accredited laboratories)	✓ 9
		✓ Shortage of resources	✓ 5
		✓ Lack of organized center	✓ 2
3. Operational obstacles and poor research governance	11	✓ Lack of commitment from researchers, institutions and government	✓ 5
		✓ Poor research management and quality control	✓ 4
		✓ Lack of clear policy and guidelines	✓ 3
		✓ Lack of framed and programmatic research agenda	✓ 3
		✓ Challenges of logistics and purchasing process	✓ 2
		✓ Lack of voluntary participation and awareness of patients	✓ 2
4. Lack of collaboration	9	✓ Lack of inter-disciplinary collaboration	✓ 9
5. Lack of reproducibility of results	6	✓ Anatomical and physiological species differences	✓ 2
		✓ Lack of animal model genetic make-up specification	✓ 2
		✓ Pathophysiologic difference of diseases	✓ 2
		✓ Poor experimental design	✓ 2
		✓ Poor quality animal experiment	✓ 2
		✓ Inappropriate statistical analysis	✓ 1
6. Prolonged ethical and regulatory approval processes	6	✓ Prolonged ethical and regulatory approval processes	✓ 6

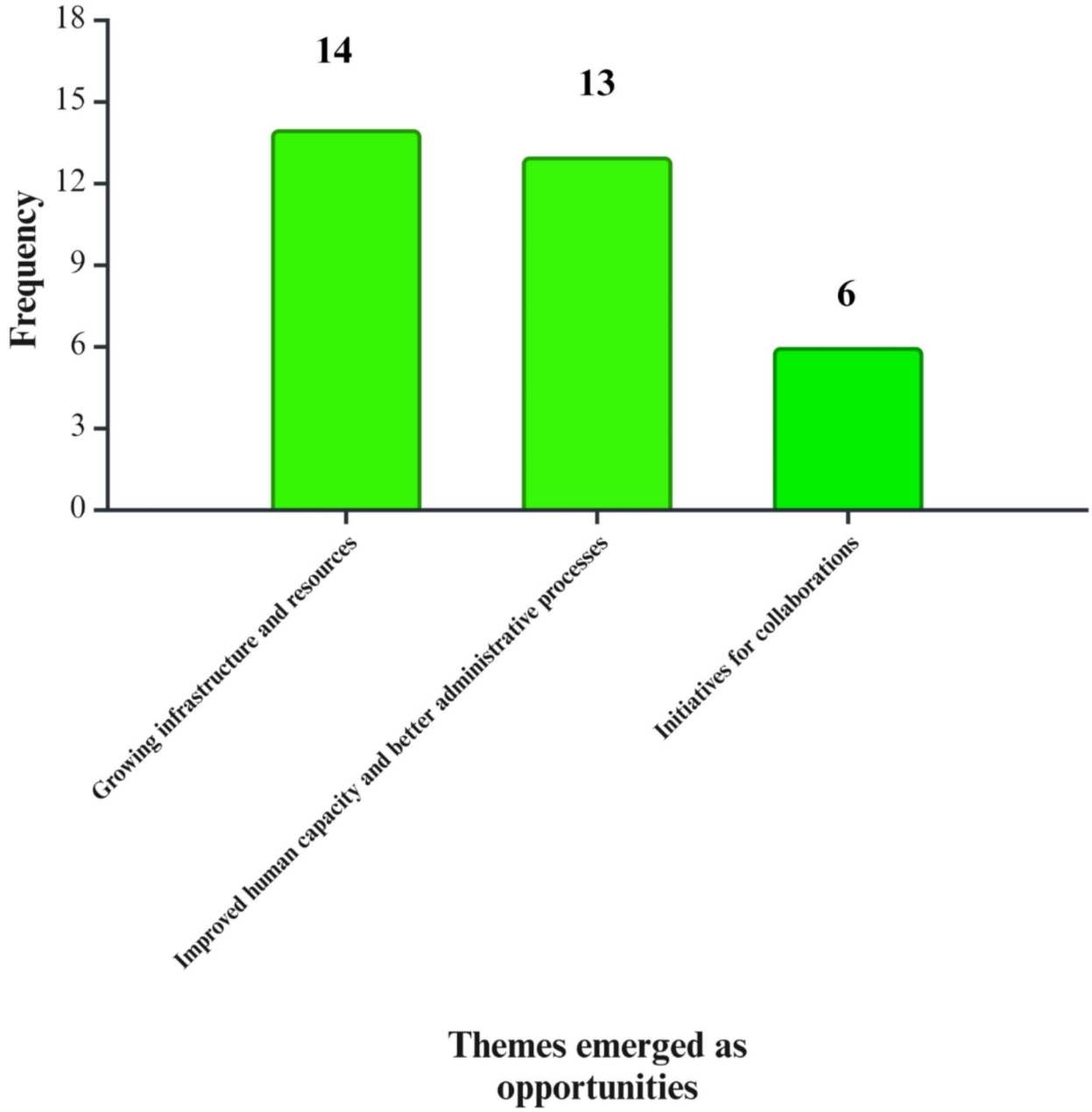

Fig. 3 Themes and the number of participants mentioned each theme as opportunities

"…There is also an attitudinal problem in researchers…most common sign of the completion of a project is this publication. So findings from a preclinical study once they are published people do not think of taking the finding to the next level" (A8, preclinical and clinical trial researcher).

Another participant noted:

"Physicians' interest is another challenge because they tend to the conventional medicines though traditional medicine is the mother of modern medicine as illustrated by a number of discoveries of conventional medicine which are originated from traditional medicines. So there are some blurred visions by medical doctors" (A14, preclinical trial researcher).

Another participant also noted that:

"…In my view the main challenge is lack of capacity of researchers in terms of knowledge and skill" (A4, preclinical trial researcher*).*

Problems related to regulatory and ethics committee, including the capacity of personnel in terms of knowledge, skill, and experiences to judge the advantage and

disadvantage of studies is another challenge reported by the participants.

"I think it is related with…the capacity of our ethics committee in reviewing and approving studies like this [translational study] is not that much or it is limited… there is no experience so…as a country that starting…this kind of initiatives I think everybody is afraid that what if something happen and you know the level of protection you have to consider what if this study is done on myself or my family or my kids. So allowing that to happen from the ethics committee side is difficult because there is no experience and…." (A7, preclinical and clinical trial researcher).

This scientist went on to express doubt on the ethics committee in facilitating the conduct of translational study despite the fulfillment of all requirements and warned that, *However, I would like also to say that no ethics committee would say no to translational study if you fulfill…whatever the GCP requirement…if the team are trained, knowledgeable skilled and if you show that you have the resource, infrastructure. But clinical trial, they do approve our clinical trial provided that you fulfill everything.*

Inadequate infrastructure

While a general lack of infrastructure and facilities were thought to hinder the translation of animal research into human trials, most participants ($n=9$) stated that lack of well-equipped, furnished and accredited laboratory facilities and shortage of resources like laboratory supplies and consumables were major barriers. As noted by the study participant:

"So if you want to do experiments on animal models that laboratory has to be GLP accredited but there are no accredited laboratories" (A17, preclinical and clinical trial researcher).

Another scientist noted:

"No appropriate infrastructure…most of the institutes have really rudimentary kind of research laboratory and only…to support students and institutional activities…you cannot expect for big research outcomes to bring about change on the health and development of our country…." (A1, clinical trial researcher).

Another study participant also stated that:

"No facilities, for example, you know simply doing in vivo studies does not make your compound to be…eligible for a clinical trial. So you need to do…pharmacokinetics studies you need to…see the probable mechanism of action of a particular agent for that then you need to have cell lines because you can easily manipulate cell lines and it is good to understand and how the agent acts in order to produce the effect so that you could see in in-vivo experiments. So you do not have such facilities and without completing these kind of studies…it is very difficult to move into a clinical study" (A8, preclinical and clinical trial researcher).

According to the interviewees ($n=2$), lack of organized center specialized in translational research was also perceived as a barrier. As noted by the study participant:

"…Teaching of clinical trials that will only have trained manpower in clinical trials unless you have the institution for translational research in which these people could be engaged, I do not think it will have an input, they will end up in the university teaching on clinical trials…. However, it is at least a good start and that would help to convince the government…at least to allocate for this" (A1, clinical trial researcher).

Operational obstacles and poor research governance

Translating animal research to human clinical trials demands commitment from researcher, partners and government. The participants mentioned lack of commitment from the researchers, institutions and the government to translate a scientific finding into product as major challenge.

"What I can say is that…probably low or poor commitment to translate the research finding into the product. When I say commitment, commitment from the researcher. Many researchers are just complaining…by the availability of reagent, consumables, laboratory facilities…the leadership from respective institutions or universities and the government in general. I underlined that it is a low commitment at each level if you are committed to change the preliminary product into the final product to be useful for public service then you have to committed in terms of working, extra working hours, you have to work day and night including weekend and you have to look for different opportunities and possibilities to get all the reagents and consumables" (A2, preclinical trial researcher).

Related to the research administrative environment participants perceived that lengthy and complex logistics and difficult purchasing process as another challenges which slowdowns the research conduct.

"…If you want to purchase a chemical let us say from abroad, it will take you three years by that time everything is over. Now there is much improvement but still we have to make it faster" (A15, preclinical trial researcher).

Some participants stated that lack of voluntary participation and awareness of patients as a barrier for conducting clinical trials. As stated by the participants:

"…May be related to an awareness of participants… most patients when they told us about clinical trials they think they are going to die they would not like to get consent to participate in clinical trials" (A16, preclinical and clinical trial researcher).

"…Getting patients who are voluntary to participate is also another difficulty…they do not have the culture of

voluntary participation in a clinical trial unless you have a financial incentive for it" (A1, clinical trial researcher).

One participant gave emphasis on the need for a clear policy which guides the conduct of translational research that *"No clear policy and central coordination…so the medical associations, association of the biologists, the veterinarians should come together and doing some policy issues governing this [translational study]. I think the policy issue is very important for such activities"* (A3, preclinical trial researcher).

Another study participant also stated that:

"…Lack of a clear cut guideline on how to do a clinical trial on traditional medicine is the major challenge because we cannot adopt the guideline for conventional approaches…." (A14, preclinical trial researcher).

Poor research management, including poor financial management or inefficient use of resources and poor quality control, and lack of framed and programmatic research agenda was the other challenges raised to hinder translating animal research into human trials. As stated study participant:

"When you conduct a research it is not only the resources but also research management by itself is a problem. So if you have research funds you get from somewhere else unless there is a smooth research financial management system which motivate the researchers… everybody will lose its hope and their interest in research in the next phase" (A15, clinical trial researcher).

Lack of collaboration

Lack of interdisciplinary collaboration among different professional groups in different institutions at the local and international level, was perceived by respondents to hinder the practice of translating animal research into human trials. Respondents identified a number of features including poor research governance and bureaucracies, minimum preparedness and awareness of the research community, delay in the approval process and communication barriers that hindered effective collaborative working relationships and practices at international level. As stated by the study participant:

"…We need to enhance collaboration with expertise and resources…from outside with certain cautions in terms of not abusing the human trials in general. But the research governance, bureaucracies like delay in the approval process, the preparedness and awareness of the research community, poor facilities and communication are actually hindering in terms of collaboration because many of the collaborators need a kind of swift, smooth…like for instance in terms of the approval process of research protocol, it took like a year in Ethiopia and they don't want to work with Ethiopian collaborator because of this. So once we can actually improve this research governance and the ethics and regulatory approval process there is also an opportunity just to draw resources from outside so that we can collaborate and hasten product development as well as translate the products into human or animal application" (A10, clinical trial researcher).

Nine participants suggested that translating animal research into human trials needs a multidisciplinary and inter-sectoral collaborative work. Therefore, there should be multi-disciplinary collaboration among biologists, medical professionals, veterinarians, chemists, health officers, policy-makers, social scientists and communities, and companies, which ultimately produce and sell that product to the population. The researchers or professors from basic science or biomedical research area are initiators and part of the whole research process. As noted by the study participant:

"Although researchers are the main actor who come up with the idea and the compound, translational research needs involvement of many actors: the government, biomedical researchers, chemists, physicians, social sciences scientists, nurses, laboratory technicians, immunologists from animals and human side" (A17, preclinical and clinical trial researcher).

Another participant also stated that:

"I think it is a concerted effort. It is not something that is left for one institution, of course the government has given that the mandate for EFDA [Ethiopian Food and Drug Authority] in Ethiopia to regulate and Armauer Hansen Institute to lead clinical trial activities. However, it doesn't mean that it has to be done there, but…the teaching and research institutions, private and government hospitals, veterinary colleagues and individual scientists should be involved…So that they can work together from animal to human side…that is in terms of doing the study otherwise in terms of stakeholders acting around it, there are a number of different stakeholders we need to have DSMB, IRB approval, investigator team members, monitor, if there is a need for sponsor, if you are soliciting some funding (funder), and CRO. So all those actors need to be there" (A7, preclinical and clinical trial researcher).

Lack of reproducibility of results

Lack of reproducibility of results was also considered as a major bottleneck for translating animal research into human trials. Poor experimental design, poor quality animal experiment, nature of diseases, animal model specifics, differences between animal and human genetic make-up, inappropriate statistical analysis, and anatomical and physiological species difference were seen as contributing factors to lack of reproducibility and replicability of findings in which an agent that is found effective in animal studies might not be effective in human studies. This was only mentioned when the interviewer asked participants in a follow-up question to give reasons for lack of reproducibility. As reported by the interviewee:

"The major bottleneck is the lack of reproducibility and replicability of findings…a drug or vaccine that is found effective in animal studies might not be effective in human studies. It could be because of inappropriate statistical analysis or poor experimental designs. So had the research been designed well it could have an effect in the clinical studies…although the assumption is…that there is…a predictive validity or a face validity between the disease you model on animals and the disease that is in humans… mostly you don't see the agent be effective in human studies. It could be related the nature of the disease. So in some diseases…you see a positive effect in both studies in another studies you do not see similar findings. So lack of reproducibility is the major challenge in the translating animal research into human trials" (A8, preclinical and clinical trial researcher).

Prolonged ethical and regulatory approval processes

Six interviewees expressed their dissatisfaction in their work in translating animal research into human clinical trials because of the delay and very stringent working environment in ethical and regulatory review and approval processes. The resulting slow and excessively strict ethical and regulatory approval process prevented efficient research conduct. The interviewees mentioned that the time taken for one research protocol to be approved ranged from one to two years. This has contributed a lot in lowering the chance to get external funds for a study or to attract donors and collaborators, because funders or donors are eager to give you the money if you are lagging behind because of the ethical process, unnecessary delay in review process could result in donors losing their interest. Therefore, we have to exploit such opportunities by improving the research process and making ethical and regulatory approval a bit faster. A participant stated that:

"…I do not think that since there is no capacity and experience even ethically they will allow you to translate animal research into human trials,…I was involved in one study which was on edible mushroom…and we proved it in animal that was for liver cancer and the intention was to translate that into human and we did not succeed the level of ethical approval that was needed" (A7, preclinical and clinical trial researcher).

Opportunities for translating animal research into human trials

Growing infrastructure and resources

Six interviewees mentioned that these days there are many universities with many postgraduate studies in various disciplines and institutions that are mandated to conduct research, which should be taken as an enabling factor. Since most of the institutions are good in basic sciences if provided special training, they can turn to be efficient in conducting translational research. There are also a motivation and support from Ministry of Innovation and Technology for institutions to be a center for problem solving research rather than a simple office for academic exercise. As the study participant noted:

*"…In the Ethiopian context, the two research communities are found either in a research institution or in academic institutions/universities. Now, there is a developing potential, especially in the universities because those universities have science faculties, health colleges, and tertiary hospitals. Therefore, we need to have a somewhat integrated planning so that we can exploit the maximum of the academic community there and then the research idea that can be developed from biomedical field can easily be translated into human or animal testing…" (*A10, clinical trial researcher).

According to the interviewees, there are also institutions like CDT-Africa, which provide education, training, and capacity building for researchers to be engaged in translational research and this can be taken as a good start and which can be considered as enabling factor. As stated by the study participant:

"…Institutions like the CDT Africa a world bank initiative dedicated to do this kind of translational study…are enabling environment and now more than ever we have got a wonderful environment to conduct this [translating animal research into human trials]" (A7, preclinical and clinical trial researcher).

The interviewees said that though there are limitations now a day there are growing or better facilities, many tertiary hospitals are now under establishment/ development than previous years. As reported by the study participant:

"I would say at least the experience that I have, at Addis Ababa University; there is phase −1 clinical trials unit, at Armeaur Hansen research institute; there is the whole ward that dedicated for phase- 1 clinical trial unit and internationally accredited laboratory. …These days, there are wonderful infrastructure wise enabling environment" (A7, preclinical and clinical trial researcher).

Five of the interviewees mentioned that the availability of high diversity of medicinal plants, microbes, to some extent availability and use of animal model following proper ethical procedure and large human population in which many of them harboring many infectious and non-infectious diseases could be taken as a big opportunity for translating animal research into human trials. Besides, the existence of multi drug resistance to the drugs being used, inaccessibility of modern medicine to most of the local communities and availability of indigenous knowledge on the use of traditional medicines for curing of diseases is among the enabling factors stated by the interviewees. As noted by the study participants:

"…No full accessibility of modern health cares. So, one approach is to strengthen research on traditional medicine, including the clinical trial because it's cheap, easily accessible, and it can serve as a means of generating income…" (A14, preclinical trial researcher).

"I think there are…opportunities like the existence of multidrug resistance to the drugs that has been used. So one of the ways forward is to investigate and come up with the new drug to replace those drugs which drug resistance are developed" (A3, preclinical trial researcher).

Four interviewees mentioned that currently, there are opportunities for getting funds at international level and companies are interested to support the initiation of traditional medicine clinical trial. In addition, the Ministry of Innovation and Technology, and Ethiopian Biotechnology Institute are a nowadays giving emphasis on product-oriented research and are allocating better fund as compared to funds made available in the previous years.

"Though competitive there are still research funds to get to clinical trial, so what is expected from us is to write the grant proposal otherwise it may not be as difficult as used to be in the past" (A16, preclinical and clinical trial researcher).

Improved human capacity and better administrative processes

Most interviewees indicated that these days researchers have better capacity in terms of knowledge, skill, training, experiences, and awareness as compared to few years back. Universities have produced higher number of trained researchers and as a result, there is a growing interest of scientists and growing work force in biomedical fields or health related research. In addition, the quality of research now is improving. As noted by the study participants:

"…Opportunity for training, capacity building and education of researchers to be engaged in translational research you can take your clinical trial program offered by CDT-Africa and funded by several projects…. So we can consider these as enabling factors" (A8, preclinical and clinical trial researcher).

"…Well, currently it looks there are a lot of opportunities for clinical trials to be considered we are building the capacity and awareness of health professionals through trainings…on how clinical trial is conducted. So I am sure these days most of them become interested in clinical trials" (A16, preclinical and clinical trial researcher).

Another study participant also noted that:

"Well, I would say the opportunity now is…if you take during my old time it was very difficult, now the attention towards education and research is far better than it used to be in the last two or three decades back" (A15, clinical trial researcher).

Moreover, interviewees mentioned that very recently there are better administrative processes including, supportive rules and regulations, initiations to speed-up ethical and regulatory approval, and the government is giving due attention to problem-solving and product-oriented research. As noted by a study participant:

"…The ethical approval process is being improved… we are working on that how to correct the problem with the ethical committee used to have…even the regulatory approval process…is going to be shorten I believe" (A16, preclinical and clinical trial researcher).

Another study participant stated that;

"The one I would say is there are supportive…rules and regulations issued by the government. …Now the mandate and the proclamation are out there so it is up to the scientist and those other stakeholders to engage" (A7, preclinical and clinical trial researcher).

One respondent also stated, "*There are enabling environment that has been worked out which helps if you really want to know the fact that a lot of preclinical study has been done before and having a database on those once, there are some initiatives to develop a database as well. It is something we can also count on experience from other country China, India, Nigeria*" (A7, preclinical and clinical trial researcher).

Initiatives for collaboration

Interviewees mentioned that one-health initiative at the national and international level could be considered as an enabling environment and it can facilitate collaboration by creating a platform for experts to meet and work together. As reported by the study participant:

"It is the good way and now we are initiating to work together in collaboration with National Veterinary Institute (NVI), EPHI, AHRI and Ethiopian Biotechnology Institute…to develop a product for human and animal use…because we have to share our expertise or facilities if something that NVI is by far better than others…." (A2, preclinical trial researcher*).*

Discussion

The goal of translational research is to bring biomedical knowledge from the laboratory to clinical application and therapeutic products [27, 28]. Previous attempts such as "clinical pharmacology" and "experimental medicine" have not been very successful in moving from science to commercialization and the patient's bedside [29]. To move from animal studies to clinical trials is a complicated process and depends on the cooperation of research institutes and companies, the settling of ownership and property rights, and the creation of a well-developed business model [30].

The identified challenges concerning translating animal research into human trials are summarized into six

themes: lack of finance and human capacity, inadequate infrastructure, operational obstacles and poor research governance, lack of reproducibility of results, lack of collaboration, and prolonged ethical and regulatory approval processes. On the other hand, the enabling factors that were perceived for translating animal research into human trials are summarized into three themes: growing infrastructure and resources, improved human capacity and better administrative processes and initiatives for collaboration.

The present study showed that lack of funding and human capacities were among the most frequently raised constraints that hinder translating animal research into human trials. Most respondents reported that they were frustrated to involve in translating animal research into human trials because of limited local research fund and highly competitive international funds. This contributed towards increased mobility of highly talented staff to Western countries like Europe and America in search of conducive research environment. Similarly, little local funding and competitive international funding have been reported as a barrier to conduct locally initiated clinical trials in previous study conducted in Ethiopia [22]. However, two preclinical trial researchers from the present study indicated that funding was not a problem; instead, it was a financial management problem. This difference in perception related to funding among the respondents might be due to variation in the type of study they were involved, experience and financial management system they have. Successful translational research requires adequate fund, an important part of which is government funding [31]. Most academic institutions do not have an adequate budget to support discovery and development programs [32] and it is a well-acknowledged fact that it is almost impossible for academicians to procure sufficient competitive grants to bring a drug or a test to the clinic and comply with all the testing procedures necessary to meet regulatory requirements [33]. For a research institute to be able to do translational research from bench to bedside, it had to cooperate with hospitals for clinical trials, and for later stage trials and product development, taxpayers' money was not enough to support its work; thus, a partnership with industry was envisioned to address the financial problem efficiently. Hence, it has become a strategy to invite industry to get involved earlier in the translational research process [34]. Moreover, this study showed that these days the government gives due attention to research and allocates better money for product oriented research than that were used in the previous years. This may be because of the reason that previously a lot was done on preclinical studies and now it is time to move to the next phase.

Many of the respondents also reported that challenges in getting or maintaining qualified experts in terms of knowledge, skill, experience, training, and awareness. This is in line with a mixed method study conducted in Australia, which states that both preclinical and clinical researchers were frequently lacking confidence in research translation skills and knowledge [35]. Translational researchers need to have multidisciplinary knowledge and capability [31]. Those translation investigators who are dually trained in scientific laboratories and clinical settings are very important personnel to link the information both from bench and bedside, but they are "rare species" [30]. Interviewees from the present study reported that translational research or medicine needs to be incorporated into the national educational curricula to cultivate trained and multidisciplinary translational researchers and further suggested that there should be financial and non-financial incentives, rewards, and recognitions given to them at national level. A flexible framework for performance assessment that tracks progress and incentivizes fruitful activities is very important for cost-effective translational research [31]. Trial training, knowledge sharing, and experience exchange are key enablers for increasing awareness, confidence, and motivation. Training was viewed as important for awareness and encouraging staff to consider their workplace challenges in a more enquiring light. Knowledge sharing boosts a researcher's confidence that trials are achievable and experience exchange is important for raising professional standards and dispelling what one respondent termed 'pseudo-confidence' meaning to continue working in a suboptimum way because knowledge of more rigorous methods is lacking [35].

Interviewees particularly stressed on attitudinal problems of researchers that misunderstood successful completion of a project as production of publications only. It is a common practice that promotion of staffs in academic institutions is measured by the number of high quality publications, not by the number of patents received. It was also pointed out that most of the studies, especially preclinical studies, were conducted by undergraduate, Masters or PhD students. However, after graduation of the students, no one is there to continue the work by taking it to the next level. This is in line with a finding conducted in USA, which stated that academics are rewarded for being the first to describe a scientific discovery (to obtain tenure, professors must demonstrate leadership in their field through grant funding, a strong teaching record, and, most importantly, high-quality publications and recognition by national and international scholars) and not for preparing a successful IND application to the FDA and the risk of delaying or perhaps preventing their promotion forces academics to pursue drug discovery and development as a side activity [32]. Despite the apparent importance of translation, translating beyond publication was not always a priority

for the research team that tended to focus on conducting new research and publishing [35].

The other theme that emerged as a challenge was inadequate infrastructure, including poor facilities and shortage of resources and lack of well-organized center. This was supported by a study conducted in Ethiopia, which stated that lack of materials; infrastructure and laboratory facilities were thought to reduce the number and scope of trials [22]. The present finding suggests the establishment of a well-equipped center specialized only for translational studies. Provision of training and education at Masters and PhD levels in clinical trials and translational research without creating an appropriate research center for the graduates to be engaged in such researches is meaningless, and they will end up in universities only teaching clinical trials courses. However, a series of education and skills development trainings have been given to address the reported needs of both preclinical and clinical researchers regarding research translation [35].

Operational obstacles and poor research management, such as poor commitment from researchers, institutions and the government, poor financial management, lengthy and complex logistics and difficult purchasing process, lack of clear policy and guidelines, lack of framed and programmatic research agenda, lack of voluntary participation and awareness of patients were identified to influence the practice of translation of animal research into human trials.

The translational medicine model which is originally from the US and associated with cancer drug development cannot be applied for traditional medicine development. The WHO has developed a separate traditional medicine development guide for traditionally claimed medicinal plants. However, this guide is not still conceptualized in to our Ethiopian context that is why participants are raised lack of country's conceptualized guide on traditional medicine development as a challenge that hinder the translation of animal research into human trials. Therefore, the US-driven translational medicine model should not be adopted as it is. The accepted translational medicine pathway should be modified into Ethiopian contexts in terms of economic, social, political, advancement in science and cultural aspects. All those should come into consideration while adopting innovation model from developed country to developing country like Ethiopia. For example as stated by fotenhauer S, Jasanoff [36], , what constitutes the public good, which publics should be served by investments in science and technology, who should participate in steering science and by what means, and how should controversies be resolved about the pace or direction of research and development should be considered.

Research has to be framed and planned with enough resources, facilities, and experts at the beginning. Correspondingly, a study conducted on barriers and enablers of implementation of the local investigator initiated clinical trials in Ethiopia showed that the majority of serious operational difficulties such as problems with trial management, burdensome administration, and difficulty purchasing supplies, problems with setting up and running laboratory tests occurred during the start-up stage of trial conduct [22].

The study illustrated that interviewees perceived lack of interdisciplinary collaboration was a challenge that hindered translating animal research into human clinical trials. Other studies also found out that lack of interdisciplinary collaboration between basic and clinician scientists and with other professional groups were considered to hinder the practice of translational research [28, 31]. The present finding suggests that translation of animal research into human trials is the responsibility of many actors from different disciplines. Multidisciplinary collaboration at national and international level can create a platform for scientists from different background and direction to come together, discuss on prioritizing issues, and read each other rather than conducting pieces of repeated researches here and there in different institutions. Translational research needs two-way or multi-way dialogue between scientists and clinicians, and cooperation between academia and industry [30]. This was also supported by other studies that interdisciplinary collaboration was supposed by scientists as important to facilitate translational research practices [28, 31] by providing chances for knowledge exchange [37], offering distinct forms of expertise [38], and creating a working environment which encourages communication and co-operation between different scientists [20]. Collaboration was seen as being best achieved through multi-disciplinary teams, working throughout the entire research process [28]. However, interviewees from the present study identified different internal factors such as poor research governance, poor facilities, awareness and preparedness in the research community, prolonged ethical and regulatory approval process and communication barriers that hamper collaboration particularly at international level. This is also supported by findings which shows the identification of a number of factors by scientists that hindered effective collaborative working relationships and practices such as previous professional groupings who do not want to share experiences beyond their group [39] and poor leadership skills of team managers/leaders and institutional arrangements [20]. Traditional barriers between academia and industry is accompanied by conflict of interest issues [30]. All of these institutions in the same network make bench to bedside interactions possible, but conflict of interests remained a problem for

cooperation and affected the stabilities of the network [34].

The study has illustrated that findings found to be effective in animal models were not effective in human studies, as noted by respondent who had experience in translating animal research into human trials. The reason could be anatomical, physiological, and genetic differences between animals and humans, poor experimental design, inappropriate statistical analysis, and the nature of diseases, which contributes to irreproducibility and lack of replicability of findings. Similarly, the irreproducibility of animal research findings due to methodological flaws, including poor experiment, design, and inappropriate statistical analysis, has been reported as challenges that contributed to the low animal-to-human translational success rates in a previous qualitative study conducted with directors of academic programs in the USA [32]. Pound et al. [40] summarized the methodological problems of animal experiments in a systematic review, highlighting several key issues. Using disparate animal species and strains with distinct metabolic pathways and drug metabolites can lead to differences in efficacy and toxicity. Additionally, variations in drug dosing schedules and regimens, inconsistencies in animal selection, randomization methods, choice of comparison therapy, reporting of loss to follow-up, and blinding of investigators contribute to variability. Small experimental groups with inadequate power, simplistic statistical analyses that do not account for confounding factors, and failure to follow intention-to-treat principles further compromise results. Lastly, Pound and his colleagues reported the selection of outcome measures, often disease surrogates or precursors, and different models for inducing illness or injury may have uncertain relevance to human clinical conditions.

Another Chinese case study from the researchers in the Zhao laboratory during clinical trials showed that the drugs that tested effectively in animal studies were not at all effective in the clinical trials with humans because the patients' conditions were much more complicated than those that were simulated in the animal studies [30]. These animal models are precisely defined in the context of a uniform genotype and a uniform environment but stand in stark contrast to humans, who have a comparatively varied genetic composition, highly variable diet, and exposure to an array of environmental stresses. Well-known structural and functional differences between human and animal models further emphasize concerns regarding the translatability of animal models. For example, a mouse heart beats at around 600 bpm compared to 70 bpm in humans [41]. Such differences can complicate the interpretation of results from animal models and their applicability to drug testing and human clinical trials.

Moreover, animal models often fail to predict drug safety in humans accurately. Despite being deemed safe in animal studies, certain drugs have caused harm during clinical testing on human subjects. For instance, Thalidomide, a drug used for morning sickness, does not cause congenital disabilities in many animal species, including rats and mice. However, in humans, it caused a widespread epidemic of severe congenital disabilities in the 1950s and 1960s. This difference is due to faster thalidomide metabolism in rats and mice and stronger antioxidant defenses in their embryos compared to humans [42]. More recently, monoclonal antibody TGN1412, a leukemia drug, was well tolerated in monkeys but caused severe reactions, including multiple organ failure, in six healthy men when given at 1/500th of the monkey dose in phase 1. The adverse effects were due to differences in the drug's target protein between species, leading to a more substantial human inflammatory response [43]. Another drug, Fialuridine, a drug developed for hepatitis B, tested safely in several animal species but caused liver failure in human trials in 1993, resulting in five deaths. The drug's toxicity was due to a unique human transporter molecule absent in the animals, which allowed the drug to disrupt mitochondrial function in humans [44].

This study also identified that the delay in ethical and regulatory processes because of limited qualification and experience of ethics committee members or unreasonably strict approval process by the committee as a barrier to translation of studies conducted on animals into clinical trials. This was supported by qualitative study conducted in Ethiopia, which stated that slow regulatory and ethical approvals due to complex and unclear guidelines, limited ethical review capacity, poor-quality submissions made it very difficult to investigate novel interventions and it was not uncommon for grants to expire before all approvals were in place [22]. Similarly, a survey of senior researchers working in USA Medical Schools and Academic Health Science Centers found that 38% of those surveyed identified complex regulatory requirements as particularly challenging for translational research, thus limiting the success of biomedical innovation being translated into benefits for patients [45]. Chinese study group conducting research on stem cells, revealed that regulation was complicated by numerous, overlapping regulatory jurisdictions inadvertently promoting inconsistency and minimal conformity with the law, resulting in scientists feeling powerless to change the system [38]. Ethical and social implications of scientific advances were perceived to add an additional layer of complexity to translational research. Scientists working on stem cells as a potential therapy for leukemia [30] and diabetes [37] reported making a deliberate effort to follow strict regulatory processes to ensure acceptance and legitimacy of their research [30]. The present study also highlighted

the initiation to identify the problems causing delay and complexity of ethical and regulatory approval processes to make it faster as mentioned by few respondents.

On the other hand, growing infrastructure and resources was the first theme emerged as opportunity for translating animal research into human trials. This includes many universities with many post graduate studies in various disciplines and institutions like CDT-Africa that are mandated to conduct research and which provide education, training, and capacity building for researchers to be engaged in translational research, motivation and support from Ministry of Innovation and Technology for institutions to be a center for product oriented research, better facilities, the availability of high diversity of medicinal plants, microbes, availability and use of animal model and large human population in which many of them harboring many infectious and non-infectious diseases, the existence of multi drug resistance for the drugs being used, inaccessibility of modern medicine to most of the local communities and availability of indigenous knowledge on the use of traditional medicines for curing of diseases is among the enabling factors stated by the interviewees. This shows the direction to that could help and enhance the practice of translating animal research into human trials in Ethiopia.

Moreover, improved human capacity and better administrative processes was mentioned as opportunity. This study shows these days researchers have better capacity in terms of knowledge, skill, training, experiences, and awareness as compared to few years back. In addition, there is growing interest of scientists, growing work force in biomedical fields or health related researches and better quality of research. This may be happening now because of the world education is geared towards e-learning, scientists may get trainings and education through online courses or scholarships, and they can increase their understanding on importance translational study. The present study also illustrated that there are better administrative processes including supportive rules and regulations, initiations to speed-up ethical and regulatory approval, and the government is giving due attention to problem-solving and product-oriented researches. Therefore, this could motivate scientists to enhance their interest to work on translating animal research into human trials.

This study revealed that despite the challenges of collaboration, there are now initiatives like one health and initiations for collaboration among research institutions. Hence, this could create a platform for scientists from different background to share their knowledge, experience, and skills in research and to discuss on common issues. Interviewees suggested that this should proceed beyond the initiation.

Strengths and limitations of the study

To our knowledge, this is the first empirical study investigating the challenges and opportunities for translating animal research into human trials in Ethiopia. This study may provide a compelling insight on challenges and opportunities for translating animal research into human trials for scientists in Ethiopia who are often unheard about that. Participants were from one of the major research and academic institutions, conducting research that contributes to health in one or another way. Although this study highlights a number of very important issues, there are also limitations. Responses of participants may have been influenced by author's involvement. The participants in this study were only researchers from preclinical and clinical trials area that were purposively selected, could not represent the views of other stakeholders involved in translational research.

Conclusion

This study attempted to identify the challenges that hinder translation of animal research into human trials. Several challenges summarized in six themes were identified: lack of finance and human capacity, inadequate infrastructure, operational obstacles and poor research management, lack of collaboration, lack of reproducibility of results and prolonged ethical and regulatory approval processes. It also highlighted the existing enabling environments for translating animal research into human trials. The major existing opportunities identified by the respondents were synthesized into three themes: growing infrastructure and resources, improved human capacity and better administrative processes and initiatives for collaboration. The study found that these identified characteristics/features are of high importance either to hurdle or enable the practice of translating animal research into human trials. Therefore, to overcome the identified challenges and allow translating of animal research into human trials to proceed more efficiently, there should be adequate infrastructure and sustained funding streams and financial support, human capacity building through trainings on translational research, good research governance, improved ethical and regulatory approval processes, multidisciplinary collaboration, and incentives and recognition for researchers. Animal research should be done to high quality standard by using a well-designed methodology. Clear guidelines on how to conduct clinical trial on traditionally claimed medicinal plants needs to be developed.

Abbreviations

AAU	Addis Ababa University
AHRI	Armauer Hansen Research Institute
bpm	Beats per minute
CDT-Africa	Center for Innovative Drug Development and Therapeutic Trials for Africa
COREQ	Consolidated Criteria for Reporting Qualitative Research

CRO	Contract Research Organization
DSMB	Data and Safety Monitoring Board, EPHI: Ethiopian Public Health Institute
FDA	Food and Drug Administration, GCP: Good Clinical Practice
GLP	Good Laboratory Practice
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
IND	Investigational New Drug
IRB	Institutional Review Board
NAHDIC	National Animal Health Diagnostic and Investigation Center
NVI	National Veterinary Institute
PI	Principal Investigator
UK	United Kingdom
USA	United States of America

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Author contributions
AA conceived, designed and implemented the study, analyzed the data, drafted and edited the manuscript. MG and AH participated in revising, reviewing and editing the manuscript critically for important intellectual content and in developing the final manuscript. All authors read and approved the final version of the manuscript.

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Data availability
To protect the anonymity and confidentiality of the participants, the data used (interview transcripts) are not made generally available, with the exception of the data that has been chosen for presentation in the manuscript.

Declarations

Ethics approvals and consent to participate
The study was approved by the Scientific and Ethics Review Committee of the Center for Innovative Drug Development and Therapeutic Trials for Africa (CDT-Africa), College of Health of Sciences, Addis Ababa University, Addis Ababa, Ethiopia. Verbal and written informed consent was obtained from each subject prior to participation. Participants were given information about the study and that participation was voluntary. All methods were carried out in accordance with the relevant guidelines and regulations at Addis Ababa University.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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