



Multidisciplinary Work Approach to Phytomedicines Research and Development (R&D) in Nigeria – Experts' Opinion

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Authors' contributions

This work was carried out in collaboration among all authors. Author OPA conceptualized the study. Authors HOE and OOK designed the study, wrote the protocol, conducted the survey process and perform the statistical analysis. Author HOE managed the literature searches. Author HOE wrote the first draft of the manuscript. Authors HOE and Author OOK managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Modern drug development strategy involves the use of computer aided *in silico* studies, bioinformatics, and nanotechnology, to predict and simulate drug metabolism, safety and efficacy. The entire process requires molecular targeting, isolation, purification, synthesis through biotechnology or chemosynthesis, formulation, and determination of safety, efficacy and process efficiency. This has brought scientist from diverse background together toward a common course of mutually beneficial innovative research approach. For phytomedicine research, this diversity requires professionals from different field such as the botany, chemistry, biochemistry, microbiology, biotechnology, pharmacy and medicine. Each of these fields also contains various specializations and specific research focus. This study looked at Expert opinion on multidisciplinary approach to innovative phytomedicine R&D in Nigeria. The analysis presented represents the

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opinion of Experts who responded to the study questionnaire. 53% of Experts believed that multidisciplinary collaboration is very productive while 39% believed it is productive. The level of phytomedicine R&D in Nigeria is believed to be poor by majority (56%) of respondents. The Experts believed that multidisciplinary R&D approach will lead to more reliable data, inclusiveness, process efficiency and better R&D outcome, results/products acceptability. Multidisciplinary R&D approach should be encouraged in Nigeria through adequate funding and policy framework.

Keywords: *Multidisciplinary approach; collaboration; phytomedicine; research; development; expert opinion.*

1. INTRODUCTION

There have been consistent and growing paradigm shift in modern approaches to drug discovery and development since the millennium with the deeper understanding and use of bioinformatics and *in silico* studies, as well as the use of nanotechnology in drug research. This has provided a new scientific framework for drug discovery and development research [1]. More reliable approaches and methodologies to predict biomolecule activity, safety and efficacy, are still being sought by researchers to cut cost, increase research efficiency and increase market success of new drugs [1]. In order to solve evolving challenges, new developmental strategies are needed, especially in the area of molecular target medicine, new drug, generic drugs, new drug delivery system and protein-based drugs.

Availability of resources to implement R&D strategies for efficient drug research processes (Fig. 1) are often limited, and at best in different faculties, agencies and institutes. Vertical and horizontal collaborative research approaches among professionals and research institutions, that rely on mapped resources, have been considered by many countries such as China, United States, India, United Kingdom, Korea and most other developed world [1,2]. It is believed that innovation and knowledge creation in multidisciplinary teams relies on proper coordination of the formal team structures and informal coordination practices. Such coordination must involve cross-disciplinary anticipation, synchronisation and triangulation, to overcome knowledge boundaries and high uncertainty. The major challenge of multidisciplinary teams is the divergent nature especially in the composition of individuals from diverging background, knowledge and aspiration, scientific practices, approaches to problem solving, communication patterns, timelines and technologies for knowledge creation [3,4].

Another source of convolution is the fluidity of drug discovery and its team as new frontiers are opened up due to emerging challenges and discoveries [5,6].

Drug development in Nigeria is perceived in many quarters as still elementary and slow due to a variety of factors, among which are the level of collaboration and cooperation among professionals, institutions and sectors. Pharmaceutical R&D mostly exists in reformulation of existing drugs into other dosage forms. However, there is a growing interest in development of natural medicines from plant sources in form of herbal medicines or phytomedicines. Approaches to this development process also employs scientific framework akin to development of orthodox medicine which are usually purified or synthesized biomolecules [7,8]. The interplay of chemicals and biological activity to which all drugs owes their status and identity, leads to the inevitability of chemical and biological processes in determining the safety, efficacy and quality of any drug product [7]. Similar technologies involved in bioactivities discovery, safety and efficacy prediction and studies are also urgently needed. Some existing technology for predicting activities, safety and efficacy, may not be readily applicable due to the multicomponent nature of most phytomedicines, hence the need for the development of research strategies and technologies that can adequately address this gap. This we believe can be achieved through a multidisciplinary collaboration.

This study aims to survey opinion of experts on multidisciplinary work approach to phytomedicines R&D in Nigeria, with the hope of identifying specific challenges in collaboration and propose ways of resolution. The study also attempt to obtain perspectives to general challenges in phytomedicine development and use in Nigeria.



Fig. 1. Scientific framework for development of medicine (Source: adapted from Lui et al., 2014)

2. METHODS

A structured questionnaire was designed and used to collect data from experts in drug development R&D across seven universities and research centres in Nigeria. The targeted sample size was 20 experts with diverse knowledge and background in drug development. This questionnaire covered experts' perception on multidisciplinary work approach to phytomedicines R&D in Nigeria. No personal identifying information was collected.

2.1 Data Analysis

The information obtained was analysed using simple Microsoft Excel spread sheets and graphical presentation.

3. RESULTS AND DISCUSSION

The demography, professional affiliation and R&D roles of responding Experts are as depicted in Figs. 2 to 6. Eighty-nine percent (89%) out of targeted respondents returned the filled questionnaires (Fig. 2). Forty percent of the respondents were female. The professional affiliations of the respondents (Fig. 3) include medicine, pharmacy, biochemistry, chemistry, microbiology, botany, virology, epidemiology, pharmacology, pharm. Technology, parasitology, zoology, ethnobotany, TM Practice, pharmacognosy,

microbiology, botany, ethnobotany, virology, epidemiology, pharmaceutical technology, pharmacognosy and traditional medicine. About 89 % of respondents were experienced in phytomedicine development, while the other 11% have had no direct involvement in phytomedicine R&D (Fig. 4). About 32% of respondents have been involved in R&D as Collaborators, 30% as Principal Investigators, 27% as Investigators, and 11% as manufacturers (Fig.5). About 40% of Experts had more than 21 years of experience in phytomedicine R&D, while close to 40% had between 11 and 20 years experiences (Fig. 6).

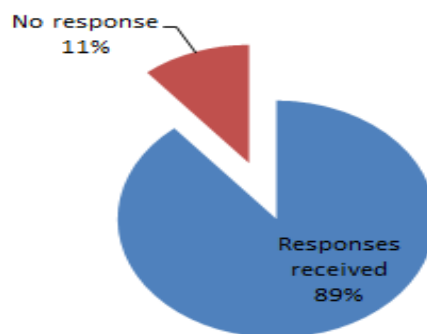


Fig. 2. % Response to questionnaire

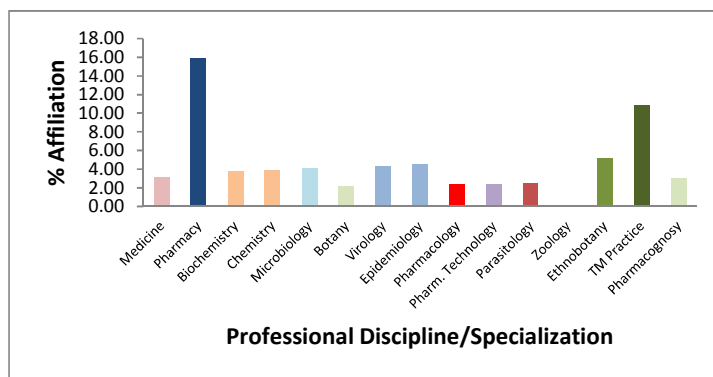


Fig. 3. Affiliation to professional discipline and specialization

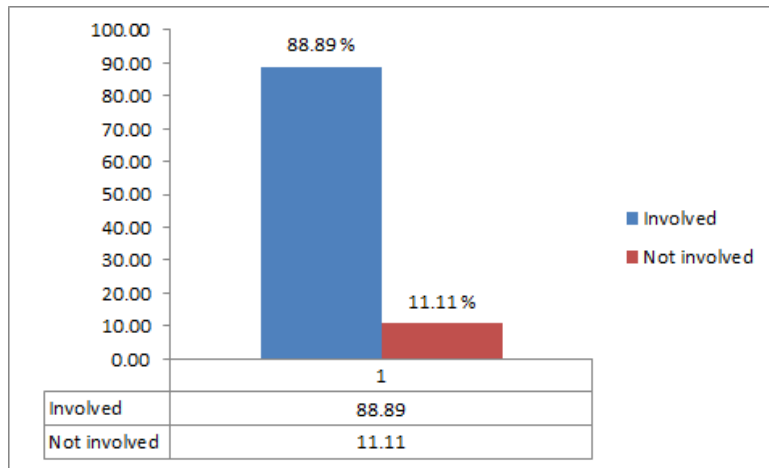


Fig. 4. Involvement in phytomedicine R&D

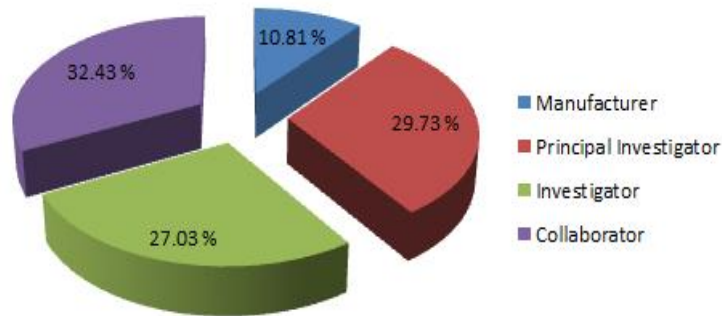


Fig. 5. Roles played in phytomedicine R&D

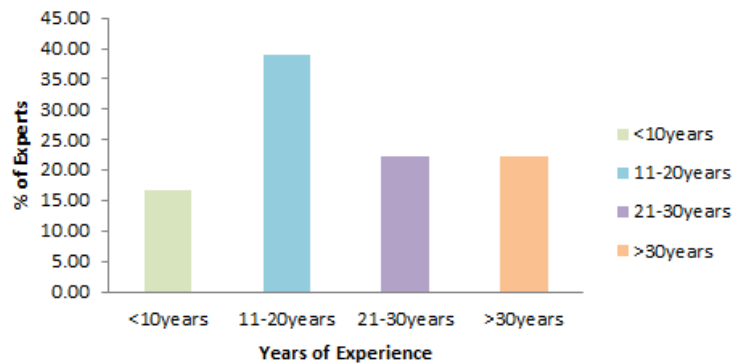


Fig. 6. Length Experience of Expert in Phytomedicine R&D

A sizeable number of the Experts have had collaboration on personal, departmental and institutional representative capacities. However only about 6% has had inter-sectoral representation collaboration experience (Fig. 7).

Disease areas of these Experts include malaria, HIV/AIDS, TB, diabetes, ulcer and cancer (Fig. 8). Some are also involved in studies involving metabolic pathways, methods developments and traditional medicines practice.

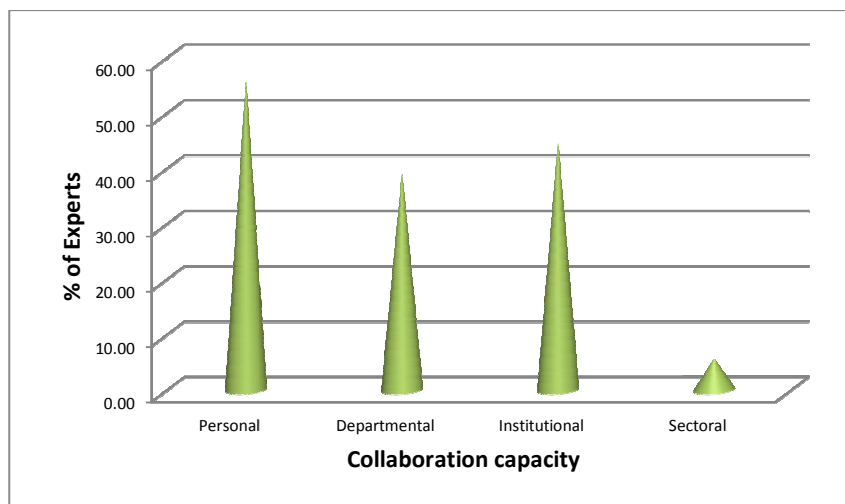


Fig. 7. Collaboration capacity

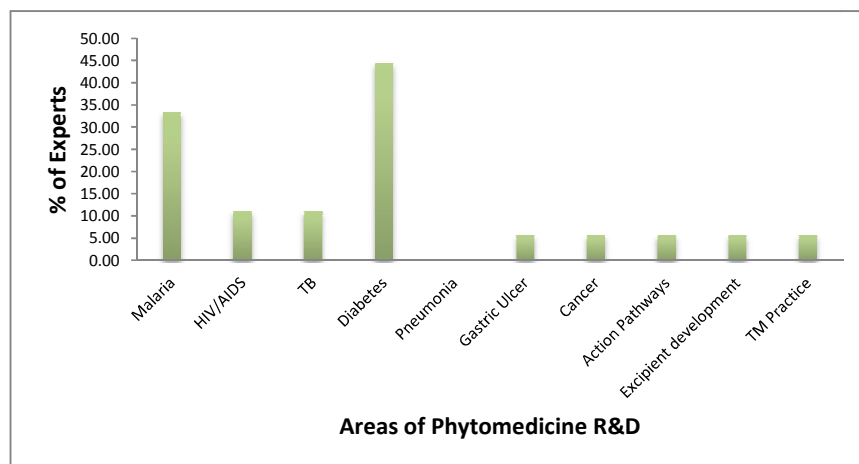


Fig. 8. Areas of phytomedicine R&D

3.1 Opinions

3.1.1 Collaboration

The Experts have collaborated with different health R&D professional (Fig. 9). However, prominent amongst these include Pharmacologists (61%), Pharmacists (55%), Biochemists (55%), Chemists (44%), Pharmaceutical Technologists (38%), Microbiologist(33%), Medical Doctors (33%) and Traditional Medicine Practitioners (TMPs, 33%), Ethnobotanists (28%) and botanists (22%).

53% of Experts believed that multidisciplinary collaboration is very productive and 39% said it

was productive. Others (11%) were either unsure or indecisive (Fig. 10). To strengthen collaboration, it was suggested that the interest of all participants must be identified and adequately addressed. This is better achieved if the collaboration on any project starts from conceptualization, and all activities and results be handled transparently. The complete framework for collaboration on any project should be drawn at the onset of conceptualization. The framework should capture mode of creation of teams and selection of team members/leaders; information dissemination / communication; funding framework; authorship and intellectual property of study outcome; and benefits sharing of study outcome.

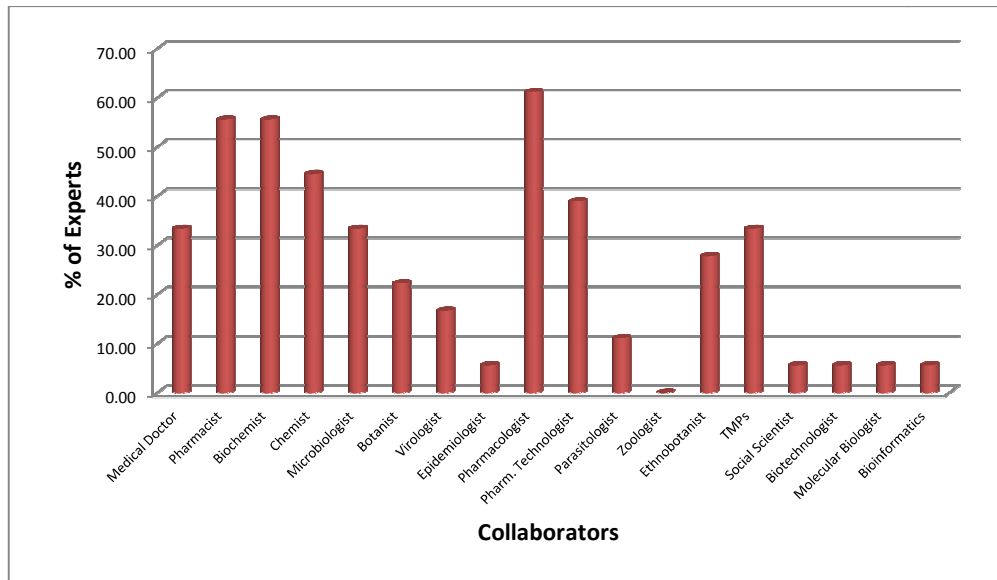


Fig. 9. Major collaborators

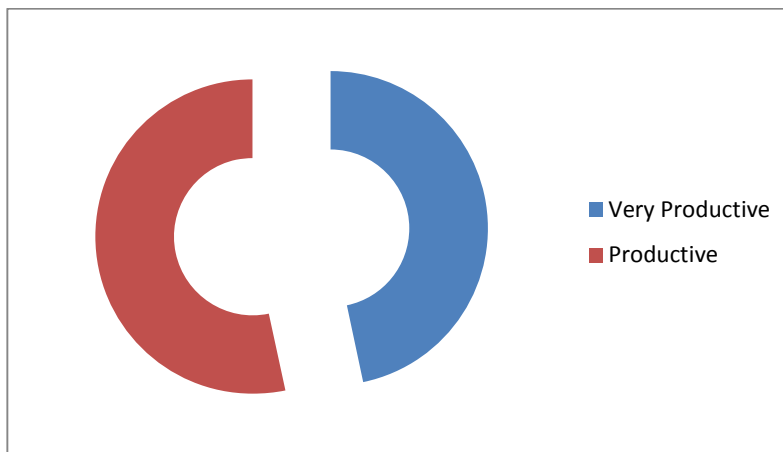


Fig. 10. Opinion of experts on collaboration

Other identified factors that can help strengthen collaboration include joint grant proposal funding, keeping to funding schedules and agreements, ensuring the selection of personnel for collaboration depends primarily on required expertise and the individual's ability for team play. Private sector and Industry engagement which can help strengthen output utilisation can also strengthen collaboration. Developing a team collaboration Portal, building mutual understanding, respect and trust, and improving communication also strengthen collaboration. Keys to sustainable collaboration are clear understanding of set goals and expectations, transparency, accountability, historical experience, and mutual respect.

Although the respondents were not certain if any relevant professional should be left out in study collaboration in order to reap the huge diverse resources in intellectual and skill contribution (Fig. 11), however, some were of the opinion that non-team players and compromised professionals should be excluded or eased out from any collaboration. Fig. 11 shows that tops on the list of desired collaborators in phytomedicine development include Medical Doctors (89%), Pharmacologists (89%), Pharmacist (83%), Biochemists (83%), TMPs (83%), Chemists (78%), Parasitologists (78%) and Ethnobotanists (78%).

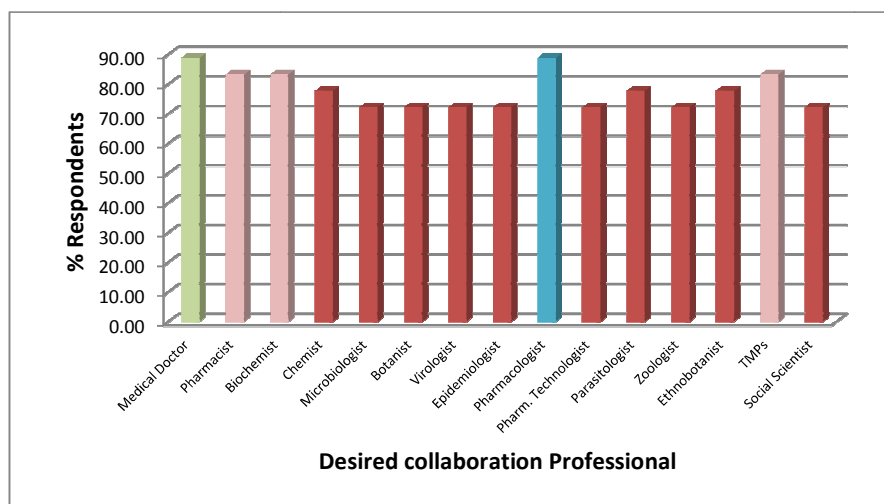


Fig. 11. Desired professional collaborators by experts

It is believed that the expressed desire to collaborate with the entire spectrum of biomedical research professionals is based the spirit of team science, which gives easier and enhanced approach to research, better output and cost effectiveness, as well as better approach to meeting timelines.

Several impediments were identified against effective multidisciplinary study collaboration. For instance the time needed for interdisciplinary teams to develop a generally acceptable framework for collaboration could be an obvious impediment in the Nigerian R&D system where funding is always a challenge and outputs may be quantity and not quality driven. Some of the challenges usually encountered which are major impediments to multidisciplinary collaborative research include authorship and intellectual property rights issues, honorarium and meeting timelines (Fig. 12). Few noted that they have not experienced any challenge in the listed categories.

Addressing the challenges and impediments to collaboration requires a robust framework that will drive the collaboration process from the onset of the collaboration; having mutual understanding and clear-cut roles for partners; defined scope of work with adequate funding; work scope / needed skill dependent partners selection; clear framework and partners agreement on authorship, publication, patents, milestones and timelines, etc; clear understanding of the concept, goals and objectives of study from onset e.g. whether it is

for product development or research paper publication; keeping to agreed funding framework; and providing a structured forum to exchange ideas, such as multidisciplinary team meetings, which helps improve working relations and promote evidence based investigations. All activities and communication must be documented.

There must be strong inter-personal rules, oversight, and transparency from onset. Everyone who will be a potential collaborator or stakeholder should be involved in every strategy meeting. There should be effective communication, clear understanding of team members, transparency and mutual trust. Conflict of interest should be identified and addressed by selecting team members of like-minds who are well known in research capacities and character traits. This may better be understood not in the traditional sense of R&D conflict of interest in terms of relationships with funders or product owners/competitors in the wider space, but in terms of hidden personal interests and expectations for self-aggrandisement. This may come from considerations of professional or workplace rivalry, and /or financial gains. This can be achieved by following the publications in the relevant field and not being restricted to in-country collaborators. Possibilities for engaging international collaborators should be exploited. Impediments can also be minimised if the industry is involved in research and development collaboration. The industry can sponsor collaborative research and help set spectrum of professional that may be involved in the study.

3.1.2 Phytomedicine R&D status

The level of phytomedicine R&D in Nigeria is believed to be poor (56%) by majority of respondents while (39%) indicated that it is fair (Fig. 13). However, 72% described phytomedicine R&D as evolving while 28%

believe it is slow (Fig. 14). The major reason for this is the poor uptake of R&D output by the industry. Generally, while research into phytomedicine is believed to be fair, translation of research output into registered products is slow.

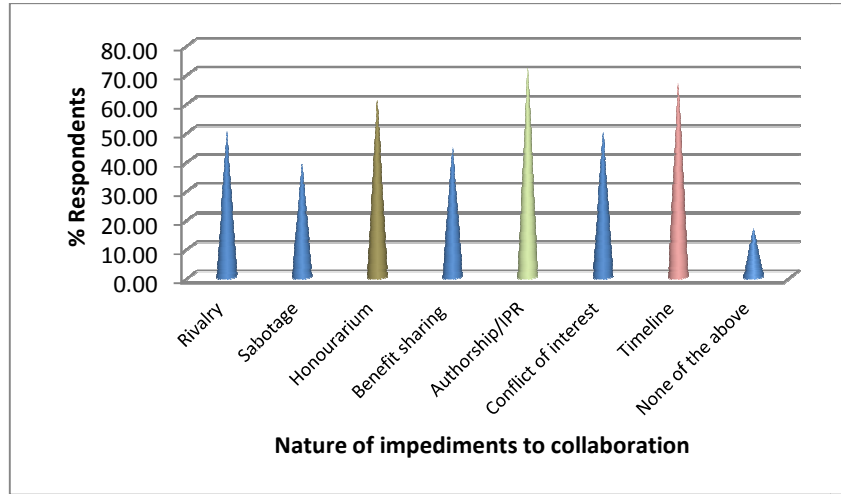


Fig. 12. Impediments to collaboration

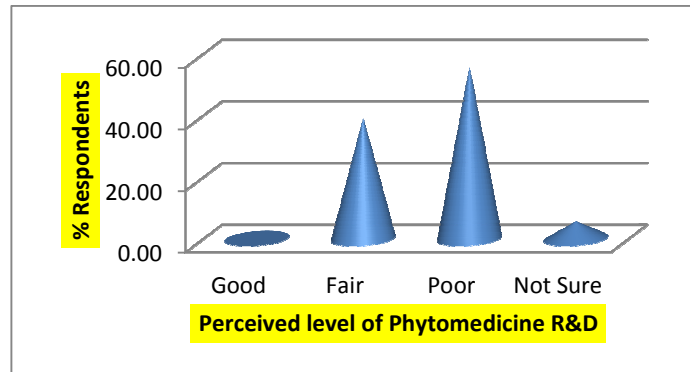


Fig. 13. Level of phytomedicine R&D in Nigeria

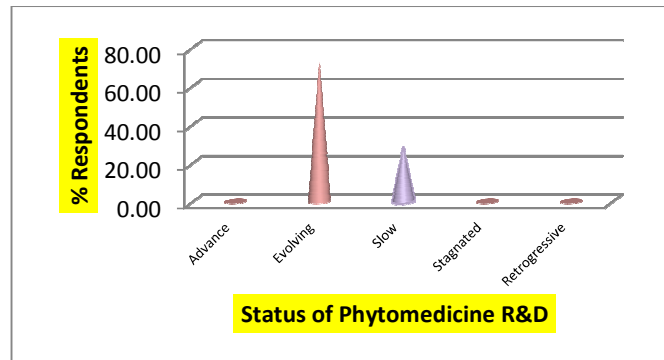


Fig. 14. Status of phytomedicine R&D in Nigeria

3.1.3 Phytomedicines' acceptability

While about 89% believe that phytomedicines use is gaining acceptability in Nigeria, about 11% either disagreed or were not sure (Fig. 15).

To improve wide acceptance the following were suggested:

- i. R&D of affordable safe and effective products
- ii. Validation of product's claims, especially the safety and efficacy.
- iii. Clinical trial of products
- iv. Development / standardization of botanicals that are efficacious, and not cost-inhibitory.
- v. Ensuring better formulation and packaging,
- vi. Improve products standardization, and scientific evidence for the use of the product.
- vii. Advocacy and media campaign to increase awareness and promote science backed remedies.
- viii. Community education and proper information dissemination.
- ix. Formulation of deliberate policy for uptake of phytomedicine R&D outcome by government.
- x. Listing by NAFDAC.
- xi. Government and private sector patronage.

Experts recommended the passage of the Bill on traditional medicine practice to address issues of herbal medicine abuse and misuse, including elimination of bogus cure claims. The bill is also expected to enable government to operate a health system where the conventional and traditional practices are well recognised and accessible in government facilities in a parallel treatment system. This they hope will encourage scientific evidenced based traditional medicine practice and use of well researched phytomedicines. They also advocated the participation of educated professionals in phytomedicine production and marketing. This can take the form of licencing to produce or market a product. For instance, Pharmacists or Chemists or any other laboratory based Scientist could be the licensee for a production facility /or advertorial for phytomedicine.

3.1.4 Improving the quality of phytomedicines

To improve the quality of phytomedicines produced in Nigeria, experts suggested

- i. Development of indigenous pharmacopeia and standardization criteria for phytomedicines;
- ii. Use of high-tech research facility;
- iii. Harnessing the capabilities of the different experts;
- iv. Adequate funding for R&D
- v. Availability and accessibility of standard production facilities
- vi. Production of products devoid of extraneous materials like sand, faeces etc.
- vii. Improving on product Consistency, packaging, availability and affordability
- viii. Establishments of medicinal plants plantations to provide steady supply of standardised raw materials;
- ix. Encouraging Good Agricultural practices as source of empowerment for the populace;
- x. Classifying Phytomedicine into OTC and regulated herbs,
- xi. Proper identification of herbs and documentation;
- xii. Training/Retraining of Practitioners and manufacturers on Formulation;
- xiii. Conducting clinical trials;
- xiv. Setting and enforcing standards for phytomedicines
- xv. Providing financial support for setting up phytomedicine manufacturing industries,
- xvi. Encouraging the use of phytomedicines of proven activity by conventional/ orthodox practioners/establishments
- xvii. Encouraging honest research output and good collaboration among scientists;
- xviii. Encouraging good agricultural practices to obtain defined and reproducible conditions. There should be comprehensive production protocols (and SOPs);
- xix. Encouraging submission of products for listing by NAFDAC.

3.1.5 Phytomedicines' Competitiveness

83% of Experts believe that Nigeria can be scientifically and economically competitive in phytomedicine development while the remaining 17% believe otherwise or were not so sure. Experts also described the level of phytomedicine R&D as poor or fair (Fig. 13). The major challenge to R&D being lack of requisite materials including equipment, apparatus, reagents and reference standards; poor funding; poor human capacity (poor R&D skills); and poor cooperation and coordination; inconclusive and

incomplete research and lack of political will in recognizing outputs. These challenges in advancing R&D have been identified in other parts of Africa [9].

Suggested solutions include more Research Specific Funding through open competitive grants; more collaboration among professionals and research centres; better research coordination from the government; better collaboration between researchers and industry; and more capacity (research skill) development; Better matching of professionals with adequate/complementary skills that have been demonstrated.

3.1.6 Multidisciplinary collaboration

Experts generally agreed that multidisciplinary collaborative approach to phytomedicine R&D was the proper way to achieving credible and quality R&D output(s)/outcome(s) because it pulls and leverages the relevant expertise and experience in a harmoniously complementary and synergistic manner. Multidisciplinary approach x-rays essential questions and proffers more cost-effective approaches to solution. However, acceptable framework for IPR issues such as authorship and patents and proper coordination through a national research council (NRC) were suggested for a more effective collaboration system.

Critical to the success of a multidisciplinary approach to phytomedicine R&D is the complementarity of the professionals, understanding of project goals and framework for implementation, building the team spirit, ability to resolve incidental issues, science- or evidenced based approach to information sharing or dissemination, transparency, accountability, mutual trust, adequate funding of study and proper coordination and governance structure. Desire for diverse, detailed and quality work, open-mindedness, and eagerness to learn from one another as well as capacity building, exchange programmes, helps to strengthen the gains of multidisciplinary R&D approach.

The impediments to multidisciplinary approach to phytomedicines development process include

- i. Poor coordination,
- ii. Mutual suspicion or lack of trust,
- iii. Lack of cooperation amongst professionals,
- iv. Antagonistic attitudes;

- v. Lack of understanding of the sciences required
- vi. Mind-set from historical backgrounds;
- vii. Lack of historical inter-disciplinary cooperation
- viii. Inadequate funding for inter-disciplinary studies,
- ix. Lack of understanding and ground-standing in differences of personal and professional perspectives
- x. Non-utilization of research findings;
- xi. Lack of transparent and objective team selection process;
- xii. Delays in decision making due to wider consultation and conflicting views.
- xiii. Lack of support from the industry.

Collaboration of experts in phytomedicines development can be improved through greater scientific interaction through conferences, workshops and seminars; study visits through exchange programmes and mentorship; creation of scientific networks, association and societies; formation of a national research network and council; imbuing positive attitude to team work; establishment of multidisciplinary research cohorts and teams; development of agreed MOU on roles, responsibilities and funding; developing common research problem, mutually define a conceptual framework, research methods including data analysis, communication strategies (formal and informal), documenting activities and sharing experiences, payment of appropriate honorarium; availability of accessible R&D resource (equipment and facilities) maps.

Experts believed that the future impact of multidisciplinary approach to phytomedicine R&D include improved skills and professional capacity of collaborators; opportunity to learn new skills, methods and strategies from collaborators; reliability of data; broad spectrum acceptance of study outcome among different professional groups; more conclusive study for societal acceptance and use; better products; better patients outcomes; better opportunity for winning competitive grant proposals; increased collaboration network; increase scientific/professional visibility; personal fulfilment and a feeling of great sense of self-worth and accomplishment; better team play; broader perspectives to ideas and issues; better project planning and coordination; Improved understanding, trust, accountability, cooperation and transparency; strengthen or encourage development of phytomedicine from indigenous resources.

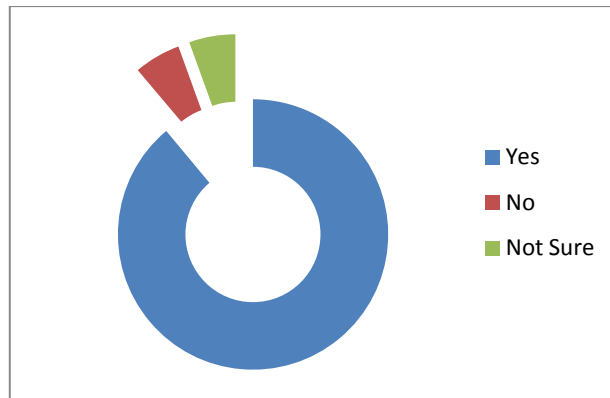


Fig. 14. Phytomedicine acceptance

3.2 Advancing the Development of Phytomedicine

3.2.1 Funding framework:

For the phytomedicine research and development to grow in Nigeria, Experts recommended a complete overhaul of the funding framework and policy. This includes the quantum of funding accessible from government and partners, and the fund release pattern from government. The current fiscal budgetary approach to research in research institute and academia is not sustainable for innovative research.

The level of funding from an established funding agency like TETFUND is grossly inadequate, and is limited to only the universities without proper framework for adequate collaboration with relevant research institutes. Government should develop an R&D road map for utilisation of Nigerian medicinal plant biodiversity. Such document should identify national health/disease R&D priorities and establish milestones for indigenous phytomedicine development for inclusion in Essential Medicines for national use. There should be a workable policy for effective regulation of development and use of phytomedicine from field/lab to bedside. The NAFDAC listing policy could be reviewed and improved upon.

The government needs policy reforms to accommodate new funding framework for innovative R&D, and to get the private sector involved in both research funding and R&D output uptake. There should be a national R&D policy that should incorporate multidisciplinary framework, collaboration framework, governance

structure, monitoring framework, reward or compensation framework for both locally funded grant research and partner or foreign funded grant projects.

3.2.2 R&D equipment and personnel

Closely associated to the funding framework is the dearth of R&D equipment and consumables. There should be government intervention on accessibility to equipment and consumables for R&D. Funding for R&D equipment and consumables should be released according to plan to be able to get the full complement of their use. The procurement process should be less cumbersome. Training of personnel on use of research equipment should be prioritised with same priority as obtaining the equipment itself. This will reduce the rate of equipment breakdowns and maintenance as a result of lack of competence, and improve output.

3.2.3 R&D uptake by Industry

In addition to developing a workable funding policy framework, there should be new policy drive to ensure deliberate R&D output uptake by the industry. This will encourage better project conceptualization for national growth. It will also encourage better cooperation and synergies among professionals as well as boost their morale, and support the development of young professionals in the field [9,10].

4. CONCLUSION

The study shows that promoting team science which recognises and leverage the multidisciplinary contributions to research outputs to ensure in-depth critic and contributions to

study, shared responsibilities, outcome acceptability across broad spectrum of professionals and work efficiency, appears to be the new order for developing affordable health product that could stand the test of time. Multidisciplinary approach also guarantees funding efficiency through transparency and accountability, as well as research honesty as a result of multiple contributors. Multinationals like Merck was able to adopt multidisciplinary collaboration approach in the race to vaccine R&D since 1957 and was able to develop several viral vaccines in quick succession and achieve its corporate goals [11]. However, for a more productive collaboration among different professionals, there must be clear understanding of goals and framework of collaboration from the onset. There should be mutual respect, transparency and accountability.

The contributions of the relative productivity of different scientific disciplines in predicting the future economic growth of a nation has long been identified. The rich and poor countries differ in the relative proportion of their scientific output in the different disciplines [12]. More than economic, social, financial, or tech-sophistication indices, the relative scientific R&D productivity of middle income countries like Nigeria and some other African countries has been observed to strongly correlates with their present and future wealth. Countries with higher relative productivity in basic sciences such as physics and chemistry had the highest economic growth in the subsequent five years compared to countries with a higher relative productivity in applied sciences such as medicine and pharmacy. Results suggest that the economies of middle income countries that focus their academic efforts in selected areas of applied knowledge grow slower than countries which invest in general but targeted areas of basic sciences [12]. It is believed that middle income countries will benefit more if they apply the act of synergies and a good blend of basic and applied research.

Phytomedicine R&D in Nigeria is considered evolving or slow. Experts recommended the establishment of a better funding framework and access to equipment and staff training for better output. They also suggested that the minimum goal for any grant funded phytomedicine research and development study should be a NAFDAC Listed product. There should be a new policy framework which should be clear and implementable with articulated and clearly defined roles. For instance, what role(s) does

government, research institutions, academics and industries play? Establishment of botanical gardens across the zones of the country should be a policy for enhancing local phytomedicine development and production.

Finally it was recommended that inter-disciplinary and inter-institutional R&D collaboration should be encouraged for far-reaching, in-depth and innovative R&D outcomes. Multidisciplinary research approach foster humility and cooperation as well as broadens the vista of research and research perspectives.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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