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Academia-Industry Interactions in Nigeria Pharmaceutical Innovation System

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Abstract

This study examined the types, nature and intensity of academia-industry interactions in Nigeria's pharmaceutical innovation system. Eight (8) top-ranked universities offering Pharmacy as a course of study, 2 Pharmaceutical Research Institutes and 25 pharmaceutical firms were sampled for the study. Interactions are predominantly in the form of knowledge flow and consultancy, staff exchange/fellowship programmes as well as sponsored workshop participations. Intensity of interactions is limited as only 20% of pharmaceutical researchers from Universities and 7% from Research Institutes had strong interactions with Pharmaceutical firms, while only 4 firms have strong interactions with the researchers.

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Keywords: Academia; pharmaceutical industry; research and development (R&D); interaction; innovation

1.0. Introduction

Innovation has been identified as the basis for rapid industrial growth and competitiveness. Innovation Systems (1, 2, 3) constitute an analytical framework for understanding and evaluating the socioeconomic structure and innovativeness of nations. This approach which is largely based on the interactive learning theory of Lundvall underscores the importance of interactions among the agents within a system. The Innovation system framework therefore consists of analyzing the existence of actors in a given system (institutions, universities, industries, etc), their main competences and the interactions into innovation networks that occur among them. The framework is therefore a useful tool for measuring innovation success, constructing a more competitive and efficient innovation system by policy makers and other authorities within a virile NIS.

Several empirical studies continue to show the essentiality of interactions among agents within a virile NIS as a determining factor for a robust innovation performance (3, 4, 5, 6). For example, (4) argue that knowledge interactions among firms, public research institutions and technology policy are key determinants of innovation success. Knowledge arising from University and Research Institutes' Science and Technological researches significantly impact on the industrial sector through the production of prototypes, design of new processes and other products, and lowering of research and development (R&D) costs (4, 7). The Universities and public

Research Institutes (RI) also provide major inputs for industrial production processes in terms of human capital, either through the education of graduates, who become industry researchers or through personal mobility from the academic institutions to the firms (4). On the industry side, the extent of knowledge exploitation for economic development, within the context of academia-industry linkages, depends largely on internal capability of firms, the nature and intensity of interactions. Evidence from OECD show that many industries have developed the research capacities that are sometimes more advanced than that of the public sector. In addition to in-house R&D, industrial firms out-source R&D to Universities and RI through consultancy & contract research, joint research or training. Personnel mobility, conferences, informal contacts and commercialisation of intellectual property rights are other channels of interactions. Through these interactions academic researchers receive additional income, research fund, gain access to industry resources and an awareness of industry-related problems useful for further research.

The relevance of academia-industry interactions to technological progress and economic development, especially in terms of stimulating technological advancement in the private sector, promoting industrial competitiveness and encouraging the generation of new products, processes and services should be of interest to emerging and developing economies. Nigeria, like many developing countries, still struggles to develop a strong NIS able to cope with the challenges of globalization and market competition as well as attain technological advancement and improve the well being of the citizenry. With a population of nearly 160million people (current projections) and about 60-70% of this figure living within the poverty line coupled with poor infrastructural facilities and a weak industrial base, the quest for a full-fledged NIS to drive all the sectors of the economy is of strategic importance. The need to increase productivity, achieve industrial competitiveness and subsequently attain sustainable socioeconomic development is increasingly becoming important for Nigeria's survival as a nation. Policy interventions aimed at promoting and strengthening academia industry relations in order to maximise its advantages for economic development have become urgent and imperative in view of the prevailing poverty and poor human development indices. Several policy initiatives and many developmental strategies have been adopted to fasttrack Nigeria's economy within the context of NIS framework (8,9,10), but to what extent have academia-industry interactions impacted on Nigeria's economic development remains a relevant question.

Studies of Nigeria's NIS (11, 12, 8, 9, 10) revealed Nigeria's under-developed innovation system and weak research-industry interactions. It was argued that labour conditions of employment and cost implications (in time and money) have hindered or disinclined Nigerian university professors from engaging in interactions that could lead to commercial ventures such as academic entrepreneurship and formation of spin-off companies (7). The general problems of the university system in Nigeria and the paucity of physical and knowledge infrastructures were also considered as obstacles to university industry interactions and the innovation process. Furthermore, a baseline assessment of the pharmaceutical sector carried out by the Federal Ministry of Health in collaboration with WHO (13) appears not to take cognisance of any sectoral innovation development.

The pharmaceutical subsector, a multibillion dollar industry, represents a huge potential for boosting Nigeria's economy and producing essential pharmaceuticals, especially drugs, to meet the healthcare needs of the nation and improve the quality of life of its populace. However, in the face of global competitiveness, drug resistance and emergence of new diseases the need to develop new drugs, particularly from indigenous raw materials and recipes, improve on existing ones with enhanced efficacy, precision in action, safety and quality becomes important. Although the capability to produce active pharmaceutical ingredients (API) of generic and specialised drugs is non-existent as at 2010 (14), more indigenous pharmaceutical firms are venturing into the market. It is important to formulate policies to build or strengthen the capacity of these firms to manufacture drugs from local materials. This will require the input of research knowledge and active collaboration with external sources of knowledge such as Universities and Research Institutes. The present study examines the current status of academia industry interactions in the Nigerian pharmaceutical innovation system with the objectives of assessing the nature and intensity of such interactions, identifies gaps and suggests policy directions.

1.1 Brief Profile of Nigeria's Pharmaceutical sub-Sector

The Pharmaceutical industry is an important sub-sector of the manufacturing sector as it contributes 2% of GDP or US\$7.396 billion PPP (₦ 1.109 trillion PPP). There are about 128 local drug manufacturers in Nigeria, which represent between 60- 70% of the total pharmaceutical manufacturing concerns in the West Africa subregion (14). The pharmaceutical manufacturing sub-sector has an aggregate investment of over N300 billion and employs over 600,000 people. Between 2000 and 2008, the sub-sector received foreign direct investment of about US\$1.5bn. The domestic pharmacy market was worth about US\$ 600million in 2009 and was projected to grow substantially at about 12% annually to reach US\$ 717 million by 2011 (14). The estimated market for prescription ethical pharmaceuticals is US\$ 500 million and that for over the counter (OTC) pharmaceuticals about US\$ 900 million. PMG-MAN estimates the market for biological products to be worth US\$ 100 million according to (14) report on Nigeria's Pharmaceutical sector profile. Out of the 71 companies registered as active members of the Pharmaceutical Manufacturing Group in 2012 only eight (8) are listed on the Nigerian Stock Exchange. These attributes were major considerations in purposively selecting the subsector for the impact assessment of academia industry interactions.

2.0 State-of-the-Art

2.1 Innovation Systems

The innovation system approach emphasises interactions among knowledge institutions (universities and research institutions), firms and governments for innovation success. The role of universities and other research institutions were conceived in the 'linear model of innovation' to be limited to the creation and dissemination of knowledge, which is utilized occasionally in the production of goods and services or in design or process innovation. The recognition of this fact made governments of the industrialised countries to link universities to industrial innovation through the establishment of science parks, business incubation centres, public seed capital funds and other bridging institutions since the 1970s in order to enhance research-based, local economic development (15). "Mode or Type 2" innovation concept viewed research to be more interdisciplinary and inter-institutionally collaborative, encompassing the interaction of many more communities of researchers and other actors within any given research area. Innovation is no longer seen as a linear process but as a spiral mode operationalised through strategic networking between different actors at the national and international levels in multidisciplinary knowledge networks (16). The Mode 2 concept reflects the increased scale and diversity of sources for knowledge inputs required for scientific research. Subsequent developments in the innovation process recognise government action and legal frameworks as factors influencing academia-industry interactions.

The Triple Helix concept emphasised increased interaction among institutional actors, with each actor assuming the role of the other such that universities engage in entrepreneurial tasks of marketing knowledge and creating companies while firms take on academic responsibilities (15). The interaction of academia, public research and industry is agreed to take place in an economic and policy environment (16). The Triple Helix theory connotes that universities have embraced economic and social development as a new mission without jettisoning her traditional engagements of teaching and research (17). In accepting this new task, universities are said to become part of a coherent system that includes industry and government and underpins innovation and economic progress (17).

Great attention is now shifting on exploiting the potential of the various forms of academia-industry linkages to accelerate research and technological development for sustainable development. Dwindling public funding for research plus increased competition for the available research funds have led to aggressive disposition of universities towards becoming entrepreneurial in seeking new sources of funding and capability for research, especially through university-industry linkages. Several studies have consequently showed an increasing level of academic commercial activities such as patenting, licensing, enterprise and spin-off creation (17, 16). Within the context of the entrepreneurial mission, academia-industry research collaborations have been found to be extremely important mechanisms for generating technological development (17). Other forms of interactions

such as joint scientific publications, joint research ventures, contract research and consultancies, training of firm staff, joint supervision of PhD and Masters Theses, staff exchange, formal and informal meetings have also increased (4). At the same time, several policy initiatives of governments worldwide are being introduced with increasing rapidity to promote academia involvement in technology transfer activities. This has led to developments in Europe, especially in OECD countries, where research capacities of firms have taken roots and are yielding greater R&D outputs than those of the academia.

2.2 Academic Industry interactions

Academia industry interaction, in the context of this study, is limited to "university-industry interaction" and "research institute-industry" interactions as defined by (16). Martin argued that research organisations engaged in basic, applied and development research play a significant role in knowledge production, and many of them are also engaged in interactions/linkages with the industry. Academia-industry interactions have since assumed an important role in the policy arena and become a veritable object of study in academic circles. Universities are increasingly being called upon to contribute to economic development and competitiveness and policy-makers have put in place initiatives aimed at increasing the rate of commercialization of university technology. Notably, policy-makers implemented laws that provide commercialization incentives to universities by granting them ownership of intellectual property arising from their research.

Other policies encourage universities and firms to engage in partnerships and personnel exchange, for instance via university-industry centers or science parks. Finally, a third type of initiative seeks to build universities' knowledge transfer capabilities by supporting recruitment and training of technology transfer staff. The subject matter keeps on expanding and is now known to embrace a wide range of modalities in the form of student placement schemes, staff exchanges, sabbatical staff engagements, consultancy services, continuing professional development, joint research and development, joint publications, informal meetings (including talks and communication), small enterprise development (including the creation of spin-offs for the commercialisation of R&D products and the development of consortia for collaborative R&D at the international level (4,16).

Academic industry interactions are conceptualised as a means to bridge the perceived gap between science base and the productive sector which would allow the rapid transformation of new knowledge into innovation. They are an important tool for making high education more relevant to employment as well as ease the entry into the labour market. Collaborative engagement with industry may benefit academics' research activities by establishing relationships with knowledge users and mobilizing resources that complement public research funding. In many disciplines, interaction between researchers and producers of technology underlies the progress of both science and technology in a mutually beneficial way.

2.3 Academia industry interaction and Pharmaceutical innovation

Case studies show that drug discovery is characterised by a high degree of public and private interaction in research. The pharmaceutical innovative process is reported to be a learning process with multiple points of public-private interaction as well as information feedback taking place along the whole innovative chain from drug discovery to market and back to drug discovery. Existing qualitative and quantitative evidence show a strong influence of academic research on pharmaceutical innovation. Reports show that 79% of US drug and medical patents originated from public science institutions, while firm-level interaction with public research was positively related to performance in drug delivery (18, 19). (20) showed that the pharmaceutical industry had the highest percentage of new products based on recent academic research. (21) reported that public research influenced new project ideas in the pharmaceutical industry more than in any other manufacturing industry.

2.4 Nigeria NIS and pharmaceutical innovation

Pharmaceuticals are an integral component of health care systems globally. Pharmaceutical innovation is the discovery, development, production and delivery process that enhance the availability of medical products and people's access to them. Evidence from literature indicate little or no pharmaceutical innovation is taking place in

Africa since her capacity for pharmaceutical R&D and local drug production is among the lowest globally. This is responsible for the inability of many African countries to produce essential medicines for the teeming population daily confronted with poverty and a range of debilitating diseases. Several local and international initiatives have however been adopted by many African countries in the recent times to remedy the situation.

In Nigeria, the thrusts of the National Drug Policy (1990) and (2005 revised) editions were to make available at all times medicines which are effective, affordable, safe and of good quality in all sectors of the health care system; improve the quality of health care through the rational use of medicines and boost local capacity for the manufacture and export of essential medicines (13). The revised 2005 Drug Policy set a 70% local essential drugs manufacturing target achievable over the 10 years following 2005 and also sought to promote pharmaceutical research and development of raw materials for the production, compounding and formulation of pharmaceutical products. The Presidential Forum on the Pharmaceutical Sector held in 2003 and the favourable 2005 Fiscal Policy were practical steps taken by Government to ensure that the local pharmaceutical industry becomes a major actor in providing good quality essential medicines and increase the vibrancy of the sector for the improvement of the people's health. Meeting the healthcare needs of Nigerians for medicines on a sustainable basis will depend on a mix of many factors, including a robust S&T system, active production of drugs locally, strong pharmaceutical innovation and a vibrant NIS in the health sector.

Local production of drugs, especially the essentials drugs, is identified as an important component of a long term solution to the provision of adequate health care in developing countries (14). The capacity to produce drugs to meet national health needs is argued to depend on building national capacity for innovation. Successful pharmaceutical innovation is the result of a complex web of interactions involving private and public research, development, teaching and healthcare delivery institutions, government ministries, regulatory authorities and other stakeholders (22). The new national STI policy (2010) recently adopted by the Government provides a suitable platform for attaining these goals since it aims to promote effective linkages and collaborations among knowledge institutions and industries engaged in health sector. It is designed to strengthen demand-driven R&D in natural and orthodox medicines as well as pharmaceutical research. The new STI policy is also fashioned to facilitate the development of biological diagnostic tools, vaccines and encourage R&D in alternative and molecular medicine.

Weak academic-industry interaction is a common feature of Nigeria's NIS (8). Furthermore, baseline assessment report (13) and sector profile on the Nigerian pharmaceutical industry (14) were not explicit on any innovative performance in the sector. Although corruption, counterfeiting of drugs and a weak infrastructural base have been a huge disincentive for local production of drugs and growth of the sector, the activities of NAFDAC, one of the regulatory agencies, coupled with reforms taking place in the sector since 2001 have considerably addressed this situation. The impact of the reform is evident in increased firm profitability, re-investment and local manufacturing of drugs (23, 24). Reports show that primary, secondary packaging materials as well as about 25% of excipients are locally sourced (14). UNIDO report (14) indicates that no Nigerian pharmaceutical manufacturer has attained WHO cGMP (current Good Manufacturing Practice) or WHO prequalification requirements. However, recent developments have witnessed the endorsement of five pharmaceutical firms (Evans pharmaceuticals, May and Baker, SWIPHA, CHI Pharmaceuticals and Fidson HealthCare) for WHO prequalification (25). This is a significant effort towards pharmaceutical innovation development in Nigeria. Information is scanty on the state of pharmaceutical innovation in Nigeria despite NAFDAC reform initiatives since 2001 and other government intervention efforts geared towards increasing local production of drugs. Although not much has been done in delivering active pharmaceutical ingredient into the market, the production of HEMOXINTM or NICOSANTM for the Nigerian market is a modest demonstration of innovation success resulting from academia industry interaction and the evolution of a virile NIS in Nigeria. NICOSANTM is a non-toxic, efficacious, phytopharmaceutical and anti-sickling patented drug clinically proven to reduce the sickling of the red blood cells of patients suffering from sickle cell diseases. The product is composed of extracts from *Piper*

guineeneses seeds, *Pterocapus osun* stems, *Egenia cayophyllum* flowers and *Sorghum bicolor* leaves, all indigenous to Nigeria and found in the wild or cultivated (26). The drug has been marketed in Nigeria since 2006 under approval of the National Agency for Food and Drug Administration, a regulating agency of Federal Government of Nigeria, and given the status of Orphan Drug Designation the US and EU countries. The innovation success of NICOSANTM derives from interactions among key players in the Nigerian pharmaceutical sub-sector: research institute (NIPRD) and other stakeholders from the research community, a Nigerian Firm (Xechem Pharmaceuticals Nigeria Ltd) and the Nigerian Government with the active support of WHO.

3.0 Methodology and Data Analysis

A survey was conducted in Year 2011/2012 to examine the type and intensity of interactions between the Nigerian pharmaceutical firms and the academia (universities and research institutes, URIs). Two sets of questionnaires were administered for the academia and the pharmaceuticals firms, respectively. Eight (8) top-ranked universities offering Pharmacy as a course and two (2) public research institutes were purposively targeted. Ten (10) researchers in each institution were randomly sampled. Also, twenty-five (25) pharmaceutical firms stratified into listed and non-listed firms on the Nigerian Stock Exchange were randomly sampled. Five (5) out of 8 listed firms and 20 non-listed firms were then targeted. Questionnaire retrieval rates were 91% and 100% for the academia and the industry, respectively. Collected data were analyzed by statistical tools.

4.0 Results and Data Interpretation

4.1 Quality of Research Personnel

59% of the academic staff in the 8 Faculties of Pharmacy sampled had PhD degrees while 41% possessed M Sc. degrees (Fig. 1). In the Research Institutes, about 84% of the respondents surveyed holds Masters of Science degrees while the rest had PhD degrees (Fig. 2). Furthermore, staff distribution by rank indicate that about 4 out of 5 respondents were substantive lecturers from Lecturer I to the Professorial position, who could conduct research; about half of this number (43%) were senior researchers. In the research institutes, over 90% of the respondents were of the rank of Senior Research Officers to Chief Research Officers. These data indicate the availability of high quality human resources with the capability to conduct research and generate new knowledge useful for enhancing pharmaceutical innovation in Nigeria through interactions.

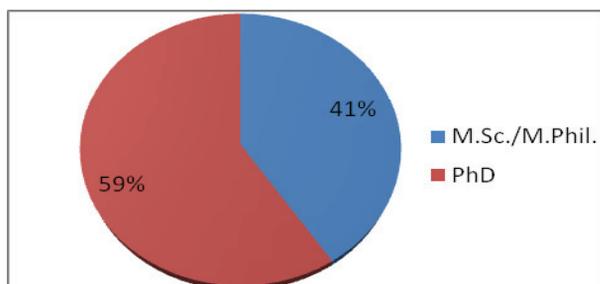


Figure 1: Academic Qualifications of researchers in Universities

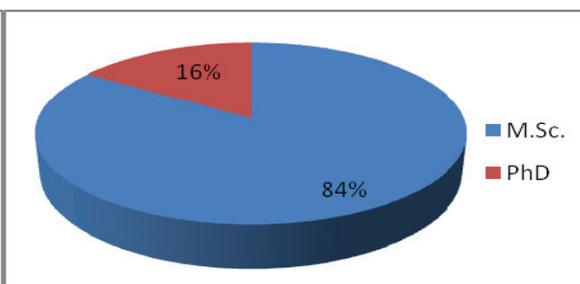


Figure 2: Academic Qualifications of researchers in Research Institutes

4.2 Research Interests of Researchers

The scope of research conducted in the URIs covered mainly five (5) different areas of specializations, which are: Pharmacology, Clinical Pharmacy, Pharmaceutical Chemistry, Pharmacognosy, and Pharmaceutical Technology. Also, about 73% and 88.2% of researchers in the URIs, respectively carried out applied research in Cancer, Tuberculosis, Asthma, High Blood Pressure, Malaria, HIV/AIDS, Diabetes and Sickle Cell anaemia. Malaria and Diabetes were the leading study areas of university researchers while HIV/AIDS in addition to Malaria and Diabetes constituted the leading research focus of RIs. For every 10 researchers in URIs, three carried out research on Malaria and about 2 focused on Diabetes. In RIs, 1 in 5 of researchers was involved in HIV/AIDS research. It is noteworthy that the focus of researchers in the university was mainly on Malaria and

Diabetes while that of the RIs was more on Malaria, Diabetes and HIV/AIDS. The fact that Malaria and HIV/AIDS are listed among the diseases being targeted for control by the Millennium Development goals coupled with the high prevalence of Malaria in Nigeria could have attracted more researchers to focus on these diseases more than others.

Furthermore, malaria research received the highest funding (23.3%) while Tuberculosis, Diabetes and Asthma received about 6.7% funding each (Fig. 3). However, about 66% of the funds received in the RIs were spent on Malaria and HIV/AIDS research (Fig. 4) which is a priority focus of the Nigerian Government. Other diseases such as cancer and Tuberculosis received 17% of R&D funding each. This shows that unlike the Universities who have liberties to utilize funds on curiosity-driven researches, Government-owned RIs could only conduct demand-driven researches in the areas of interest of Government. The study also revealed that the R&D activities of pharmaceutical researchers were supported by the provision of books/journal donations, travel aids/grants, staff exchange/fellowship programme, R&D facilities, sponsored participation at workshops and R&D grants/funding.

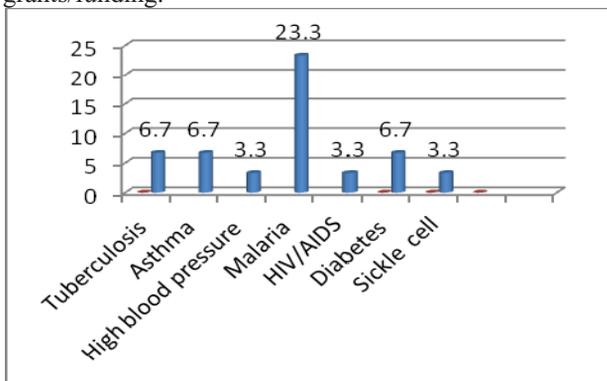


Figure 3: Research areas University researchers received funds

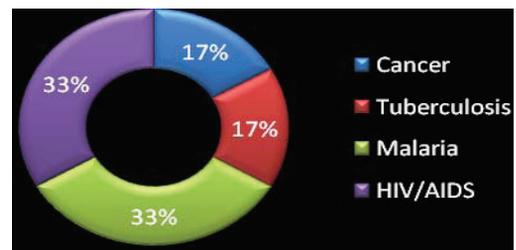


Figure 4: Research areas researchers in Research Institutes received research funds

Other funding sources included Educational Trust Fund (13.91% and 19.3%) for Universities and Research Institutes, respectively. One notable profile of R&D funding sources was the high percentage of researchers URIs engaged in self-sponsored research. About 17% and 25.2% of respondents in universities and research institutes respectively derived major funding through self-sponsorship. A new funding mechanism, committing 1% GDP to R&D, included in the recently approved Science, Technology and Innovation (STI) policy for the country provides another option. It is noteworthy that only 0.22% of funds received by researchers in Universities were from Nigerian /indigenous pharmaceutical firms while researchers in the RIs were not funded by these firms.

4.3 Output of Research Activities of Researchers

R&D output that about 56% and 32% of researchers from the universities and RIs, respectively were majorly in from of journal publications (Figs. 5 and 6). Others outputs from the Universities and RIs were respectively in the form of: book publications (15.3%; 7.9%), technical reports (6.9%; 15.8%), production of products (7.6%; 18.4%) & services (3.8%; 13.2%) and patents (2.3%; 7.9%). It is of importance that researchers in the RIs had varied R&D outputs than their research counterparts in the Universities.

4.4 Profile of Pharmaceutical Firms

Out of the 25 companies surveyed, 15 (60%) were indigenously- owned, which confirms earlier reports of 60-70% indigenous ownership of pharmaceutical firms in Nigeria (14). 9 (36%) firms were foreign – owned while only 1 (4%) was a multinational firm. Of the 5 quoted companies, 4 were foreign owned and 1 was a multinational. Only 40% i.e. 10 firms (5 quoted and 5 non-quoted) have R&D staff and reported conducting in-house R&D activities. These 10 firms collectively have 4 Ph D and 16 Masters of Science Degree holders.

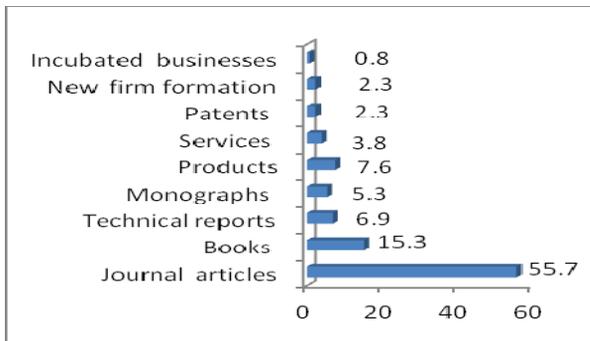


Figure 5: Research Output from Universities

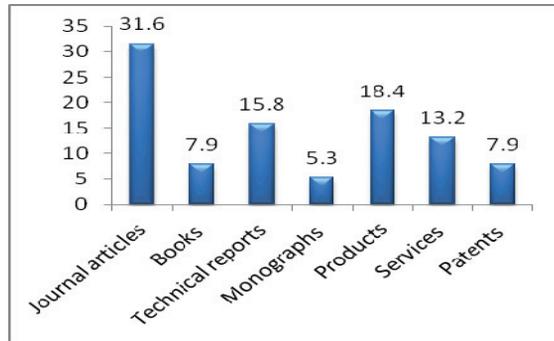


Figure 6: Research Output from Research Institutes

4.5 Drug Production: Sources of materials and Drugs of Interest

The three (3) major sources of materials utilized for drug production according to the firms sampled were derived from: imported concentrates, local raw materials and a combination of imported concentrates and local raw materials. Study showed that a high percentage of respondents (61%) from the firms made use of a combination of imported concentrates and local raw materials. About 30% of respondents used imported concentrates as their only source of drug production materials while a small fraction (9%) of respondents affirmed that they used only local raw materials for their drug production. Although an earlier UNIDO report (14) indicated that no Nigeria pharmaceutical firm had the capability to produce API of generic and specialized drugs, this study shows a gradual increase in the local content of indigenous drug production in Nigeria. The study also showed that the pharmaceutical firms focused more on producing drugs for treating Malaria (28%), High Blood Pressure (23.3%), HIV/AIDS (14%), Diabetes (14%) and Asthma (11.6%). Other areas of focus of the firms for drug production were Tuberculosis (4.7%), Sickle cell and Ulcer with 2.3%.

4.6 Academia-Industry Interactions

4.6.1 Intensity of interactions

Of the pharmaceutical researchers surveyed twenty percent (20%) from universities (Figure 7) and seven (7%) RIs (Fig. 8) indicated strong interaction with Pharmaceutical firms. On the other hand, of the 25 pharmaceutical firms surveyed, sixteen (16%) indicated stronger interaction with pharmaceutical researchers in universities and RIs (Fig. 9). It is noteworthy that the respondents (16%) from pharmaceutical firms that claimed interactions with pharmaceutical researchers comprised four (4) out of the five (5) pharmaceutical firms listed on the Nigerian stock exchange. This connotes that it is only the major players in the Pharmaceutical Industry that were interacting/collaborating with pharmaceutical researchers.

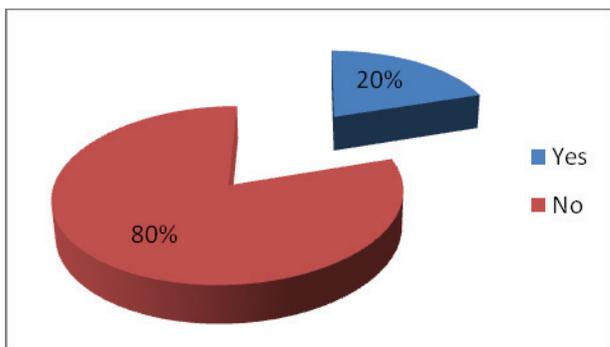


Figure 7: Interaction of University Researchers with Nigerian Pharmaceutical Firms

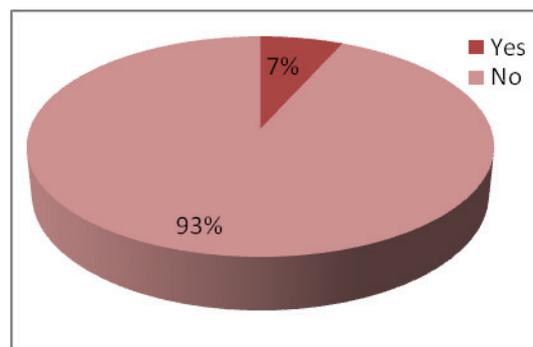
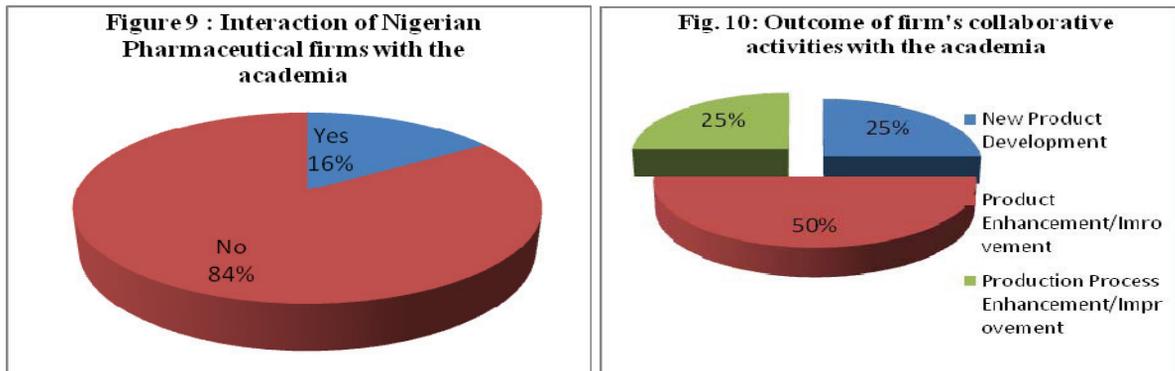


Figure 8: Interaction of Researchers in Research Institutes with Nigerian Pharmaceutical Firms

Figure 10 indicates the areas of interaction of Nigerian pharmaceutical firm with the academia. This is majorly in product improvement and enhancement (50%), new product development (25%) and Production Process Enhancement/ Improvement (25%). It is important to note that only firms listed in Nigerian stock exchange interacted with the academia.



4.6.2 Frequency and benefits of Interaction of pharmaceutical firms with academia

The frequency of interaction of pharmaceutical firms with universities and RIs, respectively. Data showed that pharmaceutical firms collaborated with university researchers daily, once a while and when the need arises with the frequencies of 17%, 50% and 33% respectively. On the other hand, pharmaceutical firms interacted with researchers in RI less frequently on weekly (20%), monthly (20%), once a while (20%) and only when the need arises (40%) basis. Some of the benefits derived from industry –academia linkage according to respondents included 57% knowledge sharing, 29% provision of Research facilities and 14% access to University students for internship. The obstacles respondents considered to be responsible for weak industry-academia collaboration included: inadequate funding (22%), lack of awareness (22%) and lack of information on initiation process for collaboration (22%) Others were lack of information on academia capability (17%), poor infrastructure (9%) and lack of proximity (8%).

4.7 Government support for Research-Industry interaction

The study revealed that both researchers and industrial firms claimed not to be aware of any Government policies fostering academia-industry interactions. The paper therefore argues that policies should be formulated to promote and foster academia-industry interactions.

5.0 Conclusion and Recommendation

5.1 Conclusion

This study identified the type, nature and intensity of academia-industry interactions in Nigeria's pharmaceutical sub-sector.

The study revealed that Nigeria's pharmaceutical researchers are of high quality, with many of them possessing PhDs. Key research activities are in Malaria, Diabetes and HIV/AIDS. Most pharmaceutical firms in Nigeria were found to be indigenously-owned; however, the firms quoted on the stock exchange are majorly foreign-owned. R&D activities are concentrated within these foreign-owned firms; with the focus being on malaria, High Blood Pressure, HIV/AIDS, Diabetes and Asthma. Pharmaceutical research activities in Nigeria are primarily self-financed by the researchers –25% of researchers self-finance their research work). Other key financiers identified are International Development Agencies, the Federal Government and the Education Trust Fund. The

types of support included books/journal donations, travel aids/grants, staff exchange/fellowship programme, provision of R&D facilities, sponsored participation at workshops and R&D grants/funding.

Academia-Industry interactions have been found to be severely limited. Less than 0.22% of funds received by researchers in Universities were from Nigerian indigenous pharmaceutical firms while no researcher in the Research Institutes received research funding from the firms. Only quoted firms acknowledged collaborations with researchers in URIs, whereas no indigenous firm in Nigeria acknowledged collaborations. Surprisingly, 20% of University researchers and 7% of RI researchers reported strong collaboration with Industry. Since, the industry reports limited collaboration with the researchers, it is only logical to conclude that Nigerian researchers collaborate with pharmaceutical firms *outside* Nigeria. It might also be logical to conclude that the direction of interaction is from the Industry to the researchers. This is because only one firm acknowledged collaboration with researchers and from a strategic management viewpoint that firms are at a critical advantage being able to determine which researcher it will collaborate with.

It is significant to note that both researchers and industrial firms claimed not to be aware of Government policies fostering academia-industry interactions.

5.2 Policy Recommendations

- i. Government needs to promote a strong national Pharmaceutical innovation ecosystem in order to stimulate robust academia-industry interactions in the sector.
- ii. Government needs strong awareness campaigns to eliminate the zero awareness of government policies by the Academia and Industry.
- iii. Robust funding mechanisms are required to reduce the percentage of researchers self-financing their research work.
- iv. Further research should be carried out in order to determine why indigenous firms do not engage researchers in the URIs. This could require new policies of government policies and could be seen as part of national security.

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