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A comparison of basic and state-of-the-arts skills sets of biomedical science technical staff in Lagos public universities

TA John

Department of Pharmacology, Lagos State University College of Medicine, 1 Oba Akinjobi St. GRA, PMB 21266, Ikeja, Lagos, Nigeria

Abstract

Background: Biomedical science has advanced drastically in developed countries in the last two decades with many health and economic benefits [1]. In Nigeria, biomedical science has not thrived and the contribution from Nigerian universities, indeed African universities, to publications in global high impact journals is low [2].

Objectives: The present work was based on the hypothesis that there is a lack of state-of-the-arts experimentation in Nigerian biomedical science experiments.

Methods: An investigation was carried out on the professional skills of biomedical science technical staff of the two (federal and state) public universities in Lagos, Nigeria using a closed-ended questionnaire survey. The 17 respondents were asked about their training, the frequency of utilization of 99 skills, and their expertise.

Results: The respondents were "untrained" more in state-of-the-arts skills (34% for electrophoresis, 28% for genomics, 22% for immunochemistry, and 34% for proteomics skills) than in general professional skills (5%), basic technical equipment skills (16%), or general biomedical science knowledge and skills (16%). Frequencies of responses were higher for general skills than for state–of-the-arts skills in the responses "utilizing frequently" (9.96%-31-61% versus 0.36%-4.2%), and "I'm expert" (9.55%-19.88% versus 5.88%-8.48%).

Conclusion: It was projected that with continued investment in modern equipment and infrastructure, there will be increased drive for training and usage of modern bioscience research skills and multidisciplinary approaches and production of high-tech scientific publications.

Keywords: *State-of-the-Arts, biomedical science, technical staff, skills*

Correspondence: T. A. John, Department of Pharmacology, Lagos State University College of Medicine, 1 Oba Akinjobi St. GRA, PMB 21266, Ikeja, Lagos. Email: theresaadebola@yahoo.com; adebola.theresa@lasunigeria.org.

Resume

La science biomédicale a énormément avancée dans les pays développés dans les deux dernières décennies avec les bénéfices en santé et en économie. Au Nigeria, la science biomédicale ne s'est pas affirmée et la contribution des Universités Nigérianes, bien que les Universités Africaines par des publications dans les journaux internationaux est faible. Cette étude est basée sur l'hypothèse qu'il y a un manque des expériences avancée et modern dans les recherches biomédicales au Nigeria. Une investigation était faite sur les aptitudes professionnelles du personnel technique en science biomédicale dans deux universités fédérale et provinciale à Lagos en utilisant un questionnaire fermé. Les 17 participants étaient questionnés par rapport à leur formation, la fréquence de l'utilisation des 99 aptitudes et leurs expertises. Les participants étaient non formés sur les techniques modernes (34% en électrophorèse, 28% en génomique, 22% en immunochimie, et 34% en proteomique) qu'en techniques professionnelles générales (5%), techniques de base en équipements (16%), ou connaissance générale en science biomédicale (16%). Les fréquences des réponses étaient plus élevées dans les aptitudes générales que les techniques avancées 'utilisées fréquemment (6%-31-61% contre 0.36%-4.2%), et "Je suis un expert" (9.55%-19.88% contre 5.88%-8.48%). Il était projeté que avec un investissement élevé dans les équipements modernes et infrastructures, Il y aura une augmentation dans la formation et l'usage des techniques modernes de recherché et des approches multidisciplinaires et la production des publications.

Introduction

Global biomedical science has undergone dramatic changes in recent times with many health and economic benefits [1]. African contribution is low [2,3,4,5,6]. Biotechnology and biotechnological skills are the backbones of sound biomedical science. There is need for studies to assess the skills of biotechnologists working in African university settings. This study was conducted among technical staff manning the basic science departments of the

medical schools of the two public universities in Lagos. The goal of this study was to identify some factors that can boost the contribution of Lagos biomedical scientists to both publications in high impact journals worldwide and global economic development within a system of sound ethics and well-developed professionalism.

We therefore investigated the general professional, basic science, and state-of-the-arts skills sets of technical staff in the basic science departments. This study is important because acquisition of state-of-the-arts skills by biotechnologists and biomedical scientists is a key change-factor for funding and policy formulation.

Materials and methods

The study was conducted in the two universities in Lagos, namely University of Lagos and Lagos State University. Lagos itself is the commercial nerve-centre of the Nigerian economy. The University of Lagos was established in 1962 while the Lagos State University was created in 1999. Both institutions have been involved in biomedical research through their faculties of Basic Medical Sciences.

The study consisted of a cross-sectional survey done by questionnaire interviews [7] during June-July of 2008. The questionnaire was administered by three research assistants under the supervision of the author. The respondents were approached by the three research assistants who were themselves technologists from the state university and knew their peers. Explanations about the purpose of the study were provided to each respondent by the research assistants before completion of the questionnaire. The questionnaire was self-completed by each respondent. The author had no contact with respondents in order to minimize fret. Seventeen respondents were interviewed, 9 from the state university and 8 from the federal university. They were representatives pooled from the different departments of the Faculty of Basic Medical Sciences of each university. The aim was to get at least one respondent from each department. The departments at the time of survey had 1-3 technologists each. The questionnaire covered relevant questions such as respondents affiliation including specific department, number of years spent in the Nigerian academic system and personal contact (Email or telephone). The respondents' skills were assessed by asking the following questions:

"Below is a list of some professional skills that are useful in present-day biomedical science professions. To indicate your level of exposure or competence for each skill, please mark x in any category in the answers for each of the skills below. Please include in lower blank cells (105-110) any skills you wish to include but are not listed here."

The questionnaire inquired about 104 skills or areas of knowledge. Numbers 1-8 were General Professional Skills: Civics; Communication skills; Computer processing and Internet skills; Ethics; Intellectual property /industrialization/capitalization; Teamwork; Time management; and Statistics. Numbers 9-44 were Basic Technical Equipment Skills: Autoclave; Balances, including electronic microbalance; Block heater; Buffers, solvents, and detergents including components such as phosphate, tris, tween, triton; Cell counting; Cell fractionation via centrifugation ; Centrifugation, microcentrifuge, ultracentrifuge; Chromatography; CO_2 incubator; Confocal microscopy; Culture dishes and multi-well plates; Digital data recording; Disperser, homogenizer, and sonicator; Dry ice, use and storage; Electron microscopy; Electronic data recording; Electrophysiology, electrodes and sensors; Extractor (soxhlet, automated, etc.); Filtration, including vacuum and syringe filtration; Flocculator; Gel electrophoresis; Histology; Lamellar flow hood; Light microscopes; Liquid nitrogen, use and storage; Micro array; Micro pipettes, digital pipettes and burettes; Microplate reader; Microtome; Molarity ; Osmolarity; pH meter; Refrigeration, 4C, -20C, -80C; Safety-wears (eyes, ears, hands, body); Spectrophotometry; Sterile tissue culture. Numbers 45-65 were General Biomedical Science Knowledge and Skills: Animal care, handling and experimentation; Cell-based assays; Chromatographic techniques; Data recording, lab book management; Ethics/professional integrity; Imaging; Immunohistochemistry; Immunoprecipitation; Internet browsing; Isolated tissue/organ assay; Lab hazards management, safety and protection; Protein extraction; Protein quantification; Radiolabeling and radioassay; Research administration; Research funding; Spectrophotometry; Sterile techniques; Tissue/cell culture; Transfection; Western blot analysis. The last section numbers, 66-104, inquired about Specialized Biomedical Science Knowledge and Skills which are shown in Table 1.

The respondents' options for each skill or knowledge were: untrained, received training, unable to utilize, utilizing frequently, or I am expert. The data were analyzed by summing up responses in each category and converting sums to percentages. Data plots were prepared to highlight and compare the

skills-sets of biomedical science technologists in Lagos public universities.

Respondents' reliability in answering questions was investigated by duplicating entries in the questionnaire which should generate the same response. Four items were repeated. The repeats were spectrophotometry (#43 and #61); protein extraction (#56 and #100); sterile tissue culture, sterile techniques, and tissue/cell culture (#44, #62, and #63); and DNA/RNA synthesis and PCR/RT-PCR (#75 and #83). Kappa coefficient of reliability was used to deduce if exactly the same responses can be reproduced by the same respondents for the same inquiry.

Table 1: Responses of 17 biomedical science technical staff, pooled from basic medical science departments of Lagos public universities, on their own state-of-the-arts biomedical science knowledge and skills. Entries depict number of responses.

Responses for specialized biomeical science knowledge and skills		untrained	received training	trained but unable to utilize	utilizing rarely	utilizing frequently	I am expert
Electrophoresis							
66	Electroblotting	6	2	2	-	-	1
67	Gel apparatuses and accessories	4	2	2	-	-	3
68	Hybridization	6	2	1	-	-	1
69	Imaging and documentation	7	1	-	-	-	1
70	Power supplies	5	3	-	1	1	1
71	Precast gels and gel kits	7	2	-	-	-	1
72	Slot blotting apparatus	6	2	1	-	-	1
Genomics							
73	Barcode readers	7	1	-	-	-	1
74	DNA isolation	3	1	2	-	-	3
75	DNA/RNA synthesis	4	1	2	-	-	1
76	Gene delivery and expression	5	1	2	-	-	1
77	Genotyping	3	4	2	-	-	2
78	Modifying and restriction enzymes, restriction analysis	3	1	2	-	-	1
79	Northern blot	6	1	1	-	-	1
80	Nucleic acid controls	5	1	2	-	-	1
81	Nucleic acid labeling and detection	5	2	2	-	-	1
82	Nucleic acid purification	5	1	2	-	1	1
83	PCR/RT-PCR	5	1	2	-	-	1
84	RNA interference	5	1	2	-	-	1
85	Sequencing and mutagenesis	5	1	2	-	-	1
86	Southern blot	5	2	1	-	-	1
87	Transcription and regulation	5	1	2	-	-	1
88	Vectors and competent cells	5	1	2	-	-	1
Imunochemistry, Immunohistochemistry							
89	Detection equipment	4	3	2	-	-	1
90	ELISA	2	5	1	-	-	1
91	Flow cytometry	4	1	2	1	-	1
92	Fluorometer: quantitation of DNA, RNA and protein	3	2	2	-	3	1
93	Immunoassays,	3	2	1	-	2	1
94	Immunolabeling	5	2	1	-	-	1
95	Immunoreagents and kits	5	2	1	-	-	1
Proteomics							
96	Affinity purification	7	-	1	-	1	1
97	Protein arrays	7	-	1	-	-	1
98	Protein detection	6	-	2	-	-	1
99	Protein expression and analysis	6	-	2	-	-	1
100	Protein extraction	4	1	2	-	1	3
101	Protein interactions	6	-	2	-	-	1
102	Protein labeling	6	1	1	-	-	1
103	Protein structure	6	1	1	-	-	1
104	Sample preparation	4	-	1	1	1	3

Results

The numbers in Table 1 show the sums of some responses obtained from 17 respondents (eight from the federal university and nine from the state university) who completed the questionnaires. These respondents were from various departments including: anatomy, physiology, biochemistry, immunology, microbiology, chemical pathology, and pharmacology in either university. The range of time spent at the job was 7 months to 41 years, the mean ± SE length of experience was 13.24 ± 3.13 years, and the median years of experience was 8 years.

The respondents did not add other skills in spaces provided (cells 105-110, Table 1), therefore the total optional responses used, (Figure 8), including all categories was 99 x 17 = 1,683 (i.e. number of skills, not counting 5 repeats x number of respondents). Figures 1-7 show each category of skills-set with the percentage responses out of overall number of possible responses per category.

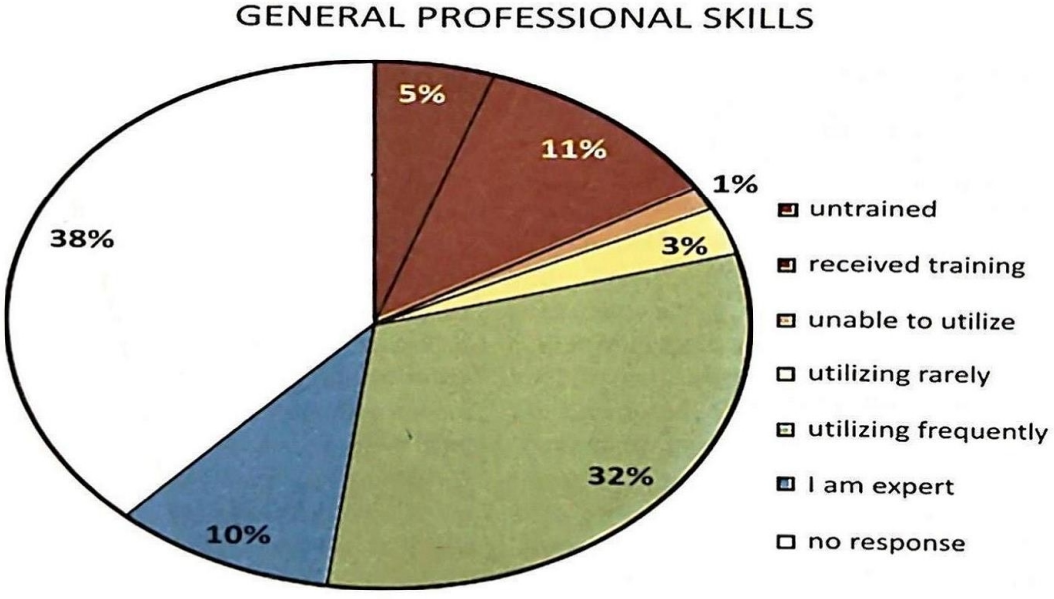


Fig. 1: Responses of 17 technical staff of basic medical science departments of public universities in Lagos indicating their general professional skills.

For skills respondents recorded as "utilizing frequently" the percentages were 32% for general professional skills, 12% for basic technical equipment skills, 9% for general biomedical science knowledge and skills, 1% for electrophoresis skills, 0% for genomics skills, 4% for immunochemistry skills, and 2% for proteomics skills.

For skills respondents recorded as "I'm expert" the highest frequency was for the basic skill of use of balances (9/17). Other skills recorded as "I'm expert" in higher frequencies (5/17-7/17) are also basic or general science skills and include: autoclave, pH meter, animal care handling and experimentation, data recording, lab book management, ethics/professional integrity, Internet browsing, isolated tissue/organ assay, lab hazards management, safety and protection, spectrophotometry, and sterile techniques. The highest frequency of "I'm expert" for state-of-the-arts skills, 3/17, was for gel apparatus and accessories, DNA isolation, protein extraction and sample preparation.

Table 2 shows responses for all the various categories of knowledge and skills. In total, for specialized skills in the fields of electrophoresis, genomics, immunohistochemistry, and proteomics' there were 195 responses for "untrained" versus 48 responses for "I'm expert". Figure 8 compares percentage frequency of responses for "general skills" with those for "state-of-the-arts skills". In Figure 8, frequencies were higher for general skills than for

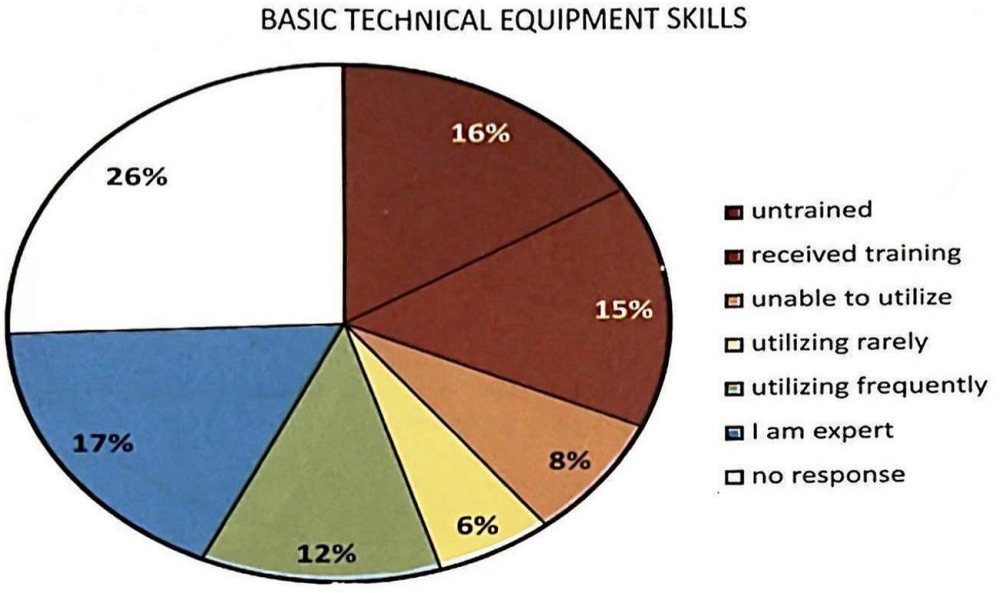


Fig. 2: Responses of 17 technical staff of basic medical science departments of public universities in Lagos indicating their basic technical equipment skills.

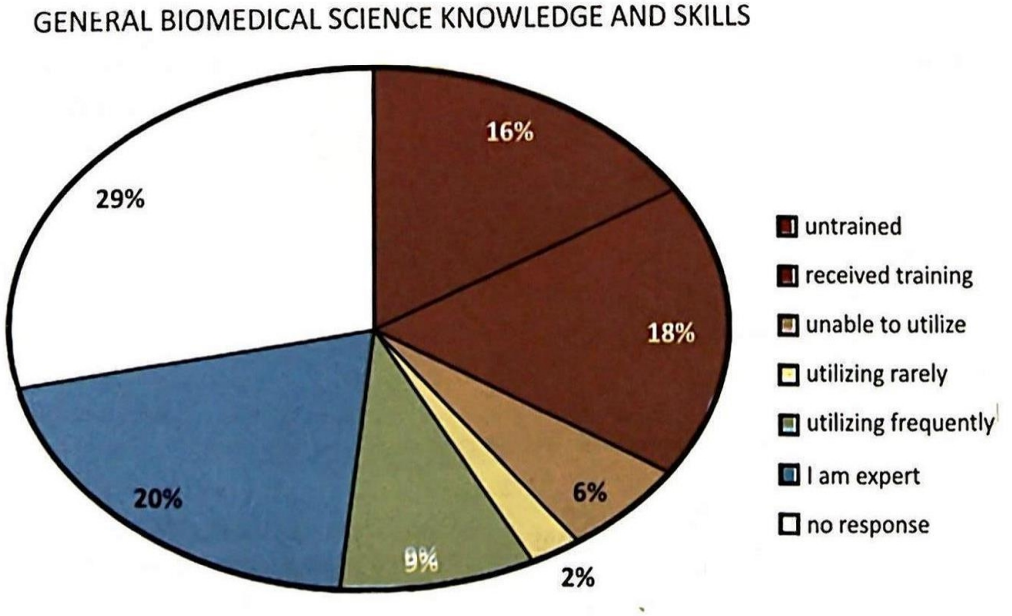


Fig. 3: Responses of 17 technical staff of basic medical science departments of public universities in Lagos indicating their general biomedical science knowledge and skills.

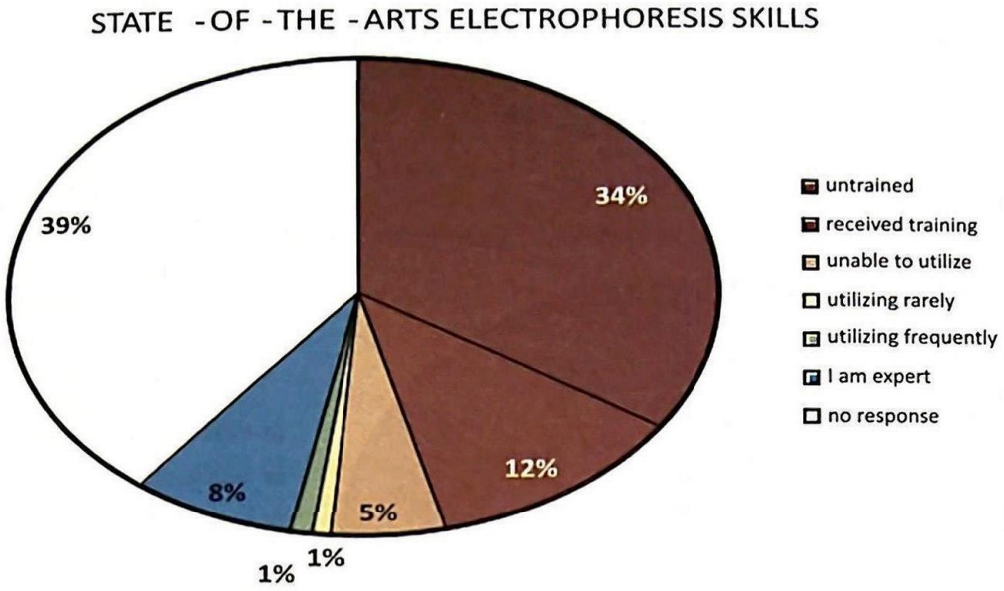


Fig. 4: Responses of 17 technical staff of basic medical science departments of public universities in Lagos indicating their state-of-the-arts biomedical science skills in electrophoresis.

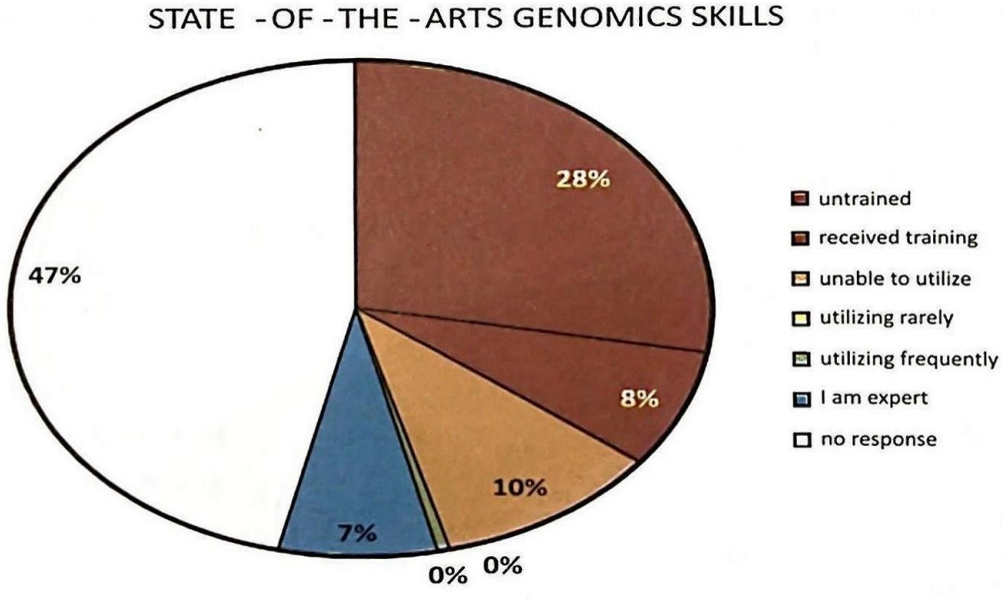


Fig. 5: Responses of 17 technical staff of basic medical science departments of public universities in Lagos indicating their state-of-the-arts biomedical science skills in genomics.

state–of-the-arts skills in the responses: "received training" (11.02%-18.2% versus 1.96%-14.28%), "utilizing rarely" (2.24%-5.71% versus 0% 0.84%),"utilizing frequently" (8.96%-31-61% versus 0.36%- 4.2%), and "I'm expert" (9.55%-19.88% versus 5.88%-8.49%). Frequencies were higher for state-of-the-arts skills than for general skills in the responses: "unable to utilize" (5.04%-10.29% versus 1.47%-7.67%) and "no response" (39.49%-46.69% versus 25.65%-38.23%).

The reliability of the respondents was tested. For spectrophotometry (#'s 43 and 61) the responses were 3, 4, 2, 0, 2, 4 versus 1, 4, 2, 1, 3, 6 and the Kappa coefficient of reliability was -0.67. For protein

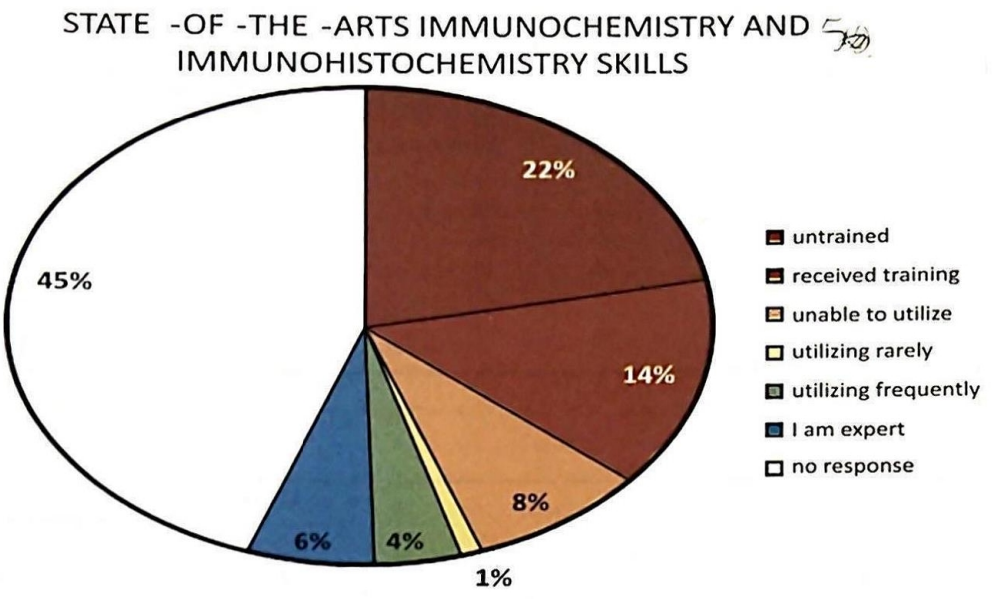


Fig. 6: Responses of 17 technical staff of basic medical science departments of public universities in Lagos indicating their state-of-the-arts biomedical science skills in immunocheistry and immundhistochemistry.

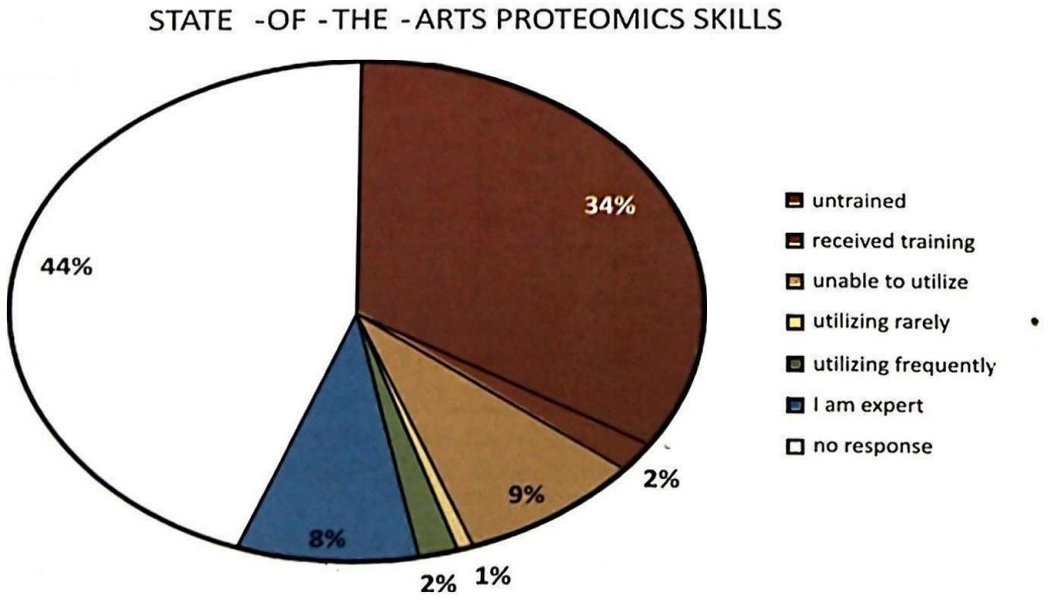
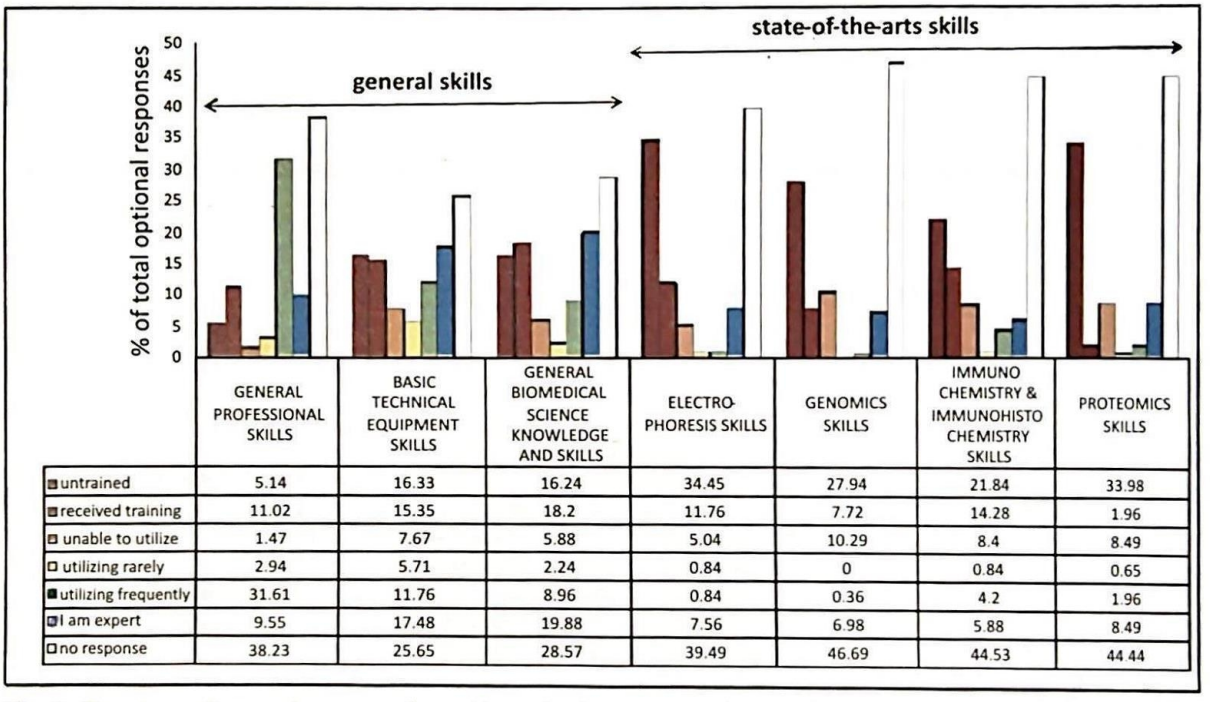


Fig. 7: Responses of 17 technical staff of basic medical science departments of public universities in Lagos indicating their state-of-the-arts biomedical science skills in proteoics.

Table 2 Responses of 17 biomedical science technical staff, pooled from basic medical science departments of Lagos public universities, on their own professional knowledge and skills. Entries depict number of responses. (SOTA means state-of-the-arts)

		RESPONSES FOR VARIOUS PROFESSIONAL KNOWLEDGE AND SKILLS					
		untrained	received training	trained but unable to utilize	utilizing rarely	utilizing frequently	I am expert
1	General professional skills	7	15	2	4	43	13
2	Basic technical equipment skills	100	94	47	35	72	107
3	General biomedical science knowledge and skills	58	65	21	8	32	71
4a	SOTA - Electrophoresis	41	14	6	1	1	9
4b	SOTA - Genomics	76	21	28	0	1	19
4c	SOTA - Immunochemistry, immunohistochemistry	26	17	10	1	5	7
4d	SOTA - Proteomics	52	3	13	1	3	13



	GENERAL PROFESSIONAL SKILLS	BASIC TECHNICAL EQUIPMENT SKILLS	GENERAL BIOMEDICAL SCIENCE KNOWLEDGE AND SKILLS	ELECTRO-PHORESIS SKILLS	GENOMICS SKILLS	IMMUNO CHEMISTRY & IMMUNOHISTO CHEMISTRY SKILLS	PROTEOMICS SKILLS
untrained	5.14	16.33	16.24	34.45	27.94	21.84	33.98
received training	11.02	15.35	18.2	11.76	7.72	14.28	1.96
unable to utilize	1.47	7.67	5.88	5.04	10.29	8.4	8.49
utilizing rarely	2.94	5.71	2.24	0.84	0	0.84	0.65
utilizing frequently	31.61	11.76	8.96	0.84	0.36	4.2	1.96
I am expert	9.55	17.48	19.88	7.56	6.98	5.88	8.49
no response	38.23	25.65	28.57	39.49	46.69	44.53	44.44

Fig. 8: Coparison of general an state-of-arts biomedical science professional skills of technical staff of basic science departents of public universities in Lagos. (Order of list in legend corresponds to order of coluns in graph).

extraction (#'s 56 and 100) the responses were 2, 4, 1, 0, 1, 4 versus 4, 1, 2, 0, 1, 3, and the Kappa coefficient was -0.67. For sterile tissue culture (#44) responses were 3, 5, 3, 0, 0, 2 versus 1, 3, 1, 0, 3, 5, and 2, 6, 3, 0, 0, 1 for sterile techniques (#62) and tissue/cell culture (#63) respectively and the Kappa coefficient was -0.83. For DNA/RNA synthesis (#75) responses were 4, 1, 2, 0, 0, 1 versus 5, 1, 2, 0, 0, 1 for the synonymous PCR/RT-PCR (#83), and the Kappa coefficient was -0.17.

Discussion

As stated in the Introduction, global biomedical science has undergone dramatic changes in recent times and African contribution to publications in high impact journals worldwide has been low [2]. There are not many published research on the *status quo* of

African science. "The United Nations Institute of Statistic's Bulletin on Science and Technology Statistics presents macro-level information on scientific publication output in Africa as a whole for the years 1981–2000" (UIS, 2005) and this output represented 1.4% of the worldwide publications in 2000, where the share of Sub-Saharan Africa was below 1% [2,8]. Tijssen's follow-up study [2] and a few others [4,5,6] published between 2002-2007 in the peer review journal, *Scientometrics* (with impact factor [9] of 2.167 in 2009), reflect the low contribution of Africa to global science in recent decades. The present report, looking at skills, adds to our understanding of why African science has not displayed global relevance in recent decades.A multidisciplinary approach is commonly utilized to carry out present day research in biomedical science [1]. This means that to prove a hypothesis one utilizes principles and skills from various disciplines. Certain techniques derived from anatomy, immunology, and biochemistry have become mainstay and are commonly utilized across basic science disciplines of anatomy and cell biology, physiology, biochemistry, microbiology, immunology, pharmacology, and pathology. These techniques include cell culture, gel electrophoresis and western blotting, PCR/RT-PCR, immunohistochemistry, and numerous antibody based assays. Such techniques are generally combined with various specific disciplinary techniques, e.g. organ bath assays or human subject studies in pharmacology or animal disease models in pathology. This is because present day science, as published in global high impact journals, seeks cellular and molecular level evidence in addition to organ and whole animal evidence.

In the present study, the basic science technical staff of medical schools in the two public universities in Lagos were asked about their professional skills. We note that for each skills-set, there was a large proportion of "no response." It is not known why there were no responses by respondents for some specific skills listed and it may be that these are areas the respondents were naive about and did not want to commit themselves to responding. The percentages of no responses were greater for the state-of the arts skills-sets (39-47%) than for general skills sets (26-38%), (Figures 1-7).

It is also interesting that the respondents were "untrained" more in state-of-the-arts skills (34% for electrophoresis, 28% for genomics, 22% for immunochemistry, and 34% for proteomics skills) than in general professional skills (5%), basic technical equipment skills (16%), or general biomedical science knowledge and skills (16%). From Table 2, responses that indicated utilization of skill or expertise were low for state-of-the-arts skills and high for other skills. On the other hand, responses that indicated lack of training were relatively high for state-of-the-arts skills. It is evident that, as a group, the biomedical science technical staff in Lagos public universities are presently not up-to-date in state-of-the-arts capability in biomedical research. This is reflected in their responses about their training, the responses about the frequencies with which they utilize skills, and the possibilities to utilize the skills (Figure 8).

From Figure 8, the general skills sets were more utilized than state-of-the-arts skills sets. For skills utilized rarely, the general skills were also more utilized than the state-of-the-arts skills. In fact, the responses for "I'm expert" were greater for general skills (9.55%, 17.48% and 19.88%) than for state-of-the-arts skills (7.56%, 6.98%, 5.88%, and 8.49%). On the contrary, there were greater responses for "unable to utilize" for state-of-the-arts skills than for general skills. In another survey of the same institutions looking at the availability of research facilities, responses for "well maintained and always functional" were greatest for basic equipment. On the other hand, responses for state-of-the-arts facilities were clustered in "not available" and "no response" columns. This bias indicates the environment is not yet caught up with global trends in biomedical science and lacks state-of-the-arts facilities for biomedical science research [10].

The respondents appear to retain only general science skills, especially from their particular discipline. In Table 1, for each of the 7 electrophoresis skills, 16 genomics skills, 7 immunochemistry skills and 9 proteomics skills listed, not more than 3/17 responded "I am expert." This can be compared with basic technical equipment skills such as use of autoclaves and balances or general biomedical science knowledge and skills such as data recording/lab book management and ethics/ professional integrity where 7/17, 9/17, 7/17, and 7/ 17 respectively responded "I am expert." Furthermore, the level of confidence of respondents where they responded is less than 100% as is seen in the reliability test where responses for 4 skills were not identical in each repeated case. Kappa coefficient, which ranges from -1 for agreement by chance to +1 for perfect agreement, was used. Their responses for spectrophotometry asked under basic and general skills respectively had low correlation; Kappa was 0.67. Their responses for protein extraction asked under general and proteomics skills respectively also gave Kappa was -0.67. Their responses for sterile

tissue culture asked under basic skills and twice under general skills gave Kappa of -0.83. Their responses for DNA synthesis asked twice under genomics skills gave Kappa of -0.17. This is also an indication of lack of familiarity with the terms used (especially the state-of-the-arts terms (Kappa of -0.83 to -0.17) and respondents could not reliably give reproducible answers about their own knowledge or expertise in these areas.

This study highlights one reason why there has been a low contribution of biomedical science publications to global high-impact journals. Local skills do not match global skills. State-of- the-arts "microdisciplines" are indispensable components of present day science. It is often at the level of microdisciplines such as signal transduction, genomics, and proteomics that traditional subjects such as physiology, physics, chemistry, pharmacology, microbiology, immunology, and pathology merge [11,12,13]. Traditional science disciplines also merge at the level of "macrodisciplines" such as biodefence which require multidisciplinary inputs down to precision levels of microdisciplinary approaches. In recent times, stakeholder interests and research funding have become quite focused on macrodisciplines and "hot topics" such as AIDS, cancer, malaria, stem cells, etc. [14,15] and supporting microdisciplines of molecular biology and genetics [11,14]. High impact journals are thus inundated with such publications and they have formed a new standard.

In a different survey of the Lagos public universities using the same group of workers' opinions, the dominant factors that affected their work negatively were judged to be "lack of equipment" (12/17) and "lack of materials" (10/17). This reflects a lack of adequate investment in research in their environment. Asked for changes hoped for, the dominant response (11/17) was "provision of equipment", some emphasizing modern equipment [16]. In Nigeria and the rest of Africa, there may be a need to promote and support financially the state-of-the arts technologies, skills, and experimental procedures in biomedical science research in order to pave a way to a greater global impact of research from the African environment. Researchers doing modern science need to acquire important multidisciplinary state-of-the-arts skills, no matter their original disciplines. This kind of change of course requires transformative leadership [17] and much funding.

Conclusion

Overall, the results indicate a lack of knowledge and utilization of state-of-the-arts skills such as skills utilized for electrophoresis, genomics, immunochemistry, and proteomics aspects of biomedical research. Since these procedures are routinely included in present day biomedical science publications across basic science disciplines, the results are indicative of why biomedical science publications from Lagos public universities are low in numbers in global high impact journals. They are also indicative of why there is a low level of useful discovery from the investigated environment because for industry to capitalize effectively on scientific discovery, the evidence is acceptable if it is multidisciplinary and state-of-the-arts.

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