

The Challenges of Nigeria Vaccine Supply Chain, a Community of Practice Perspective

Timilehin M. Omole^{1*}, Felix O. Sanni², Paul A. Olaiya³, Olusegun Aturaka³, Musa Abdulsalam³, Zachary T. Gwa³,
Olumide F. Ajani³, Potter J. Aiden¹, Chigozie G. Njemanze⁴

¹Department of Procurement and Supply Chain Management, FHI360-GF, Port Harcourt, Nigeria

²Department of Chemistry, Federal University of Agriculture, Abeokuta, Nigeria

³Department of Procurement and Supply Chain Management, Axios Foundation, Abuja, Nigeria

⁴Department of Strategic Supply Chain Management, University of Roehampton, London, UK

*Corresponding Author

Abstract: - Vaccine supply chain is a critical success factor in the improvement in immunization coverage towards universal health coverage. Immunization in Low and Middle-Income Countries (LMICs) generally suffers lots of setbacks due to supply chain bottlenecks. This research therefore explored the supply chain ecosystem in Nigeria to determine the challenges of supply chain in Nigeria and possible solutions to them. The study took pragmatic approach to explore the Nigeria vaccine supply chain ecosystem. In a mixed method, we explored some quantitative and qualitative questions using an internet-based questionnaire (Google form). From the survey, a total of 200 valid responses were received and analyzed using SPSS and Microsoft excel combined and patterns/correlations. Among the professionals, only few people (21.0%) had above average (very good and excellent) knowledge of vaccine chain while more than 30% had very poor knowledge of vaccine supply chain in Nigeria. This poor knowledge of vaccine supply chain that cuts across all professions is a major challenge to efficiency and success of vaccine supply chain in Nigeria. All the five factors considered as bottlenecks to vaccine supply chain in Nigeria were highly rated as major challenges by over 90% of all respondents. Thus, a lot has to be done to create awareness on vaccine supply chain across all healthcare profession and more efforts are needed both by government and professionals to overcome the challenges of bottlenecks to vaccine supply chain in Nigeria.

Key words: Challenges, supply chain, vaccines, immunization, awareness, bottleneck

I. INTRODUCTION

A supply chain consists of all parties involved, directly or indirectly, in fulfilling customer's requests. The supply chain includes not only manufacturers and suppliers, but also transporters, warehouses, retailers, and even customers themselves [1]. Supply Chain management encompasses all activities involved with procurement and manufacturing, including collaboration with suppliers, service providers, and customers [2]. Therefore, supply chain combines different functions: logistics, purchasing and strategic procurement, inventory, planning, production, intra-and inter-organizational relationships and performance measures [3]. Supply chain also involves the coordination and collaboration among the different functions within supply chain network [3]. Supply

chain is an important part of any organization as forms the backbone of global trade and support growth and consumption [4]. It is confirmed that supply chain is at the very heart of success for world's important pharmaceutical companies [5]. Malik *et al* [6] reported that industry leader had predicted that any competitor who manages supply chain better would be more successful in the long run. This validates why much emphasis is placed upon vaccine supply chains and how different approaches including technology and innovation can be used to improve the supply chain performance of any industry.

II. REVIEW OF LITERATURE

A. Vaccine

Vaccines and immunization generally are cost effective public health tools in reducing the burden of infectious diseases. Therefore, the death of over 6 million under 5 children could be prevented with the use of vaccines and immunization [7]. Vaccines beyond the prevention of illnesses and death also present some economic gains for individuals and communities [8]. These together validate that paying more attention to vaccines promises significant yield of improved quality of life socioeconomically as well as in public health. In the history and evolution of supply chain, globalization and technology appears to be a great influence for supply chain improvement [9]. Collins [10] also asserts that transcending good to great in the industry also have some correlation with the adopting correct and suitable technologies. Following this same trend some horizontal innovations and technologies are currently changing the landscapes in the market place.

Vaccine is an essential lifesaving commodity with high economic benefits [11]. According to CHAI [12], vaccines globally reach 112 million infants annually averting two to three million of deaths annually. In Nigeria, under-five mortality due to vaccine-preventable disease is almost 40% of the total under 5 deaths [7]. Interestingly, this Nigeria data also accounts for 15% of global under 5 mortalities due to VPD [7]. Therefore, the burden of vaccine-preventable diseases remains huge and weighs heavily more on the budgets of the LMICs. Looking at vaccine supply chain in

LMICs with Nigeria as an example, issues around cost, cold chain and reaching the last mile are critical to the success of any vaccine supply chain intervention [11], [13], [14]. Given the humanitarian challenges and the millions of lives that could be saved with more efficient vaccine supply chain, we must help managers assess and adopt available innovations and technology to improve their processes. It is therefore important to highlight what the supply chain problems are to position the appropriate innovations and technologies to solve the problems.

Also, while the vaccine world focuses introducing new vaccines into the already stretched vaccine supply chain of LMICs [15], [16]. Paying attention to vaccine supply chain by everyone involved in vaccines is critical to deliver on the desired impact of vaccines [15]. It is therefore important that we explore the issue of vaccine supply chain with anyone who has anything to do with vaccines with the bid to improving the vaccine impact especially in the Nigeria. Supply chain is usually found wanting in most global health discussions and this include vaccine supply chain [17]. There is widespread poor performance of vaccine supply chain and delivery system in Nigeria could be due to a lot of factors like age of the cold chain system [12], [17]. These supply chain issues and the 1.5 million of children dying annually from vaccination-preventable disease highlight a huge gap between the status of vaccine coverage and the vision of universal coverage [12], [8]. There are also dwindling funding for myriad of increasingly challenging humanitarian and public crisis and interventions.

B. Vaccine Supply Chain – Nigeria

Nigeria, an example of the LMICs is the most populous country in Africa with population at about 180 million people [18], [8], [19]. Nigeria had made some commendable progress towards GAVI graduation in terms of vaccination [18]. There are however more grounds to cover to make the progress sustainable towards the GAVI graduation. In the front row amongst the challenges are the 7.5 million children to be vaccinated yearly, cold chain and logistics, new vaccine introduction and weak data [18], [8], [20]. Given the economic burden and benefits of vaccination, the country must confront the challenges of vaccines/immunization supply chain. Immunization Practice Advisory Committee, IPAC had called for national investment in immunization supply chain to improve on vaccine coverage [21]. Nigeria has however recorded impressive progress in immunization by adopting best practice of end-to-end supply chain from the commercial sector [18]. Building upon IPAC advisory, the identified areas for improvement in immunization supply chain include; Vaccine arrival, Temperature control, Storage capacity, Infrastructure, Stock management, Distribution and Information systems [21]. These are related to different challenges and obstacles identified by different authors and industry players [22]. [8], [12], [20]. It is therefore imperative to consider different challenges associated to the Nigeria context of vaccine supply chain. To push it further we would

also evaluate some solutions which would include technologies and innovations that could circumvent some of these challenges and enhance the end-to-end vaccine supply chain in Nigeria.

III. MATERIAL AND METHODOLOGY

Internet-based questionnaire (Google Form) was used to reach different professionals with experience of Nigeria supply chain of vaccines. The sample cut across different levels of operation, geography and areas of practice. The population size of professionals in Nigeria's development/health public health was estimated at over 5000. A cluster of professionals whose works relates to the supply chain of public health commodity were selected as the sampling frame [23]. A target sample frame, though growing stands at 1047 as at the time of this data collection in December 2017 [24]. This involved number of professionals in Nigeria who have identified as part of International Association of Public Health Logisticians, IAPHL. The IAPHL is an association of public logistician from all over the world coming together to share knowledge, best practices and network. Using this sample frame, sample size calculator was used to calculate the expected sample size. At a confidence level of 95%, a confidence interval of 5 for sample frame of 1047, 281 professionals were needed as the sample size using sample size calculator (Creative Research System, n.d). This was considered a good and credible representation of the population for this phase of the research.

The questionnaire was shared on the listserv of the IAPHL and other smaller internet based social network (Whatsapp, Telegram and LinkedIn) and opened for one (1) calendar month after which it was closed to further responses. At the end of one month time horizon, (December 3, 2017 to January 2, 2018) a total response of 201 were received and the questionnaire closed to further responses using the switch on the Google form. Following this stage, the data were harvested for onward analysis. To improve the response rate and achieve this feat, a few steps were taken. These steps include; assuring confidentiality and providing a good introduction of the survey and how responses will shape a smarter supply chain. The researcher also ensured that questionnaires were easy to use and understandable and only takes 5-10 minutes of a participant's time. The permission and support of the administrator of the different platforms were also secured to give the process speed and credibility. This approach follows the strategy by Easterby-Smith *et al* on how to improve response rate [23]. The data analysis combined SPSS version 21 and Microsoft Excel. With SPSS, we better managed data with case selection, file reshaping, and creating derived data. A metadata dictionary was stored with the data. Statistical analysis tasks performed with the base package include the generation of descriptive statistics, prediction of numerical outcomes, and prediction of identifying groups.

IV. RESULTS AND DISCUSSION

The 200 valid responses of which 141 (70.5%) were males and 59 (29.5%) were females with male: female ratio approximately 2:1. The most frequent age group was 31– 40 (113, 56.5%) while the least frequent age group was 21-30 (39, 19.5%). Majority of the responses were from Health/Public Health/Development Professionals (81, 40.5%) followed by 52 (26.0%) from Supply Chain Professionals (49,

24.5%) while only 3 (1.5%) responses were got from IT professionals. Technical or executive officers constituted 41.0% of the respondents, 29.5% were middle managers, 12.5% were senior managers while 4.0% were regulatory/policy makers. This distribution of respondents assures that the survey is heterogenic enough to capture different perspectives from different areas and at different levels of practice.

TABLE I DEMOGRAPHICS WITH PROFESSIONAL EXPERIENCE

Parameter	Frequency	Percentage
Gender		
Male	141	70.5%
Female	59	29.5%
Age category		
21 - 30	39	19.5%
31 - 40	113	56.5%
41 and above	48	24.0%
Profession		
Supply Chain Professional Only	52	26.0%
Health/Public Health/Devt Professional Only	81	40.5%
Supply Chain and Health/Public Health/Devt	49	24.5%
IT professionals Only	3	1.5%
Financial/Business and Project Mgt	8	4.0%
Regulatory and Safety Professionals	7	3.5%
Specialization		
Consultant	26	13.0%
Middle Manager	59	29.5%
Regulatory and Policy Maker	8	4.0%
Senior Manager	25	12.5%
Technical/Executive Officer	82	41.0%

A. Knowledge of Vaccine Supply Chain, Technology and Innovation Awareness as Major Challenges Among Professionals

Just 4.5% of the professionals had excellent knowledge of vaccine supply chain, 16.5% had very good knowledge and 44.0% had good knowledge of vaccine supply chain (Figure I). Among Supply Chain Professional, 7.7% rated their knowledge of vaccine supply chain poor, 26.9% fair, 50.0% good, 13.5% very good while just 1 had excellent Knowledge of it. The rating is similar among Health/Public

Health/Development Professional Only and Supply Chain and Health/Public Health/Development Professionals. For IT professionals, 2 people had fair knowledge of vaccine supply chain, 1 had good knowledge while none had very good or excellent knowledge of it. Three of Financial/Business and Project Management Professionals had poor knowledge of vaccine supply chain, 2 had good knowledge while just 1 each had fair, very good and excellent knowledge. Among Regulatory and Safety Professionals, 5 had good knowledge and 2 had very good knowledge of vaccine supply chain while none excellent knowledge of it (TABLE II).

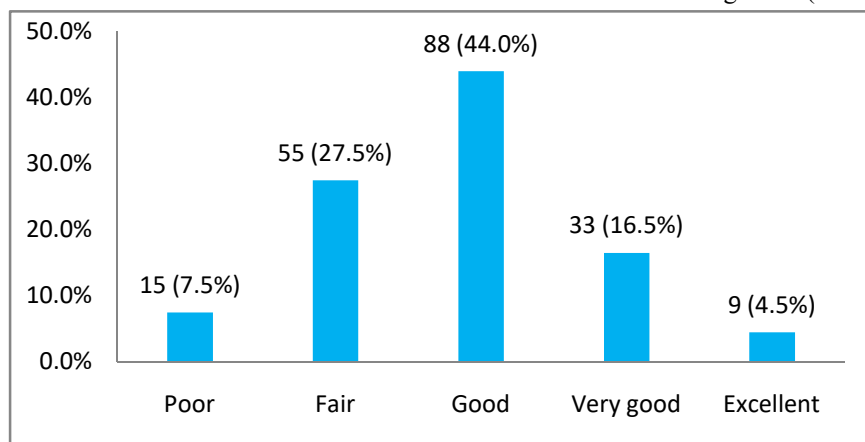


Figure I: Knowledge of Vaccine Supply Chain

TABLE II KNOWLEDGE OF VACCINE SUPPLY CHAIN BY PROFESSION (P = 0.109)

Knowledge of vaccine and its supply chain	Profession (%)					
	Supply Chain Professional Only	Health/Public Health/Dev't Professional Only	Supply Chain and Health/Public Health/Dev't Professionals	IT professionals Only	Financial/Business and Project Mgt Professionals	Regulatory and Safety Professionals
Poor	4 (7.7%)	7 (8.6%)	1 (2.0%)	-	3 (37.5%)	-
Fair	14 (26.9%)	26 (32.1%)	12 (24.5%)	2 (66.7%)	1 (12.5%)	-
Good	26 (50.0%)	34 (42.0%)	20 (40.8%)	1 (33.3%)	2 (25.0%)	5 (71.4%)
Very good	7 (13.5%)	10 (12.3%)	13 (26.5%)	-	1 (12.5%)	2 (28.6%)
Excellent	1 (1.9%)	4 (4.9%)	3 (6.1%)	-	1 (12.5%)	-
Total	52 (100.0%)	81 (100.0%)	49 (100.0%)	3 (100.0%)	8 (100.0%)	7 (100.0%)

B. Bottlenecks as Major Challenges to Vaccine Supply Chain in Nigeria

In order to determine the problems or bottleneck to vaccine supply chain in Nigeria, respondents were asked to determine whether the five major factors highlighted are barriers to vaccine supply chain in Nigeria or not.

Data availability and reliability was seen as an extreme barrier to vaccine supply chain efficiency by 13.5% of the respondents, 38.5% saw it as moderate barrier while 39.5% called it somewhat a barrier while just 8.5% did not see it as a barrier (TABLE III). Logistics distance between vaccine manufacturers and Nigeria was not seen as a barrier by a very few respondents (7.0%), 29.0% considered it somewhat barrier, 45.5% saw it as moderate barrier while 18.5% called it an extreme barrier (TABLE III). Similarly, only 5.5% did not see cost of managing vaccine through the supply chain network to service delivery points as a barrier to vaccine supply chain in Nigeria, 22.5% called it a somewhat barrier, 53.0% a moderate barrier while 19.0% called it an extreme barrier (TABLE III).

Cold Chain and vaccine Integrity/Potency was seen as an extreme barrier by 15.0% of respondents, 41.0% chose

moderate barrier, 34.5% somewhat barrier while just 7.5% did not see it as a barrier. Geographical/topographic/security obstacles to the last mile delivery was not seen as a barrier to vaccine supply chain in Nigeria by the least number of respondents, 7.5% whereas 32.5% saw it as somewhat barrier, 40.0% as moderate barrier while 20.0% classified it as an extreme barrier (TABLE III).

TABLE IV is a combination of responses of professionals on vaccine supply chain bottlenecks: ‘Data availability and reliability for Forecasting/decision-making’, ‘logistics distance between vaccine manufacturers and Nigeria’, ‘cost of managing vaccine through the supply chain network to service delivery points’, ‘cold chain and ‘vaccine integrity/potency and geographical/topographic/security obstacles to the last mile delivery’. Among Financial/Business and Project Managers, 12.5% believed that the five factors combined are not barriers, 22.5% as somewhat barriers, 40.0% moderate barrier while 25.0% called them extreme barriers. Similar trend was observed among Health/Public Health/Developers, Supply Chain, Health/ Public Health/Developers and Supply Chain professionals only. On the other hand, 53.3% of IT professionals saw them as extreme barriers, 33.3% as somewhat barriers and 13.3% as moderate barriers.

TABLE III VACCINE SUPPLY CHAIN BOTTLENECKS

Factor	Response (%)			
	Not a Barrier	Somewhat a Barrier	Moderate Barrier	Extreme Barrier
Data availability/reliability for Forecasting or decision-making	17 (8.5%)	79 (39.5%)	77 (38.5%)	27 (13.5%)
Logistics distance between vaccine manufacturers and Nigeria	14 (7.0%)	58 (29.0%)	91 (45.5%)	37 (18.5%)
Cost of managing vaccine through the supply chain network to service delivery points	11 (5.5%)	45 (22.5%)	106 (53.0%)	38 (19.0%)
Cold Chain and vaccine Integrity/Potency	19 (9.5%)	69 (34.5%)	82 (41.0%)	30 (15.0%)
Geographical/topographic/security obstacles to the last mile delivery	15 (7.5%)	65 (32.5%)	80 (40.0%)	40 (20.0%)

TABLE IV Summary of Description of Vaccines SC Problems/Bottleneck by Profession (p = 0.006)

Description	Profession (%)					
	Financial/Business and Project Mgt	Health/Public Health/Dev	IT Only	Regulatory and Safety	Supply Chain,Health/Public Health/Dev	Supply Chain Only
Not a Barrier	5 (12.5%)	33 (8.1%)	-	5 (13.2%)	14 (5.7%)	19 (7.3%)
Somewhat a Barrier	9 (22.5%)	132 (32.6%)	5 (33.3%)	15 (39.5%)	65 (26.5%)	90 (34.6%)
Moderate Barrier	16 (40.0%)	172 (42.5%)	2 (13.3%)	14 (36.8%)	118 (48.2%)	117 (45.0%)
Extreme Barrier	10 (25.0%)	68 (16.8%)	8 (53.3%)	4 (10.5%)	48 (19.6%)	34 (13.1%)
Total	40 (100.0%)	405 (100.0%)	15 (100.0%)	38 (100.0%)	245 (100.0%)	260 (100.0%)

C. Suggested Ways to Overcome the Challenges of Vaccine Supply Chain in Nigeria

The views of professionals on the next step going forward, 27% suggested that there should be more focus on awareness creation/education/capacity building on vaccine supply chain (27.0%), 23.5% suggested that political leaders should be

willing to support and create enabling environment for the success of vaccine supply chain in Nigeria, 19.5% suggested particular disruptive technologies/ innovation/ Infrastructure such as Thermostable, electricity, etc. while 8.0% suggested more research data on vaccine supply chain (Figure II).

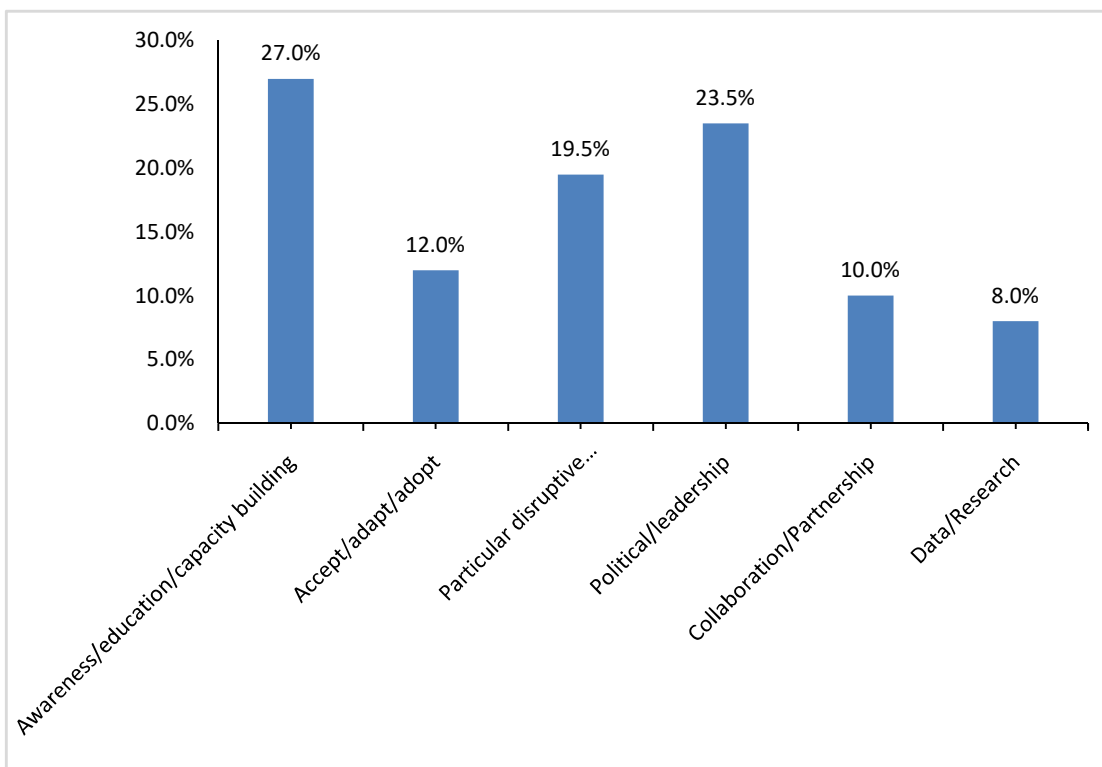


Figure II: Suggested Ways to Overcome the Challenges of Vaccine Supply Chain in Nigeria

D. Discussion

This research found that the workforce is dominated by young middle-aged professionals of age 31-40. Among the professionals, only few people (21%) had above average (very good and excellent) knowledge of vaccine chain while more

than 30% had poor knowledge of vaccine supply chain in Nigeria. This poor knowledge of vaccine supply chain that cut across all professions is a major challenge to efficiency and success of vaccine supply chain in Nigeria. The knowledge of vaccine supply chain was not statistically different among professionals (p >0.05). In a research conducted by Ameen *et*

al. 2016 to assess vaccine management practices among primary healthcare Workers in Nigeria, they reported that majority (91.2%) of the study respondents were aware of vaccine management. They further stated that the result might not be unconnected with the fact that vaccine management topics, such as vaccine storage and handling, cold chain management, VVM interpretation and use of MDV policy are usually discussed in seminars or training workshops on immunization service delivery. In addition to print and mass media, training workshops and seminars organized by Government or Health Agencies such as WHO,

EU-PRIME and UNICEF, are effective sources of knowledge acquisition to PHCWs. This was further corroborated with the finding in this study which revealed that up to 93% of PHCWs in both groups acquired knowledge on vaccine management through these sources before intervention [25]. On the contrary, this study found that only 21% of respondents had reliable knowledge of vaccine supply chain. This might not be unconnected with the fact that awareness and trainings are more focus on vaccine managements than on supply chain. More attention is therefore needed in the area of training of professionals in other to overcome this important limitation to the efficiency of vaccine supply chain in Nigeria as previous research has that prior training attendance had positive influence on vaccine management knowledge [25].

Approximately 92% of respondents viewed data availability and reliability as a challenge to vaccine supply chain efficiency in Nigeria, 93% also considered logistics distance between manufacturers and Nigeria as a form of challenge. Generally, all the five factors considered were highly rated as major challenges by over 90% of all respondents. Thus, a lot has to be done to overcome the challenges of bottlenecks to vaccine supply chain in Nigeria.

Similarly, approximately 88% and 87% of financial/Business and Project Managers and Regulatory and Safety professionals respectively admitted that all the five factors ('Data availability and reliability for Forecasting/decision-making', 'logistics distance between vaccine manufacturers and Nigeria', 'cost of managing vaccine through the supply chain network to service delivery points', 'cold chain and 'vaccine integrity/potency and geographical/topographic/security obstacles to the last mile delivery') identified as bottleneck to vaccine supply chain in Nigeria as major challenges. Also, over 90% of professionals in Health/Public Health/Development, information technology, Supply Chain, Health/ Public Health/Development as well as supply chain experts admitted the five factors as major challenges to vaccine supply chain in Nigeria. Our findings corroborate with UNICEF [26] which identified limitations in supply chain system design as: insufficient and misallocated human resources, ineffective use of data for management, weak distribution systems, inadequate budget and distribution systems, deficient cold chain equipment and increasing volume and value [26].

Considering the responses to the earlier quantitative enquiries, respondents were given the opportunity to proffer the next steps forward using internet-based qualitative technique. From the available feedback, the emerging innovations and technologies are useful tools to improve the vaccine supply chain in Nigeria. The respondents however shared some common ways forward. Issues around creating awareness, education and advocacy carried the highest percentage of 27% followed by political/leadership commitments at 21%. This though needs more in-depth qualitative enquiries; it also tends to support the fact that awareness is a major driver the technological or innovation adoption [7], [27], [28].

V. CONCLUSION

Public sector health care supply chains continue to grow increasingly complex. Existing programs in primary health care (PHC) and the Expanded Program on Immunization are being scaled up to reach the Millennium Development Goals. A critical success factor in the improving immunization coverage is vaccine supply chain is. Immunization in Low and Middle-Income Countries (LMICs) generally suffers lots of setbacks due to poor knowledge of vaccine supply chain as well as supply chain bottlenecks. This study took pragmatic approach to explore the Nigeria vaccine supply chain ecosystem. We discovered that poor knowledge of vaccine supply chain cuts across all professions and thereby constitute a major challenge to efficiency and success of vaccine supply chain in Nigeria. There were five major identified bottlenecks to vaccine supply chain in Nigeria which included data availability and reliability for forecasting/decision-making, logistics distance between vaccine manufacturers and Nigeria, cost of managing vaccine through the supply chain network to service delivery points, cold chain and vaccine integrity/potency and geographical/topographic/security obstacles to the last mile delivery. All the five factors considered as bottlenecks were highly rated as major challenges by over 90% of all respondents. Thus, a lot has to be done to create awareness on vaccine supply chain across all healthcare profession and more efforts are needed both by government and professionals to overcome the challenges of bottlenecks to vaccine supply chain in Nigeria. Although there were challenges, professionals suggested ways forward which included creating more awareness/education/capacity building, political drive/interest, disruptive technologies or innovation and Infrastructure among others. It is therefore imperative that more works should be done to explore the feasibility or impacts of technologies/innovations in Nigeria vaccine supply chain.

REFERENCES

- [1]. Chopra, S. and Meindl, P. (2007). *Supply Chain Management: Strategy, Planning and Operation*. Pearson Prentice Hall, Upper Saddle River.
- [2]. Haraburda, S.S. (2016). *Transforming Military Support Processes from Logistics to Supply Chain Management*, *Army Sustainment*, 48, 2, pp. 12-15.
- [3]. Goel, N and S. Goel, (2015), 'Disruptive Innovations in Supply Chain', *South -Asian Journal Of Multidisciplinary Studies (Sajms)*,

Issn:2349-7858 Volume 1 Issue 4, Universal Multidisciplinary Research Institute Pvt Ltd.

- [4]. Angeleanu, A. (2015), 'New Technology Trends and Their Transformative Impact on Logistics and Supply Chain Processes', *International Journal Of Economic Practices and Theories*, 5, 5, pp. 413-419.
- [5]. LogiPharm, (2017), 'The Supply Chain of the Future A LogiPharma Report', <http://movianto.com/wp-content/uploads/wbr-logipharma-report-01.pdf>.
- [6]. Malik, Y, Niemeyer, A, and Ruwadi, B. (2011). Building the supply chain of the future, *Mckinsey Quarterly*, 1, pp. 62-71.
- [7]. Adeloye, D, Jacobs, W, Amuta, A, Ogundipe, O, Mosaku, O, Gadanya, M, and Oni, G 2017, 'Review: Coverage and determinants of childhood immunization in Nigeria: A systematic review and meta-analysis', *Vaccine*, 35, pp. 2871-2881, ScienceDirect, EBSCOhost, viewed 15 November 2017.
- [8]. GAVI, 2016, 'Gavi, the Vaccine Alliance: Supply and Procurement Strategy 2016-20', <http://www.gavi.org/about/>.
- [9]. Childress, Vw (2015), 'Supply Chain, Logistics, And Global Economics', *Technology and Engineering Teacher*, 75, 4, pp. 22-27.
- [10]. Collins, J., (2001), 'Good to Great; Why Some Companies Make the Leap . . . and Others Don't', Collins Business.
- [11]. Wright, C., (2016) *Supply Chain 2035: Preparing for the Next 20 Years*, Available at: <http://thepump.jsi.com/supply-chain-2035-preparing-for-the-next-20-years>, (Accessed: 30/08/2016).
- [12]. CHAI, (2016), 'Clinton Health Access Initiative, Annual Report; 2015', <http://www.clintonhealthaccess.org/content/uploads/2016/08/2015-Annual-Report.pdf>.
- [13]. Kristensen, DD, Lorensen, T, Bartholomew, K and Villadiago, S., (2016), 'Can thermostable vaccines help address cold-chain challenges? Results from stakeholder interviews in six low- and middle-income countries', *Vaccines* 34(2016)899-904, <https://www.journals.elsevier.com/vaccine>.
- [14]. Lydon, P., Raubenheimer, T, Arnot-Krüger, M., and Zaffran M., (2015), 'Outsourcing vaccine logistics to the private sector: The evidence and lessons learned from the Western Cape Province in South-Africa', *Vaccines* 33(29):3429-3434, <https://www.journals.elsevier.com/vaccine>.
- [15]. Lee, B, Wedlock, P, Haidari, L, Elder, K, Potet, J, Manring, R, Connor, D, Spiker, M, Bonner, K, Rangarajan, A, Hunyh, D, and Brown, S. (2017). 'Economic impact of thermostable vaccines', *Vaccine*, 35, pp. 3135-3142, ScienceDirect, EBSCOhost, viewed 27 November 2017.
- [16]. Seidman, G, and Atun, R. (2017). 'Do changes to supply chains and procurement processes yield cost savings and improve availability of pharmaceuticals, vaccines or health products? A systematic review of evidence from low-income and middle-income countries', *BMJ Global Health*, 2, 2, p.
- [17]. Privett, N, and Gonsalvez, D. (2014). Short communication: The top ten global health supply chain issues: Perspectives from the field, *Operations Research For Health Care*, 3, pp. 226-230, ScienceDirect, EBSCOhost, viewed 30 November 2017.
- [18]. Sarley, D, Mahmud, M, Idris, J, Osunkiyesi, M, Dibosa-Osador, O, Okebukola, P, and Wiwa, O (2017). 'Transforming vaccines supply chains in Nigeria', *Vaccine*, 35, Building Next Generation Immunization Supply Chains, pp. 2167-2174, ScienceDirect, EBSCOhost, viewed 21 November 2017.
- [19]. World Bank, (2016), World Bank Factsheet, <http://data.worldbank.org/country/nigeria>.
- [20]. Zaffran M, Vandelaer J, Kristensen D, Melgaard B, Yadav P, Antwi-Agyei, KO, and Lasher, H, (2013), 'The imperative for stronger vaccine supply and logistics systems', *Vaccine* 2013;31(suppl 2). doi: <http://dx.doi.org/10.1016/j.vaccine.2012.11.036>.
- [21]. WHO, (2014), 'Immunization supply chain and logistics: a neglected but essential system for national immunization programmes, A call to action.' Geneva (Switzerland), (WHO/IVB/14.05). World Health Organization; Available at; http://www.who.int/immunization/programmes_systems/supply_chain/en/.
- [22]. Brison, M, and LeTallec, Y 2017, 'Commentary: Transforming cold chain performance and management in lower-income countries', *Vaccine*, 35, Building Next Generation Immunization Supply Chains, pp. 2107-2109, ScienceDirect, EBSCOhost, viewed 21 November 2017.
- [23]. Easterby-Smith, M., R. Thorpe, and P. Jackson, (2012) *Management Research*, 4th edition, London: SAGE Publications.
- [24]. IAPHL (2017). 'IAPHL Updates on Membership Numbers, Dec-2017' http://1i4rh11vcjs3zhs5v8cwkn2.wpengine.netdna-cdn.com/wp-content/uploads/2017/12/IAPHL-Updates-on-Membership-Numbers_Dec-2017.pdf.
- [25]. Ameen H.A., Salaudeen A.G., Musa O.I., Aderibigbe S.A., Akande T.M. and Ameen K. (2016). Predictors of vaccine management practices among primary healthcare workers (PHCWs) in Ilorin, North Central Nigeria. *Res. J. of Health Sci.* 4(2), pp 148 – 161.
- [26]. UNICEF (2014). Immunization Supply Chain Strategies: 2014 Vaccine Manufacturer Consultation Copenhagen, 9 October 2014, pp 1 – 29.
- [27]. Uta, L., Chiliya, N. and Chuchu, T., (2014). 'Determining the Feasibility of Adopting Technological Innovation to Enhance Service Delivery in Selected Johannesburg Health Institutions', *Mediterranean Journal of Social Sciences*, <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.892.115andrep=rep1andtype=pdf>.
- [28]. Abubakar, FM and Ahmad, HB, (2013), 'The Moderating Effect of Technology Awareness on the Relationship between UTAUT Constructs and Behavioural Intention to Use Technology: A Conceptual Paper', *Australian Journal of Business and Management Research*, Vol.3 No.02 [14-23] | May-2013 ISSN: 1839 – 0846, <http://www.ajbmr.com/articlepdf/aus-29-75i02n3a2.pdf>.