Page 517 to 524

Volume 2 • Issue 6 • 2018

Research Article

Nutrition and Food Toxicology

ISSN: 2573-4946

Real Time Digital Biosensors Technology and Applications on Public Health Nutrition Transformation and Livelihood in Low and Middle Income Countries

Ernest Tambo[1,2]*, Ghislaine Madjou[2], Valery TTakoubo[3], Jeanne Y Ngogang[1] and Lazare Kaptue[1]

[1]Department of Biochemisry and Pharmaceutical Sciences, Higher Institute of Health Sciences, Université des Montagnes, Bangangté, Cameroon

[2]Africa Disease Intelligence and Surveillance, Communication and Response (Africa DISCoR) Institute, Yaoundé, Cameroon

[3]Department of Physics, faculty of Sciences, Universite de yaounde I, yaounde, cameroon

***Corresponding Author:** Ernest Tambo, Department of Biochemisry and Pharmaceutical Sciences, Higher Institute of Health Sciences, Université des Montagnes, Bangangté, Cameroon.

Received: April 04, 2018; **Published:** April 18, 2018

Abstract

Real-time, effective and affordable nutrition and dietetics wearable or implant biosensors technology and applications are emerging field with immense opportunities and benefits to the global food insecurity and nutrition challenges and issues. As a powerful public health nutrition game changer, it requires more research and development support in tackling food security and nutrition safety challenges and evidence in local and global priorities needs worldwide. Such revolution real time, home, work and hospital-based rapid, accurate and cost-effective self-detection and diagnosis of direct or indirect causes or diet deficiency or excess are much needed for generating evidence-based information and knowledge for individual and vulnerable group nutritional and dietary mitigation and lifestyle adaptation through wearable sensors and technology. Importantly, they foster national decision-making nutrition policy and guidelines, interventions and best practices in self-management, healthier lifestyle and increasing life expectancy, livelihood and wellness. However, urgent political commitment and financial investment is needed in building and sustaining dietary and nutrition wearable and implantable technologies and devices of research and development. These can enhance evidence-based, coherent and coordinated nutrition and dietary programs and strategies to a targeted group or illness vital in addressing malnutrition and undernutrition public health burden amongst African children.

Moreover, improved balanced dietary and nutrition promotion and awareness, education and best practices culture amongst youths and adult populations is crucial in improving sustained lifestyle adaptations including people living with HIV (PLWHIV) and diabetes or overweight or stroke patients. Also, building trust and confidence in wearable sensors consumers' for healthy diet and fitness prognosis, prospective data and data sharing on diet/nutrition informatics platforms; can support mutual engagement and participatory communication amongst public consumers, dietetic and nutritionist professionals quality interventions, management and better health outcomes. They mainly foster and sustain new ideas and solutions including the quest for food and nutrition enlightenment, knowledge and resilience. However, and understanding of and potential challenges and opportunities health and nutritional/dietary insecurity, health inequities and weak food safety standard's needs, assessment of food-borne diseases and comorbid conditions have public health benefits and stimulate ample resource development in personalized medicine accessibility and availability much needed in limited resource and remote settings for positive behaviour changes, livelihood and generational lifestyle transformations.

Keywords: *Wearable sensors; Nutrition; Diet; Public health; Digital technology; Prevention; Management, Africa; low and middle income countries (LMICs)*

Volume 2 Issue 6 April 2018

Introduction

Global food security, nutrition and dietary related public health diseases and burden still account for an essential component of the total burden in low and middle income countries (LMICs), especially in Africa. It represents a complex diversity and interplay between clinical and epidemiological burden and nutritional., maternal and children challenges of persistent communicable and rising non-communicable diseases (David., *et al*. 2015). Approximately 842 million people worldwide, representing 12% of the global population suffered from malnutrition, under-nutrition, hunger and diet related deficiencies between 2011 and 2013. Today, industrial revolution with production of foods for economic gain, obesity epidemics related to unhealthy eating habits and over-nutrition in both developed and developing countries continues to exacerbate the rising in chronic diseases such as cardiovascular disease, cancer and premature aging populations (David., *et al*. 2015; Khoury., *et al*. 2013). Also, the situation is complex due to low food production and shortage, poverty, inadequate food distribution, supply disruptions, food waste, government policies that inhibit trade and negatively affect farmers and growth of biofuels.

The growing use of some agricultural technology and products (that is, pesticides) and climate change impacting on environmental and extent price volatility situation have potential to worsening famine, hunger and starvation in LMICs mainly in Africa (David., *et al*. 2015; Khoury., *et al*. 2013; Sun., *et al*. 2010). Adequate and safe food and nutrition supply is one of the fundamental responsibilities and right of citizenry of each government, nation and global community. Yet, addressing the global nutrition situation is that of fasting and feasting to chronic stunting and obesity picture from childhood to premature ageing with millions of people at increased risk of developing diet-related chronic diseases such as cardiometabolic diseases, kidney disease, cancer and diabetes, etc (Khoury., *et al*. 2013; Tambo and Ngogang, 2016). On the other hand, malnutrition and undernutrition or diet related deficiencies are estimated at 3.5 million deaths annually, largely preschool and infant children, pregnant and lactating women and elderly in LMICs (David., *et al*. 2015). Africa population continues to grow at 2 to 3% per annum and expected to double to 2 billion people by 2025. This results in rapid urbanization and increasing food consumption patterns that require improved food and nutrition safety, efficient technologies and immense opportunity in agro businesses and related fields in tackling the growing nutrition transition and increasing nutritional health associated with diseases diagnostics and treatment packages (David., *et al*. 2015; Zhu., *et al*. 2015).

The public health nutrition wearable and implantable sensors approach provides a new perspective in human or animal nutrition and dietary. It leads to reliable and effective breakthroughs in nutrition and health interdisciplinary approaches and solutions in tackling the ever-growing local and global nutrition challenges (David., *et al*. 2015; Zhu., *et al*. 2015). These challenges are worsened the increasing demographic and population, climate and environmental changes, and health systems, weak integrated policy, management and administration bottlenecks (David., *et al*. 2015; Khoury., *et al*. 2013; Evenson., *et al*. 2015). Modern convenient and cost-effective wearable sensors have been demonstrated useful for self-education and exercise, tracking and predicting energy level and advice on interventions or activities required to improve the excess or deficiencyand possibly on short and long-term adaptation changes from plant-derived or animal-derived sources. In achieving appropriate and balanced choices and quantities of unique fruit and vegetable phytochemical/micronutrient categories and needs (Evenson., *et al*. 2015; Johnson- Glenberg., *et al*. 2014; Granado-Font., *et al*. 2015). The effectiveness of wearable devices and fitness trackers, and mobile application on healthy life and care delivery outcomes such as weight loss and maintenance have been documented in developed countries (Khoury., *et al*. 2013; Tambo., *et al*. 2016; Zhu., *et al*. 2015; Johnson-Glenberg., *et al*. 2014).

Nutritional and dietary wearable technology revolution has a critical role and importance in contributing to nutritional and food challenges paradigm shift in Africa and other LMICs (Kelly., *et al*. 2015). It provides real time, home, work and hospital-based rapid, accurate and cost-effective detection, and diagnosis of nutrition/energy or diet deficiency or excess is much needed. It also supports the generation of quality evidence-based information and knowledge for individual, vulnerable group to national decision-making nutrition policy and guidelines, programs and interventions towards healthier lifestyle and increasing life expectancy, more productivity and wellness (Tambo., *et al*. 2016; Kelly., *et al*. 2015). Hence, real time displaced people in protracted crises and refugees camps, fit for purpose and flexible applications of smart wearable or implantable sensors approaches and strategies are urgently needed in providing clues into effective fitness and feeding behavior best practices. Yet, the nature and extent of its applications in community require further research in establishing wearable sensors on nutrition safety in increasing food production value and shelf-life usefulness and effectiveness in LIMCs and worldwide (Kelly., *et al*. 2015; Shuger., *et al*. 2011).

This paper provides insights into adoption and applications of dietetics and nutrition smart wearable biosensors or applied implantable technology approaches for evidence-based public health nutrition education, and empowerment implementation in improving nutrition fitness and clinical deficiency (malnutrition or under-nutrition consequences) management strategies. Also, it provides opportunity for lifestyle adaptation, monitoring food intake or energy consumption/loss attitude and culture as timely remedy in revamping health, in reducing the rising trends of obesity related cardiovascular diseases; poverty alleviation, livelihood and sustainable development in LIMCs.

Dietetics and Nutrition Technologies and Smart Sensors Needs

Novel nutrition smart wearable or implantable technologies and sensors can contribute to shaping the research and development in food, nutrition and dietary policies, guidelines and measures. These should be defined jointly as a unique platform of policy-makers, nutritionists, dietetics and other research scientists, clinicians, and public health professional (Ayres., *et al*. 2011). Local, national, regional and international health organizations including food and pharmaceutical firms partnerships and networking engagement and investment in collective research and development, collective harmonization and standardization of solutions adoption and implementation are crucial.

These insights are critical in developing smart biosensors approaches and tools in tackling these obesity and malnutrition challenges and issues, conducting preclinical studies, monitoring safety assessments and knowledge translation into public wearable products or medical devices research policy, prognosis/diagnosis, care and service delivery (Ayres., *et al*. 2011; Popkin, 2014; Monsivais and Johnson, 2012). The increasing and growing burden of obesity related cardiometabolic diseases and nutrition related deficiencies, and consequence call for the paradigm shift and importance of smart technologies and devices as a game changer in tackling nutritional deficiencies and related consequences on growth, development, education, work, health and economic are considerably enormous in LMICs and specially in Africa (David., *et al*. 2015; Ayres., *et al*. 2012). Smart wearable sensors detection and therapeutic are used in exploring from personalized to community-based nutritional approach to prevention and treatment of chronic nutritional and related disease and improving existing conventional and complementary nutrition therapies in relation to lifestyle, biochemical and genetics of individual/community and environmental influences (David., *et al*. 2015; Popkin, 2014). Promoting healthy nutrition, disease and ageing is paramount in improving and maintaining physical and mental function from conception, childhood to older age (David., *et al*. 2015; Monsivais and Johnson, 2012; Tambo., *et al*. 2016). This has been undoubtedly major current and future challenges on the important role of nutrition specifically in most vulnerable groups in LMICs in growth and development, prevention and control of diseases (David., *et al*. 2015; Monsivais and Johnson, 2012).

The importance of determining nutrition smart technologies and smart sensors needs is paramount toward evidence-based early detection and cost-effective nutrition approaches and interventions in response to global nutrition challenge. Additionally, efficient and appropriate food policy and measures could support the reduction of obesity, malnutrition and unhealthy diet amongst vulnerable communities in LMICs. Essentially, nutritional and dietary standards school or faith-based educational curriculum upgrading and awareness,

monitoring is core self-management and enhanced productivity and wellbeing (Pelletier., *et al*. 2013). Thus, early nutrition detection sensors in informing, educating on appropriate and reliable prevention and control, and regulation tactics to less or excessive energy intake or unbalanced diets provide new continuous detection and monitoring tools needs for both vulnerable populations, professionals and related stakeholders (Katzmarzyk., *et al*. 2014). These are real time and practical opportunities to acquire knowledge on the gains of nutritional wearable sensors functions and applications implementations, skilled advised and collaborative nutrition and dietary compliance and adherence to their patient, inter-sectoral and multidisciplinary healthcare approach and service delivery (Sun., *et al*. 2010; Tambo., *et al*. 2016; Johnson-Glenberg., *et al*. 2014; Sylvia., *et al*. 2014).

Furthermore, they include nutrition approach immune inflammation and regulation such as people living with HIV/AIDS, growing obesity or overweight and diabetes pandemic, diet associated diseases and disparities such as rickets, kwashiorkor and marasmus, impaired vision, stunted growth and development, poor education performance, acute to chronic malnutrition in LMICs (David., *et al*. 2016; Evenson., *et al*. 2015; Kelly., *et al*. 2015). Integrative technology and medicine approach can ease one to identify the underlying causes of associated nutritional influences and consequences and promptly evidence in informing response packages or interventions; examples are applications of individualized powerful modulators nutritional interventions in inflammatory and immune-related diseases, medical nutrition therapy and advanced nutrigenomics (David., *et al*. 2015; Johnson-Glenberg., *et al*. 2014; Shuger., *et al*. 2011; Sylvia., *et al*. 2014).

Policy and Platform in Dietetics and Nutrition Technologies and Sensors

Over decades, health and economic of most LMICs specially Africa continues to be impeded with the persistence and resurgence of public health consequences related to food and nutrition challenges and poverty facing all ages. Mainly, limited resources and low allocation in agriculture in quality food production and increasing westernized life style in urban towns in LMICs settings including Africa have led to food insecurity, unhealthy eating and fast food health impact that requires innovative and evidence-based solutions (Sun., *et al*. 2010; Zhu., *et al*. 2015; Schaefer., *et al*. 2014). Strategic political commitment, leadership and investment are needed in building integrated, effective and robust digital nutrition and health approaches and strategies.

These can include nutrition and dietetic data and database or nutritional health informatics platforms, wearable and digital nutritional devices and tools in scaling up public awareness and literacy, coordinated mechanisms in engaging and monitoring the activities of all stakeholders (Schaefer., *et al*. 2014; Kuriyan., *et al*. 2014). Collective and participatory dialogue and communication amongst the public consumers, dietetic and nutritionist professionals on the needs of smart digital nutrition and dietary sensors in improving the quality food intake and energy consumption, malnutrition or obesity informed interventions and fitness programs, appropriate and balanced management and quality outcomes (Shuger., *et al*. 2011; Kuriyan., *et al*. 2014). Nevertheless, addressing and reinforcing operational and flexible wearable and implantable sensors or devices data privacy, safety and security need to be ensured at all times. In contemporary age, the need for real-time accurate, automatic and personalized dietary and nutrition deficiencies and disorders is very important. Early smart wearable or implantable sensors detection and monitoring acceptability, uptake and applications that can guide in self-education and clinical support systems to health professionals mainly nutritionists and dietetics is vital in tackling the growing threats and epidemics of man-made and natural human and environment challenges and impacts on health (Khoury., *et al*. 2013; Sun., *et al*. 2010; Shuger., *et al*. 2011; Sylvia., *et al*. 2014; Kuriyan., *et al*. 2014). Recent advances in robotics and digital technology represent a paradigm shift of learning and knowledge acquisition of perceptual/cognitive behavior and attitude for smart wearable robotics devices in nutrition and diet monitoring and evaluation. Also, included are body sensor network for providing self-individual/personalized and community wireless monitoring platforms that are pervasive, intelligent and context-nutrition education and smart awareness on energy balance, fitness and medical advice or programs (Sylvia., *et al*. 2014; Patel., *et al*. 2012).

Reshaping Nutrition and Dietaryopportunities Amongst Vulnerable Populations in Lmics

Evidence-based knowledge from wearable nutrition or implantable technology and devices on clinical and nonclinical nutrition and dietary policy and in public health nutrition therapy support and management are needed in meeting the food and nutrition deficiencies and needs of vulnerable populations (Louisa., *et al*. 2014; Kuriyan., *et al*. 2014; Shyamal., *et al*. 2012). Also, in promoting nutrition industry and pharmaceutical as well as professionals' inspiration, professionalism and enthusiasm for advanced nutritional sciences and service delivery (Doherty., *et al*. 2013). Understanding contextual nutritional indicators for healthy nutrition, fitness and security development framework can be the most effective and holistic approach in tackling under and over nutrition. related diseases and humanization crises

This is necessary using wearable or implantable devices coupled with digital technology to change the course of malnutrition, undernourishment, obesity related cardiometabolic diseases, population fitness and income related public health burden monitors in slowing the rising chronic diseases epidemics in Africa and worldwide (David, 2015). Developing safe, effective and accessible smart wearable or implantable sensors or device systems in nutrition, imaging and sensing and robotics in prompt clinical management and monitoring technologies have great potentials in reshaping the future of public healthcare nutrition for both developing and developed countries (Johnson-Glenberg., *et al*. 2014; Granado-Font., *et al*. 2015; Kelly., *et al*. 2015; Yilmaz., *et al*. 2010). These require focused leadership and investment capitalizing not only scientific and technological innovations, but with a strong emphasis on clinical translation and precise patient or group benefits and global nutrition positive impacts (Khoury., *et al*. 2013; Sun., *et al*. 2010; Zhu., *et al*. 2015; Evenson., *et al*. 2015; Johnson-Glenberg., *et al*. 2014; Kelly., *et al*. 2015; Sylvia., *et al*. 2014; Kuriyan., *et al*. 2014).

Yet, food and nutrition security is a complex public health that relies on smart national/regionalpolicy and approaches in addressing hunger, malnutrition, infectious and chronic diseases and rural poverty challenges as well as future impact of climate change agriculture across continents (David., *et al*. 2015; Sylvia., *et al*. 2014; Stumbo., *et al*. 2010). It also depends on several factors including greenhouse gas and ozone emissions, climate and water scarcity mitigation and adaptation, water availability and soil, but also changing demographics, population growth needs and demand, renewable energy and policy. Improving wearable or implantable sensors implementation advantages and benefits through genuine reforms and policies in leveraging on scientific and technology in nutrition, cooperation and collaboration in technology transfer and exchanges, engagement of public-private sectors partnerships can enable farmers and partners new partnerships in LMICs (David., *et al*. 2015; Sylvia., *et al*. 2014; Patel., *et al*. 2012). Revamping food production investment in increasing agricultural productivity, careful uses of natural resources, promoting resilience and adaptations of farmers towards sustainable and effective nutrition and dietetics market based approaches and expansion of sufficient food accessibility and availability to vulnerable populations at all levels is essential (David., *et al*. 2015; Sylvia., *et al*. 2014; Kuriyan., *et al*. 2014).

Bridging dietetics and nutrition information and communication technologies with healthcare management is imperative by increasing raising global awareness of the need to improve food security, environmental sustainability and economic opportunity. Accelerating sustainable investment in agriculture to ensure that all vulnerable populations have sufficient access to affordable healthy foods and diets that are environmentally sustainable is urgent. Integration of principles guiding best practice and functional medical nutrition therapy; clinical application of the nutrition care process (detecting, diagnosing, tracking or tracing, responding, monitoring, and evaluating) toward restoring healthy function for an individual based on balanced nutritional and dietary status. Hence, focusing on precision dietary and nutrition formula evidence-based and adequate management provide immense and unique prospect for an individual/group and community response to nutritional imbalances on either or both chronic disease or infectious immunosuppressive diseases pathophysiology, preventing chronic disease emergence and requisite introduction of nutrition genetics and medical nutrition therapy [1,8,14,20,24].

The forefront of diet and nutrition wearable devices includes research and development in imaging, sensing and smart robotic assessment and interpretation in addressing evidence in nutrition and health challenges to physiological, biochemical, environment, socioeconomic and climate changes advocacy and mitigation (Hughes., *et al*. 2010; Davenport, 2015; Andrew., *et al*. 2016). There is an urgent need for nutrition and dietary smart wearable or implantable detectors and monitors at all ages and at all levels in understanding and monitoring the risk factors of chronic diseases, impact on health and pathophysiological progression. Importantly, monitoring

excess energy accumulation in deep tissues, care and treatment adverse reactions are necessary in providing pharmacovigilance and eco-toxicity information and data. These are useful in evidence-based decision making good dietetic and nutrition practice policy in health, agriculture, environmental and climate changes.

Conclusion

Investing in real-time, effective and affordable dietetics and nutrition wearable or implantable technologies and health sensors are emerging field that presents immense benefits and powerful public health and nutrition paradigm shift and transformation in LMICs and mainly in Africa. Increasing the importance of nutrition and dietetic sensors and technology applications in health, digital nutrition awareness, nutritional gamification and fitness instructional and exercise is vital in promoting food and nutrition education, electronic nutrition data and database for healthier life and wellbeing has been recognized. Leadership commitment and financial investment by local Africa governments and their communities, Food-Agricultural Organization (FAO), World Food Program (WFP), World Health Organization (WHO), Non- Government Organizations (NGOs), The World Bank, Africa Development Bank (ADB) and other private stakeholders is vital in strengthening food and nutrition technologies and wearable devices research and development. Promoting nutrition education and lifestyle adaptation awareness for health, support building of digital nutrition database platforms and communication amongst public consumers, dietetic and nutritionist professionals is needed. These are the most efficacious vehicles in building and sustaining a balanced, coordinated and fine tune dietary and nutrition resilience culture, evidence-based decision making approaches and interventions, and best practices for healthier lifestyle and increasing life expectancy and strengthening global food security and nutrition.

Conflict of interests

The authors have not declared any conflict of interests.

Acknowledgement

Thanks to the anonymous reviewers. This paper received no funding support.

References

1. Allison DB., *et al*. "Goals in Nutrition Science 2015–2020". *Frontiers in Nutrition* (2015).
2. Khoury MJ., *et al*. "Transforming epidemiology for 21st century medicine and public health". *Cancer Epidemiology, Biomarkers & Prevention* 22.4 (2013): 508-516.
3. Sun M., *et al*. "A Wearable Electronic System for Objective Dietary Assessment". *Journal of the American Dietetic Association* 110.1 (2010): 45-47.
4. Tambo E., *et al*. "Wearable Sensors and Healthcare Informatics Solutions in Non-Communicable Diseases (Ncds) Prevention and Management in Africa". *Journal of Health & Medical Informatics* (2016): 218.
5. Zhu Z., *et al*. "Wearable Sensor Systems for Infants". *Sensors (Basel)* 15.2 (2015): 3721-3749.
6. Evenson KR., *et al*. "Systematic review of the validity and reliability of consumer-wearable activity trackers". *International Journal of Behavioral Nutrition and Physical Activity* (2015): 159.
7. Johnson-Glenberg MC., *et al*. "Alien Health": A Nutrition Instruction Exergame Using the Kinect Sensor". *Games for Health Journal* 3.4 (2014): 241-251.
8. Granado-Font E., *et al*. "Effectiveness of a Smartphone application and wearable device for weight loss in overweight or obese primary care patients: protocol for a randomised controlled trial". *BMC public health* (2015): 531.
9. Kelly P., *et al*. "Developing a Method to Test the Validity of 24 Hour Time Use Diaries Using Wearable Cameras: A Feasibility Pilot". *PLoS One* 10.12 (2015): e0142198.
10. Shuger SL., *et al*. "Electronic feedback in a diet- and physical activity-based lifestyle intervention for weight loss: a randomized controlled trial". *International Journal of Behavioral Nutrition and Physical Activity* (2011).

11. Ayres EJ., *et al*. "Nutrition informatics competencies across all levels of practice: A national delphi study". *Journal of the Academy of Nutrition and Dietetics* 112.12 (2012): 2042-2053.
12. Popkin BM. "Nutrition, Agriculture and the Global Food System in Low and Middle Income Countries". *Food Policy* 47 (2014): 91-96.
13. Monsivais P and Johnson DB. "Improving nutrition in home child care: are food costs a barrier?" *Public Health Nutrition* 15.2 (2012): 370-376.
14. Tambo E., *et al*. "Digital health implications in health systems in Africa". *European journal of pharmaceutical and medical research* 3.1 (2016): 91-93.
15. Pelletier DL., *et al*. "Expanding the frontiers of population nutrition research: new questions, new methods, and new approaches". *Advances in Nutrition* 4.1 (2013): 92-114.
16. Katzmarzyk PT., *et al*. "An evolving scientific basis for the prevention and treatment of pediatric obesity". *International Journal of Obesity* 38.7 (2014): 887-905.
17. Sylvia LG., *et al*. "A Practical Guide to Measuring Physical Activity". *Journal of the Academy of Nutrition and Dietetics* 114.2 (2014): 199-208.
18. Schaefer SE and Marta Van Loan J. "A Feasibility Study of Wearable Activity Monitors for Pre-Adolescent School-Age Children". *CDC - Preventing Chronic Disease* 11 (2014): E85.
19. Kuriyan R., *et al*. "Innovations in nutrition education and global health: the Bangalore Boston nutrition collaborative". *BMC Medical Education* (2014).
20. Patel S., *et al*. "A review of wearable sensors and systems with application in rehabilitation". *Journal of Neuro Engineering and Rehabilitation* 9 (2012): 21.
21. Doherty AR., *et al*. "Using wearable cameras to categorise type and context of accelerometer-identified episodes of physical activity". *International Journal of Behavioral Nutrition and Physical Activity* 10 (2013): 22.
22. Yilmaz T., *et al*. "Detecting vital signs with wearable wireless sensors". *Sensors* 10.12 (2010): 10837-10862.
23. Stumbo PJ., *et al*. "Web-enabled and improved software tools and data are needed to measure nutrient intakes and physical activity for personalized health research". *Journal of Nutrition* 140.12 (2010): 2104-2115.
24. Keadle SK., *et al*. "Impact of accelerometer data processing decisions on the sample size, wear time and physical activity level of a large cohort study". *BMC Public Health* (2014).
25. Hughes DC., *et al*. "BALANCE (Bioengineering Approaches for Lifestyle Activity and Nutrition Continuous Engagement): Developing New Technology for Monitoring Energy Balance in Real Time". *Journal of Diabetes Science and Technology* 4.2 (2010): 429-434.
26. Davenport A. "Portable and wearable dialysis devices for the treatment of patients with end-stage kidney failure: Wishful thinking or just over the horizon?" Pediatric Nephrology 30.12 (2015): 2053-2060.
27. Tambo E., *et al*. "Can free open access resources strengthen knowledge-based emerging public health priorities, policies and programs in Africa?" *F1000 Research* 5 (2016): 853.