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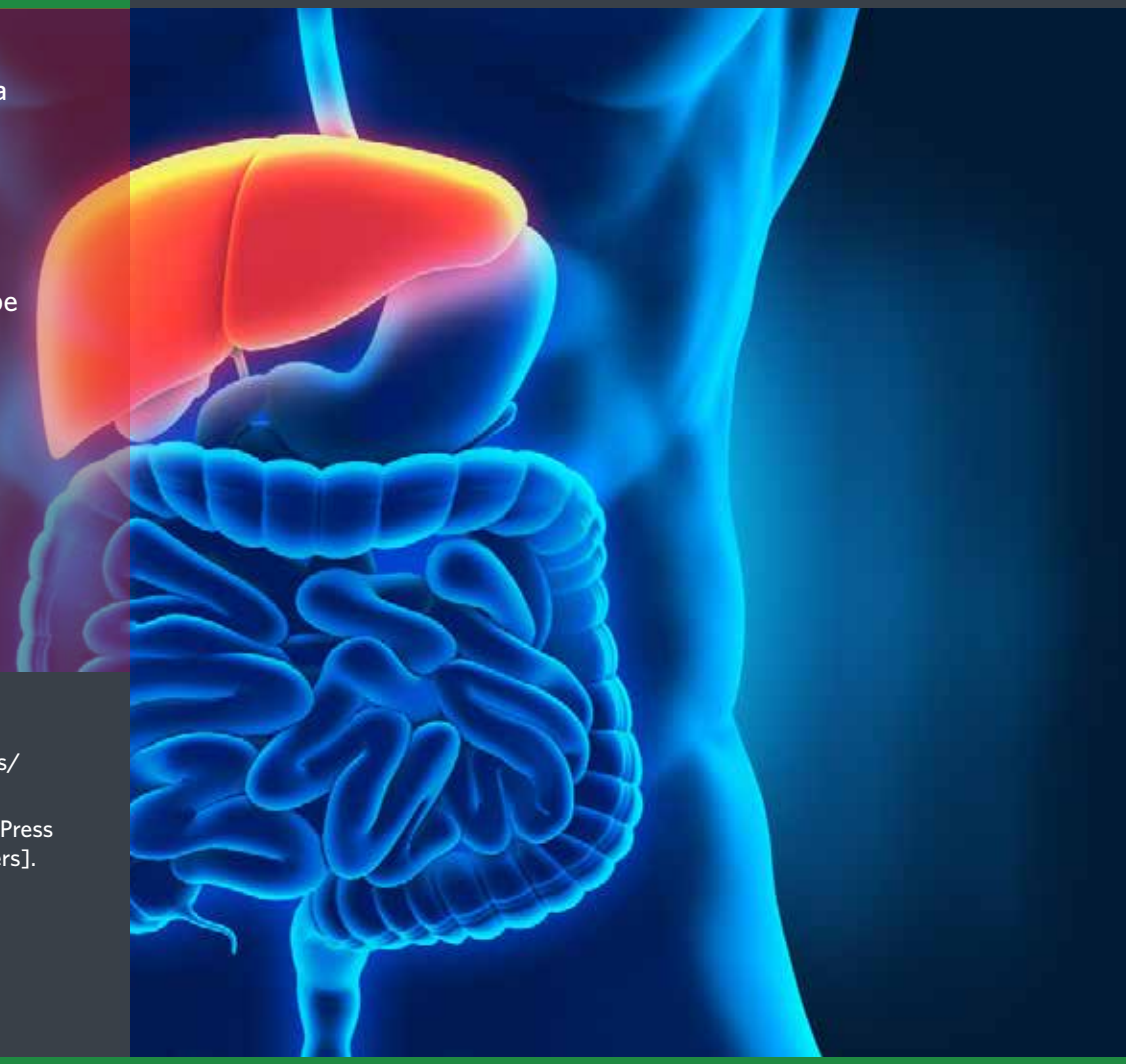

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THE EPIDEMIOLOGY OF LIVER DISEASE AS WE CELEBRATE WORLD LIVER DAY

Editorial

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Exactly a year after the official launch of The Health Press –Zambia (THP– Z) THP-Z extends its heartiest congratulations to the World Health Organisation (WHO) on the occasion of the Organisation's 70th Anniversary for the many meaningful successful years of its existence. Every year on 7th April the WHO takes time to create awareness on issues of international public health concern.

In the last 7 decades, the WHO has made efforts in spearheading eradication or elimination of specific diseases; Small pox is history now, others such as polio, measles, rubella, neonatal tetanus, Eliminate Lymphatic Filariasis are some among many others targeted for either eradication or elimination.

One of the founding principles of the world Health organisation is "The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition." The 2018 theme "Universal health coverage (UHC): everyone, everywhere" stands on this principle. According to the WHO more than half the world's population does not receive the essential health services they need [1].

Some key messages below

According to the organization's Director General Dr Tedros Adhanom Ghebreyesus, WHO is committed to ensuring health for all emphasizing that ""Good health is the most precious thing anyone can have" [2].

Although the WHO Regional Director for Africa Dr Matshidiso Moeti recognizes that Access to treatment and essential services has improved in the region she reiterates the organisations commitment to supporting Member States to achieve UHC and challenges the leadership through the following clarion call:

"Today, I call on African leaders to live up to the SDG pledges they made in 2015, and to commit to concrete actions. WHO will continue to support countries to build stronger, more resilient and responsive health systems through UHC to advance #Health for All" [3].

The WHO Representative in Zambia Dr Nathan Bakyaita in the article submitted to this issue says "At country level, the role of WHO is to support the development of the health system to move towards and sustain UHC, and to monitor progress".

According to the Honourable Minister of Health in Zambia, Honourable Dr Chitalu Chilufya, the highest level of commitment to ensuring UHC in Zambia has been shown through the action by His Excellency the President of the Republic of Zambia Mr. Edgar Chagwa Lungu by signing into law the National Health Insurance Bill.

The Honourable Minister of Health Dr Chitalu Chilufya describes it this way in a statement issued to The Health Press - Zambia

"Act No. 2 of 2018 signed by President Edgar Chagwa Lungu establishes the National Health Insurance Scheme that will ensure that all Zambians have equitable access to quality health care irrespective of their status in society. This is the first time in Zambia since independence that such a progressive Bill has seen the light of day". The Health Press – Zambia

In this issue we look at various perspectives indicating the position of Zambia in UHC issues: 'Universal Health Coverage: A Perspective of the WHO Country Office In Zambia', 'The Solidarity Model: Zambia Public Health Insurance Scheme', and a Press Statement on the National Health Insurance Scheme'. The issue has also published a review on 'Microbial translocation and its clinical significance' and an original article on 'Dental Caries on Permanent Dentition in Primary School Children — Ndola, Zambia, 2017'.

The THP-Z also celebrated along, the World Liver Day which falls on 19th April. Although the 2018 theme is "Riding new waves in liver diagnosis, staging and treatment," the editorial focuses on documenting the baseline information liver disease through a short article owing to the paucity of information titled 'the epidemiology of liver disease as we celebrate World Live Day in 2018.'

The epidemiology of liver disease as we celebrate World Liver Day

Liver disease is a broad term for a variety of liver diseases comprising over 100 types of liver disease. The functions of the liver include the production of protein, blood clotting and metabolism of iron, cholesterol and glucose. The following may affect the functions of the liver: excessive drug use, alcohol abuse, and hepatitis A, B, C, D and E. The common signs and symptoms for liver disease include: nausea, vomiting,

abdominal pain in the right upper quadrant and jaundice. Fatigue, weakness and weight loss may also occur. These signs and symptoms tend to be specific for a particular liver disease until late-stage liver disease (cirrhosis) and liver fails to function [4-6].

Persons with liver disease frequently do not present with signs and symptoms or show obvious signs of liver disease or damage unless over 75% of the liver is damaged. The common liver tests and screening include: history of alcohol abuse, liver function tests (Alanine aminotransferase – ALP, Aspartate aminotransferase – AST, Alkaline phosphatase – ALP, Gamma glutamyl transferase – GCT or Gamma GT, Bilirubin, Albumin, Prothrombin time – PT or International normalized ratio – NR), antibody or antigen tests for hepatitis A, B or C [7].

Zambia is ranked 42nd with a liver disease death rate per 100,000 of 26.02 in the world; and 22nd in Africa. Out of 47 countries in Africa, 43 are among the top 100 countries in the world with highest liver disease death rates [8]. Vaccination at birth for Hepatitis B virus has been shown to reduce the incidence of chronic liver disease [9]. Zambia initiated the Hepatitis B vaccine given through a pentavalent vaccine at week 6, 10 and 14 of age in the childhood vaccination schedule in order to prevent liver disease in the under 5 years age group. It has been estimate that full coverage of three doses of vaccine in sub-Saharan Africa is estimated to be around 67% [10]. With this low coverage, it will take a long time to have an impact on the reduction of the liver disease morbidity and mortality.

Epidemiology of liver disease

Although there is scanty information on the epidemiology of liver disease in sub-Saharan Africa, the burden of the disease in this region has increased by 57% in 20 years. No age, sex, region or race differences have been observed to be associated with chronic liver disease [11].

Conclusion

The first conference on liver disease in Africa will be held on 13-15 September 2018 in Nairobi, Kenya [12]. We hope in this conference that there will be advocacy for making a difference in finding ways to reduce the burden of liver disease in Africa. The increasing trend in morbidity and mortality rates due to liver disease will require the mobilization of resources from governments, non-governmental organizations, cooperating partners and public health experts to curtail these rates. The consoling fact is that the majorities of liver disease are preventable, treatable or even curable [13]. Access to diagnostic testing and treatment would be essential in the fight against liver disease.

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ZAMBIA'S NATIONAL HEALTH INSURANCE SCHEME

PRESS STATEMENT

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Universal Health Coverage (UHC) is a global health policy agenda that has been adopted as one of the health targets of the Sustainable Development Goal (SDG) number 3 which is to 'Ensure healthy lives and promote wellbeing for all at all ages'. And according to the World Health Organization, this health target states that we should "achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all".

Zambia's transformative agenda for inclusive economic growth is premised on successfully 'Enhancing Human Development' , and the health sector contributes to this pillar of the Seventh National Development Plan 2017-2021 (7NDP) through the provision of quality essential health-care services for the entire population.

Zambia recognizes that the path to move towards achieving Universal Health Coverage (UHC) is a smart investment for any country. Consequently, a predictable and sustainable health care financing mechanism is therefore pivotal to the health system reform if UHC has to be attained. To this effect, Zambia has identified that the establishment of a National Health Insurance (NHI) scheme, as one of the health financing strategies, will assist in ensuring a sustainable, predictable and dedicated financing for the health sector whilst at the same time provide financial risk protection for our citizenry.

The Ministry of Health's transformational agenda is meant to change the landscape of how we do business. The stated intent has been the attainment of "equity of access to cost-effective quality health services, as close to the family as possible" . We have gone further to state that this vision must be delivered to all corners of Zambia, hence our commitment to the provision of Universal Health Coverage (UHC), through the continuum of care that encompasses health promotion, prevention of disease, quality curative services, palliative and rehabilitative care cannot be over emphasized.

His Excellency the President of Zambia, Mr. Edgar Chagwa Lungu, attaches great importance to health for all 'without leaving anyone behind' and after a lengthy consultative process which began in the year 2012, and after various studies taken, the National Health Insurance Bill was finally assented to and is now law in Zambia. This law known as National Health Insurance Act 2 of 2018, therefore responds to the various calls and consensus built with key stakeholders.

The National Health Insurance Scheme model that Zambia will establish is based on the following guiding principles of Universality, Social solidarity, Equity, Affordability, Efficiency, Effectiveness and Accountability.

The National Health Insurance Scheme's statement of intent is to cover ALL Zambians regardless of their social, economic or employment status and thereby protecting households from the burden of catastrophic health costs through risk pooling. As a funding modality, the National Health Insurance Scheme will also help in supplementing the traditional tax based and donor funding mechanisms in the health sector by providing additional resources in the health sector.

Let me conclude by empathizing that the success of the National Health Insurance Scheme is dependent the commitment of all the key stakeholders and the ability as a national to together rise up together and focus on ensuring that we have a healthy, productive population and hence a workforce that is key to contributing to the economic landscape of Zambia. By having a nation of healthy and productive people, our goal in the Zambia Vision 2030 of being 'A Prosperous Middle Income Nation by 2030' may become a reality rather than just a slogan.

I thank you.

Honourable Dr Chitalu Chilufya MP
Minister of Health
Republic of Zambia

THE SOLIDARITY MODEL: ZAMBIA PUBLIC HEALTH INSURANCE SCHEME

PERSPECTIVE

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The structure and financing system of health insurance is a key component of a nation's health system. The Solidarity Model of public health financing is a concept widely utilized by many countries to reduce costs and increase efficiency and effectiveness in a nations health sector. Although various countries have different country-fitted health insurance scheme structures, the concept of a Solidarity Based Model of Health Insurance financing can be identified in many of them. By definition, the modern meaning of solidarity in health insurance refers to the equal treatment for all social groups (elderly, low- income, immigrants, disabled etc.) anchored on a contributory based system mandating that all working citizens must join the same contributory health financing fund [1]. Members of these schemes are usually nationals and residents who pay on average between 6-10% of their income to the scheme/fund which is widely accessible to the general population at various levels (different packages). The concept is meant to provide for sustainable health financing through the equitable and fair collection of contributions. The model is intended to expand coverage for vulnerable groups such as the chronically ill and elderly, and although there may be numerous arguments as to whether or not this must be supported is based on the moral fibre of the policy makers and general citizenry.

The goal of an efficient financial system through this model is typically providing adequate resources to promote access of people to healthcare services and personal care. Therefore, people who may be unable to pay for health care would not be denied access to health services or would not be driven to poverty due to high health costs [2]. Essentially, the use of the solidarity model of healthcare financing is an effort to attain universal health coverage for all citizens in a country, which is in support of Sustainable Development Goal (SDG) No. 3: Ensure healthy lives and promote wellbeing for all at all ages. One of the goals within this SDG is to achieve universal health coverage, including financial risk protection, access to quality essential health care services and access to safe, effective, quality and affordable essential medicines and vaccines for all and another related goal is to sustainably increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small islands developing states.

The Solidarity Model of health care financing has recently been utilised by the Government of the Republic of Zambia as they provided for the formulation of the National Social Health Insurance Bill in an effort to improve health care financing which would lead to universal health care for all citizens. Research by the Ministry of Health shows that only 3.9% of Zambians have health insurance cover while the remaining 96% of the population depend on out of pocket payments when accessing health services. The introduction of National Health Insurance will ensure that 100% of the population is covered under the National Insurance Scheme. In an effort to ensure that the Bill is evidence based, Government commenced consultations with various key stakeholders as early as 2012. These engagements were coupled with general consultations, validated by the Zambia Household Health Expenditure and Utilization Survey [3]. Nation-wide consultative meetings and best practice comparative studies were spearheaded by a technical working group to ensure all stakeholders views and concerns about the enactment of the Bill are taken into

consideration. It is important to note that the ZHHEUS revealed that about 96% of the respondents (about 12,000 households) were of the view that the introduction of a Social Health Insurance would be generally beneficial to the general population through improved healthcare financing.

In accordance to the contents of the Health Insurance Bill, its objectives are to;

• Provide for a universal access to quality insured health care services;

• Establish the National Health Insurance Management Authority and provide for its functions and powers which include but are not limited to, implementing, operating and managing the scheme and fund established by the Act

• Establish the National Health Insurance Fund and provide for contributions to and payments from the fund

• Provide for accreditation criteria and conditions in respect of insured healthcare services

• Provide for complaints and appeals processes and

• Provide for the progressive establishment of provincial and district health offices of the authority

Currently the proposals through a collective bargaining process are that a contribution of 2% of income will be made towards the insurance scheme. The employer will contribute 1% of income, while the employee will also contribute 1%. Eventually this insurance scheme will provide for universal health care for all which is in line with Government's intention through the implementation of the Seventh National Development Plan (2017- 2021) to not leave anyone behind. The Bill will also result in a productive population to further support Government's overall national development agenda by ensuring the general working population is healthy enough to work towards the attainment of the Vision 2030 of becoming a prosperous middle-income country by the year 2030.

In conclusion, the morality of formulating and implementing the National Health Insurance Bill is a question of whether or not the general working population can embrace the pro- poor approach to which the solidarity model was utilised to formulate the Bill.

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UNIVERSAL HEALTH COVERAGE: A PERSPECTIVE OF THE WHO COUNTRY OFFICE IN ZAMBIA

PERSPECTIVE

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This paper provides a perspective of the WHO Country Office on Universal Health Coverage following the commemoration of the World Health Day 2018 on 7 April under the theme "Universal Health Coverage: Everyone, Everywhere" and the slogan "Health For all". The World Health Day theme put a spotlight on the significance of Universal Health Coverage in health system strengthening and its importance in achieving health for and its importance to the 2030 sustainable development agenda. It argues that UHC is technically feasible and attainable. It highlights the how Zambia has integrated UHC in its health development agenda, success so far, challenges and how it can accelerate actions to move towards UHC using the existing international and regional frameworks. The role of WHO in supporting the country in moving towards UHC including monitoring progress is illustrated.

Introduction

To mark its 70th anniversary on World Health Day, The World Health Organization selected the theme "Universal Health Coverage: Everyone, everywhere" and the slogan: "Health for All". Universal Health Coverage (UHC) means that "all individuals and communities receive the health services they need without suffering financial hardship. It includes the full spectrum of essential, quality health services, from health promotion to prevention, treatment, rehabilitation, and palliative care" . The WHO Director General, Dr. Tedros Adhanom Ghebreyesus simply illustrated UHC when he said "No one should have to choose between death and financial hardship. No one should have to choose between buying medicine and buying food." UHC is firmly based on the 1948 WHO Constitution , which declares health a fundamental human right and commits to ensuring the highest attainable level of health for all. "Health for All" has therefore been WHO's guiding vision for more than seven decades.

According to the 2017 global monitoring report for tracking Universal Health Coverage released by the World Bank and WHO, at least half of the world's population still does not have full coverage of essential health services. The World Bank also states that in the WHO African Region, there are wide disparities in UHC within countries while coverage gaps remain large for many critical services such as access to HIV, TB and malaria. In addition, financial protection is generally low and patients pay for health services from their own household income, so-called out-of-pocket (OOP) expenditure. Universal Health Coverage is therefore aimed at protecting people against the impoverishing effect of health payments. So in this 70th anniversary year, WHO is calling on world leaders to live up to the pledges they made when they agreed the Sustainable Development Goals in 2015, and commit to concrete steps to advance the health of all people.

The 2017 Tokyo Declaration at the Universal Health Coverage forum calls for greater global commitment to accelerate progress towards UHC by 2030. In the interim, by 2023, the world should have extended essential health coverage to 1 billion additional people and halve to 50 million the number of people being pushed into extreme poverty by health expenses. Countries are therefore urged to develop their own roadmaps towards UHC, with clear targets and indicators. They are also called upon to use country-led, multi-stakeholder coordination platforms in line with the UHC 2030 global compact principles. Equally, the Call to Action made at the African Health Forum in 2017, recognises that the sustainable development agenda requires health systems strengthening and calls upon countries to keep UHC as the overarching approach for attaining SDG3.

Why UHC Matters

Many countries in Africa continue to grapple with high levels of child and maternal mortality, communicable and non-communicable diseases. Health systems are also not able to deal effectively with epidemics and the growing burden of chronic diseases, such as cancer and diabetes. These challenges call for renewed commitments and accelerated progress toward Universal Health Coverage (UHC). Zambia faces a high burden of communicable and non-communicable diseases. In addition, structural and social deprivation including poverty, inequalities and marginalization remain major threats to health. By investing in UHC, Zambia can make a sound investment in human capital. According to the World Bank "Countries that achieve their UHC targets by 2030 will eliminate preventable maternal and child deaths, strengthen resilience to public health emergencies, reduce financial

hardship linked to illness, and strengthen the foundations for long-term economic growth". Progress towards Universal Health Coverage (UHC) is also critical to promote equity, basic rights, and human security in health and can lead to significant economic gains. In addition, strong health and disease surveillance systems have the ability of preventing and absorbing shocks of epidemics that can cause unnecessary deaths and disrupt society.

It is worth to note that the Seventh National Development Plan has prioritised health as a key economic investment and emphasizes that the successful attainment of Zambia's goal of being a prosperous, middle-income country by 2030 as stipulated in its Vision 2030 is dependent upon having a healthy and productive population. The Ministry of Health is therefore committed to the provision of equitable access to cost effective, quality health services as close to the family as possible.

UHC and its significance to the 2030 SDGs Agenda

The importance of health in achieving international development goals and moving towards universal health coverage has been recognised by the United Nations even before the sustainable development goals were agreed in 2015. Globally, health is known to be at the centre of the Sustainable Development Goals (SDGs) because it is a cross cutting issue with direct and indirect links with other goals and targets. Goal 3 relates to the direct actions that influence health, while SDGs such as poverty, nutrition, education, gender, water and sanitation, inequality affect the achievement of health targets. All UN Member States have agreed to try to achieve Universal Health Coverage (UHC) by 2030, as part of the Sustainable Development Goals.

One of the targets under the sustainable development goal no. 3: ("ensuring healthy lives and promote well-being for all at all ages") is to "achieve universal health coverage, including financial risk protection, access to quality essential health care services and access to safe, effective, quality and affordable essential medicines and vaccines for all." Since UHC is the overarching target that should facilitate achievement of all the other health targets in SDG 3, it is in line with the key message of the SDGs of "Leaving No One Behind". UHC also lays emphasis on addressing the needs of the most vulnerable groups in society particularly women and children, the older persons, refugees and other minority populations. Without UHC, many people would not have the opportunity to live full and productive lives, and risk impoverishment in their pursuit of health care.

How can Zambia move towards UHC?

It is a known fact that Universal Health Coverage is achieved when political will is strong, and that it also requires a clear strategic vision. Zambia has already integrated Universal Health Coverage as a goal in its national health strategies and is committed to the attainment of the SDG goals. The National Health Strategic Plan 2017-2021 clearly states the mission of the Ministry of Health as that of providing the population with equitable access to cost effective, quality health services as close to the family as possible. To achieve this, significant investments are being made in improving health service delivery, human resources for health, infrastructure development, health care financing and health information. The Social Health Insurance Scheme is also regarded as a major priority which will increase the resource envelope for health and enhance UHC in the country.

The country has seen improvement in the coverage of life saving interventions and improved health status. For example, the ZDHS shows that HIV prevalence declined from 14% in 2007 to 13.3% in 2013-2014, maternal mortality reduced from 591 deaths per 100,000 live births in 2007 to 398 deaths in 2013-2014 the child mortality rate dropped from 197 deaths per 1,000 live births in 1996 to 75 per 1,000 live births in 2013-14. Improvements in child health have been achieved on account of improved immunization coverage, exclusive breast-feeding, vitamin and mineral supplementation, and malaria prevention and treatment and prevention of mother-to-child transmission of HIV. The reduction in maternal deaths is a result of improved family planning services, improved referral systems, provision of and access to emergency obstetric care, increase in trained midwives and birth attendants and voluntary HIV counselling and testing.

Despite the improvements in coverage of health services, gaps remain which require acceleration of efforts towards UHC. Like many other African countries, financial protection in Zambia is still low requiring most patients to pay for health services from their own household income, so-called out-of-pocket (OOP) payments. The WHO Regional Office for Africa has developed a framework for strengthening health systems for UHC and the SDGs while leaving no one behind . The framework provides guidance on how Member States' can re-align their health systems in a manner that facilitates movement towards UHC and attainment of their sustainable development aspirations. It has recommended six outcome areas which include: availability of essential services; coverage of essential services; health security financial risk protection, client satisfaction and coverage with interventions from SDGs. This framework builds upon the 2016 Tokyo International Conference on African Development (TICARD-VI) framework for action which set financing, governance, services, preparedness and equity as key action areas for UHC in Africa.

Accelerating the move towards universal health coverage in the country will therefore require strengthening the efficiency of

the health system in providing the entire population with access to good quality services. WHO emphasizes UHC is not only what services are covered, but also how they are funded, managed, and delivered and recommends a fundamental shift in service delivery such that services are integrated and focused on the needs of people and communities. The transformative agenda being undertaken by the Ministry of Health focusing on Primary Health Care (PHC) and health promotion is a timely development which will enhance health and equity.

The role of WHO in supporting Zambia to move towards UHC

At country level, the role of WHO is to support the development of the health system to move towards and sustain UHC, and to monitor progress. WHO has continued to work with other partners in supporting the implementation of the National Health Strategic Plan in order to contribute to the attainment of the national goal of "improving the health status of people in order to contribute to increased productivity and socio-economic development". The WHO Country Cooperation Strategy (CCS) which is the key instrument guiding the WHO Country Office's support to the country shows that during the period 2017-2021, WHO will focus its efforts in Zambia on five broad strategic agendas one of which is "achieving and sustaining Universal Health Coverage (UHC) through a revitalized Primary Health Care (PHC) approach and sustainable service delivery through strengthening of health systems".

The focus of WHO is also to strengthen actions aimed at accelerating actions towards the attainment of the targets of the Sustainable Development Goal number 3 on health. The CCS is therefore aligned with the NHSP and has prioritized the reduction of Maternal, Newborn, Child and Adolescent mortality; improving sexual and reproductive health; reducing further the burden of AIDS, tuberculosis, malaria, neglected tropical diseases, hepatitis, and other communicable diseases. Other priorities include: strengthening and re-orienting health and health-related systems to address the prevention and control of NCDs, including disabilities, injuries and mental health disorders, and the underlying social determinants; and strengthening preparedness, integrated disease surveillance and effective response to public health events/emergencies.

WHO is also working in collaboration with the European Union-Luxembourg-WHO Partnership for UHC to strengthen efforts aimed at moving UHC. With support from DFID, WHO is supporting the implementation of a programme on Emergency Preparedness and Control aimed at strengthening national capacities for responding to outbreaks and health emergencies. It is also working in collaboration with the Ministry of Health through the National Public Health Institute (ZNPHI) to strengthen the core capacities for implementing the International Health Regulations 2005.

Monitoring progress towards UHC

Together with the World Bank, WHO has developed the Global Monitoring Framework to track the progress of UHC. The framework monitors the proportion of a population that can access essential quality health services and the proportion of the population that spends a large amount of household income on health using a uniform measurement methodology for UHC indicators. It also takes into account both the overall level and the extent to which UHC is equitable, service coverage including financial protection the population, such as the poor or those living in remote rural areas. WHO uses 4 categories as indicators of the level and equity of coverage in countries: Reproductive, maternal, newborn and child health: infectious diseases: Non-communicable diseases and service capacity and access.

The monitoring system also emphasizes the importance of strengthening the breadth and depth of data at the national and subnational levels, including disaggregated data, to inform evidence based policymaking and to assess progress, as well as strengthening the capacity of local stakeholders to analyse and use data. At regional level, the WHO Regional Office for Africa has also set the overall targets that, by 2030 at least 80% of Member States will have health systems that are performing optimally for effective delivery of essential package of health and related services. In the interim, by 2021 50% of all Member States will show evidence of improving population coverage of agreed standards and assessments. By 2025 80% of Member States will show evidence improving population coverage of agreed standards and assessments.

Conclusion

The theme of the World Health Day 2018 has put a spotlight on the need for renewed commitment to accelerate the efforts for moving towards Universal Health Coverage and the attainment of the Sustainable Development Goals. Although countries have made progress in improving coverage for life saving interventions, significant gaps still exist and many people still suffer financial cost. The call made to countries at the Tokyo Declaration in 2017 to accelerate progress towards UHC by making specific plans with indicators was timely. Using the existing implementation frameworks for UHC and the Global UHC monitoring framework by WHO and the World Bank, many countries can make a difference in improving health and equity. Moving towards UHC will involve ensuring adequate health care budgets, financial protection mechanisms, human resources, information systems, health infrastructure and health technologies and adequate stocks of essential drugs. WHO therefore remains committed to continue working with other partners in supporting efforts aimed at bringing quality healthcare services to the population in an equitable manner and to support monitoring of UHC. Universal Health Coverage is both technically and financially feasible and is the best investment for a safer, fairer and healthier world for everyone.

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MICROBIAL TRANSLOCATION AND ITS CLINICAL SIGNIFICANCE

RESEARCH ARTICLE

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The literature was searched in PubMed Medline National Library of Medicine from 1990 to 2016 were used. The following words were used: 'microbial translocation' and 'clinical significance,' or 'biomarkers,' or 'toll-like receptor,' or 'pathogen-associated molecular pattern.' We found 3,300 published manuscripts using the above search. Of 3,300 manuscripts, we dropped 2087 and 723 manuscripts either they did not suit this review or were not in English; 490 manuscripts were selected for this review. From the literature, there is evidence that microbial translocation occurs in both animals and humans, but unlike in animals, its clinical significance remains questionable in humans. This could partly be explained by the current lack of a single acceptable sensitive and accurate biomarker to detect microbial translocation. Additionally, the extent to which microbial translocation in animals can be demonstrated cannot apply to humans for the sake of research without an underlying disease. In humans microbial translocation is associated with many conditions and microbial products may lead to systemic inflammation and immune activation. Although some of the microbial products or Pathogen-Associated Molecular Patterns (PAMPs) have been studied, their clinical importance is not well established, and the assays developed to measure PAMPs in blood have not been developed or validated for clinical use. However, a few molecules of microbial origin have been used as biomarkers of microbial translocation in many disease conditions. The innate immune system detects all PAMPs through cells such as macrophages, dendritic cells, and monocytes. Detection of PAMPs through pathogen recognition receptors such as Toll-like receptors which result in the activation of the transcription factors, NK-κB, resulting in the production of pro-inflammatory cytokines. We provide a synthesis of the current understanding of the nature of microbial translocation, PAMP-receptor interaction and the health significance of microbial translocation in humans.

Introduction

The human intestinal epithelial layer is one cell thick and plays two major roles. It absorbs the much needed nutrients and water for the host and excludes bacteria, antigens, and other non-self substances from crossing the intestinal barrier into sterile sites. The human gut contains a variety of bacteria species mainly the non-pathogenic ones as part of its normal microbial flora. Under normal circumstances, an individual's gut microbiome contains around 105 colony forming units (CFU)/ml of non-pathogenic bacteria in the jejunum, around 108 CFU/ml in the distal ileum and cecum and up to 1012 CFU/ml in the colon [1]. Examples of insignificant intestinal bacteria include members that belong to Actinobacteria and Proteobacteria while the majority of intestinal bacteria are members of phylogenetic lineages, Firmicutes and Bacteroidetes [2]. It has been estimated that up to 1,000 microbial species belonging to Firmicutes or Bacteroidetes species are uncultivable [3] which makes difficult to identify them by routine laboratory methods. To date, the exact relationship between human gut and microbiota has not been fully elucidated. Even less research has been conducted to understand the immune response to gut microbiota in humans.

When the bacteria count in the upper jejunal aspirate is greater than 105 CFU/ml or if the presence of colonic bacteria is detected, the condition is referred to as small intestinal bacterial overgrowth (SIBO) [4]. In such cases, aerobes tend to be fewer than anaerobes in the ratio of about 1:100 [5]. Intriguingly, it is the Gram-negative bacteria of the less abundant of the two groups of bacteria that are mainly involved in microbial translocation (MT) even across normal histological intestinal epithelium [6]. Here, we discuss MT, the underlying mechanism, and some associated conditions and its clinical significan**ce.**

Exclusion of microorganisms by mucosal barrier

The intestinal mucosa is mainly composed of muscularis mucosae, lamina propria and epithelium [7]. It is monitored by immune cells mainly of the innate immune system such as dendritic cells, mast cells, and macrophages together with the lymphoid system. In health, the anatomical structure of the intestinal surface is covered by

mucins secreted by goblet cells and gastric mucus which forms a gel-forming barrier. These exclude external elements and the majority of bacteria from direct contact with cells of mucosal layer. The mucosal layer components consist of water, electrolytes, phospholipids, proteins, and phospholipids [8]. Also, the ability of the microbes to cross the barrier is hampered by antimicrobial agents such as the defensins HD5 and HD6, as well as a large amount of IgA [8]. The epithelial layer is composed of many other cells and biological molecules. These include enterocytes involved in absorption and hormone production. They do not live for a longer time and are regularly replaced within few days. Also, paneth cells are also found in the crypts. These are involved in the production of growth hormones, digestive enzymes and defensins [9]. The gut barrier is also composed of a gastric barrier acid which kills many ingested bacterial and viral pathogens. The epithelial layer also possesses two essential components; the villi and the crypt, which are significant in the absorption of nutrients, secretion of fluids containing electrolytes and serve some immune functions [10, 11]. The villi are finger-like protrusions that increase the surface area for absorption and the crypt are at the bottom of villi and secrete essential fluids containing antimicrobial peptides. Altogether these different elements form an intestinal mucosa with a barrier, immune and absorptive functions [12].

The enterocytes are joined to the adjacent cell by a complex of tight junction proteins which are composed of claudin proteins and play a significant role in the selective regulation of ionic solutes passing through the cell. In case the intestinal barrier is compromised resulting in marked loss of barrier function, microbes or their products cross the barrier through the paracellular pathway [13]. The paracellular pathway is more permeable than the transcellular pathway which involves passive passage of substances through the space between adjacent cells. The transcellular pathway involves the action of specific channels, which move materials passively or actively across cell membranes [10]. Evidence suggests that these two routes are possibly controlled autonomously [14, 15]. The paracellular route is referred to as the leaky pathway because it allows bigger particles to transverse through such as microbial components which are unable to cross through the cells. Tight junction proteins include the family of 18 claudins, which play a significant role in the determination of pole charge. Other proteins which play important roles in the epithelial barrier function include desmosomes and adherens which form junctions joined to the actin cytoskeleton [10, 16]. Some in-vivo and in-vitro studies have demonstrated that lipopolysaccharide (LPS) and tumor necrosis factor-α (TNF-α) increase permeability of the gut thereby exacerbating the microbial translocation

Assessment of intestinal integrity

It is important to assess the integrity of the intestinal barrier which can be achieved by staining the intestinal biopsy with hematoxylin and eosin (H&E) and reveal any alterations of the mucosa [18]. This is of particular importance in that the composition and integrity of tight junction proteins such as occludins and claudins, as well as zonula occludens, can be analyzed [19]. These proteins can also be studied in detail by immunofluorescence staining technique using specific antibodies that bind specifically to the proteins under investigation [20]. Some tight junction proteins such as claudin 4 have also been evaluated using Western blotting [18] or by quantitative polymerse chain reaction (qPCR). There are many more proteins also involved in maintaining the integrity of the tight junctions and because of the complexity of their interactions in-vivo it may not be possible to single out the single most important protein involved in the maintenance of barrier integrity. One of the most promising developments in understanding the histology of the mucosa in-vivo is the use of confocal laser endomicroscopy, which is capable of revealing small gap within the epithelial layer and has already been used in individuals with environmental enteropathy .

Clinical significance of microbial translocation

There is overwhelming literature on experimental studies that have demonstrated that MT occurs in animal models under various conditions. These include environmental enteropathy (EE) [21], colitis [22], liver cirrhosis [6], small bowel obstruction and ischemia in vivo [23], hemorrhagic shock [24], trauma [25] as well as due to abuse of opiates such as morphine [26]and acute pancreatitis [27]. However, in humans, the clinical significance of MT remains to be elucidated, and some conditions where some studies have been done are discussed here.

Microbial translocation in environmental enteropathy

It has been suspected for a long time that people living in areas of poor sanitation and hygiene especially those common in tropical countries, are affected by a widespread phenomenon of asymptomatic abnormal structural and functional changes of the small intestine referred to as EE [28]. No single specific agent is responsible for EE, but it is hypothesized due to repeated exposure to fecal-oral contamination. It is associated with some factors including reduced responses to oral vaccines [29, 30], micronutrient deficiencies, growth failure and stunting in children [31] and MT [18, 32]. This subclinical condition is characterized by loss of intestinal barrier function, chronic intestinal inflammation,

microbial translocation and chronic immune activation [28, 33, 34]. Due to compromised gut barrier, microbes and their products translocate from the gut into systemic circulation resulting in immune activation. Chronic immune activation may lead to microcirculatory dysfunction, intravascular coagulation and hemodynamic disturbances leading to hypotension, metabolic derangements septic shock and death [25].

Association between fetal deaths and socio-economic and demographic variables

The chi-square results in table 1 with a p-value less than 0.05 at 95% confidence interval (CI) indicate that there was a statistically significant relationship between each of the following independent variables and the dependent variable (fetal deaths); age of mother, years lived in a place of residence, children ever born, number of living children, marital status, fertility preference, person who makes decisions on the mothers health care. The percentage of women with fetal deaths increased with increasing age; more women in rural areas (5.5%) had fetal deaths compared to urban women (5.1%); 8.3% of women who lived in a place of residence less than a year had a fetal death; women with a higher education had a fetal death (6%); the percentage of fetal deaths reduced with increase in the number of children ever born and the number of children alive; 5.8% of fetal deaths were among women in a union; 6.5% of fetal deaths were among women who were undecided about fertility preference (undecided about having another child); and 11.4% of fetal deaths occurred to women's whose health care was determined by someone else. However, women's socio-economic characteristics such as; region, education status, religion and wealth index were not significantly associated with fetal deaths.

Microbial translocation in HIV infection

HIV is known to infect the lymphocytes and macrophages of the intestinal mucosa [3]. In severely immunosuppressed people with HIV infection, particularly those with full-blown AIDS, chronic diarrhea, and weight loss are common [37]. In such individuals, the gut appearance at the microscopic level is comparable to that of EE in particular in the late stage of the disease [35]. The intestinal epithelium may be damaged by HIV allowing the pathogens within the gut to cause more damage to the gut due to host immune suppression culminating into enteropathy which may promote HIV disease [38]. Some in-vitro experiments have reported that the HIV glycoprotein gp120 interrupts the tight junction proteins [39] and also the actin cytoskeleton and microtubules are modified by the HIV transactivator factor Tat resulting in apoptosis, although HIV does not infect enterocytes, the mechanism is unclear. The suggested effects on the gut mucosa in HIV patients including paracellular permeability has been demonstrated by using immunohistochemistry techniques [40]. Taken together, these increase the chances of microorganisms in the gut to move across the intestinal barrier.

Microbial translocation in Patients with Cirrhosis

MT has been reported to occur in about 30% in patients with cirrhosis [41] and has been demonstrated to be even as high as 78% in mouse models. Bellot [40] and others showed that 16S rRNA, a biomarker of bacterial translocation, was elevated in patients with cirrhosis. This has been used as a biomarker of MT by others but with no correlation with the severity of cirrhosis. Another study demonstrated that cirrhotic patients had elevated lipopolysaccharide-binding protein (LBP) compared with healthy controls and concluded that there was a possible involvement of bacteria and their products. The conditions were improved by antibiotics [42]. Others have demonstrated MT from the positive bacteriological culture from surgical removal of mesenteric lymph nodes (MLNs) in animal models [43]. The pathogenesis of MT in cirrhosis may manifest in different ways, but the most suggested include small intestinal bacterial overgrowth (SIBO) which most investigator define as 105 CFU/ml of proximal jejunal aspirate [44]. However, the main challenge for diagnosis of SIBO procedure using proximal jejunal aspirate is the invasiveness of the procedure. For this reason, the non-invasive method of the hydrogen and methane breath tests after an oral dose of glucose or lactulose are preferred [45]. MT was only present is about 50% of cirrhotic with SIBO mice suggesting that other factors apart from SIBO were responsible for MT in mice. Some investigators have reported structural and functional alterations in cirrhosis which predisposes mice to microbial translocation [46]. The general immunological impairment of the intestinal immune system has been shown to promote MT in cirrhosis. Taken together, these results may partly explain why MT in patients with cirrhosis is common.

Microbial translocation in Inflammatory Bowel Diseases

Although the exact cause of inflammatory bowel diseases (IBDs) such as Crohn's disease (CD) and ulcerative colitis (UC) is still elusive, it is hypothesized that some individuals are genetically predisposed to have the diseases especially those with abnormal immune response to intestinal microbiota [47]. Studies have shown that patients with CD and UC have higher levels of plasma and tissue 16S rRNA compared with healthy controls suggesting MT [48]. The levels of 16S rRNA are also higher in patients with active disease than in those with the inactive disease but no difference regarding transcription factor, Nucleotide-binding oligomerization domain-containing protein 2 (NOD2), which plays a key role in the regulation of the response. The 16S rRNA levels and the NOD2 transcription factor have reported not to be associated with MT [49]. On the contrary, different studies showed that 16S rRNA in the serum of IBD patients was related to NOD2. The results were further supported by elevated levels of pro-inflammatory cytokines [50, 51]. Some studies have reported on the

type of bacteria phylum that is implicated in IBDs. Some studies have demonstrated that Bacteroidetes species are more commonly found in intestinal biopsies of CD patients compared with those with irritable bowel syndrome or healthy controls. The studies have noted that significant increase in both CD and UC whether active or inactive compared with healthy controls may be linked to some factors including smoking, diet, and biopsy or stool sample. Variations in the activity of the disease may be explained by other factors including sample size [52, 53].

Other conditions in which microbial translocation is of clinicalsignificance

In industrialized countries, one of the causes of liver disease is the non-alcoholic fatty liver disease (NAFLD). This mostly happens when there are insulin resistance and obesity compounded with steatohepatitis which may originate from simple steatosis. Some studies have reported that obesity is associated with alteration in the gut microbiota [54] and increased intestinal permeability which may lead to MT [55, 56]. In one study [52], 94 neonates and infants who required parenteral nutrition due to gastrointestinal abnormalities successfully underwent surgical procedures. They were followed up for the development of septicemia due to MT in association with parenteral nutrition. Blood samples were cultured to diagnose MT samples from 15 patients were found to be positive for the condition with almost half of them associated with sepsis [57]. In 50 pediatric patients, who were immunosuppressed and were about to undergo small bowel transplant, the correlation between MT and acute rejection or preservation injury was evaluated. A positive culture from blood or liver biopsy was considered evidence of MT. In some cases, MT was associated with colon allograft, ischemia and acute rejection [58]. In monitoring postoperative sepsis in patients after undergoing laparotomy, patients were divided into those who had a positive bacterial culture in MLN and those who were negative. After a comparison had been made, patients who had a positive culture (MT) had more sepsis compared with those with negative culture (42.3% versus 19.9%) respectively [59]. In another study, at the time patients were undergoing general surgery, intestinal serosa and MLN samples were taken and cultured, and only 10% had MT with the occurrence of postoperative sepsis being two times more than in patients with MT but with similar mortality rate [60].

The diagnosis of MT by positive culture of a sample taken from MLN which is considered to a direct measure of MT by most investigators has several limitations. First, to get such a sample, surgery is needed. This is an invasive procedure which in itself would be too much in humans, unlike in animal model just to study MT only especially with its clinical significance in most conditions still unclear. Second, not all bacteria are cultivatable and so do not mean that negative growth the MLNs are free of bacteria. Third, culture is not very sensitive because a certain number of bacteria need to be present to get a positive result compared with methods like PCR. Fourth, even if samples of MLNs were to be obtained, it is not practical to get samples from all MLNs because if certain MLNs are found to be negative, it may not necessarily mean all MLNs do have bacteria. Fifth, some bacteria may be present in the non-viable state, and so they cannot grow on culture medium [61].

Is there a best specific biomarker of Microbial translocation?

The diagnosis of MT in humans, several optional methods have been proposed and tested with varying successes and limitations. These methods are based on various types of PAMPs including LPS, lipoteichoic acid, peptidoglycan (PDG) layer components and flagellin and their interactions with cell receptors. LPS a component of the Gram-negative bacteria have been detected in the plasma of humans with EE [18, 32], HSS [35] cirrhosis and HIV enteropathy [62] as a direct biomarker of MT since it's of bacterial origin. Other investigators have considered LPS as a surrogate biomarker of MT because of its short half life (2 – 3 hours) typically affected by some factors such as antibodies, immunogenetic and physiological variables [63]. In some conditions, detection of 16S rRNA in plasma of both human and animals has been used as a direct biomarker of MT. Real-time PCR does the detection and quantification. Studies have reported higher 16S rRNA copy number in HIV infected individuals compared with HIV negative individuals [62, 64, 65] while others found infected treatment naïve individuals had higher copy number compared with infected individuals who were on treatment. Others have also reported the presence of 16S rRNA in healthy individuals [66, 67] probably confirming what others have indicated that even in healthy individuals with intact epithelial barrier translocation takes place.

Peptidoglycan (PDG) layer is a component of both the Gram-positive and Gram-negative bacteria which is detected by Toll-like receptor 2 (TLR2) [68]. It makes about two-thirds of the Gram-positive bacteria cell wall and one-fifth of the Gram-negative cell wall. It has been detected in human plasma using silkworm larvae test. Although initial experiments were not in humans, its later use in some patients during the postoperative period of gastrointestinal surgery [69] revealed its potential for application in humans. The PDG was found to be higher in more than three-quarters of patients with severe bacterial infection [70]. Conversely, its use as a universal biomarker of microbial translocation has been difficult, and it is limited to surgical institutions. Flagellin is a subunit component of flagella present in motile bacteria [71], and an ELISA assay has been developed capable of detecting the protein. One of its first uses was in patients with short bowel syndrome who had either endotoxemia or without and in these patients marked increase in serum IgM, IgA, and IgG levels specific to flagellin were observed [72]. In patients

Table 1: Different PAMPs hypothesized to be involved in microbial translocation

PAMP	Origin	TLR	PAMP location	Adaptor protein	References
Lipopeptides	GPB	TLR1	Cell surface	MyD88	[79]
Peptidoglycan	GPB/GNB	TLR2	Cell surface	MyD88, Tram	
Double-stranded RNA					[82]
	GPB	TLR3	Endosome	TRIF	[81,82]
Flagellin	GPB/GNB	TLR4	Cell surface	MyD88	
Lipoteichoicacid, lipopeptides				TIRAP (Mal)	[83,84]
Single stranded RNA	RNA viruses	TLR5	Cell surface	MyD88	[85]
Single stranded RNA	GNB	TLR6	Cell surface	MyD88	
Unmethylated CpG- DNA /16S rRNA					[79]
Lipoteichoicacid, lipopeptides	GNB	TLR7	Endosome	MyD88	[85]
[79]	GPB/GNB	TLR8	Endosome	MyD88	[85]
Single stranded RNA	RNA viruses	TLR9	Endosome	MyD88	
Single stranded RNA					[84]
Unmethylated CpG- DNA /16S rRNA					

PAMP, Pathogen-Associated Molecular Pattern; GPB, Gram positive bacteria; GNB, Gram negative bacteria; TLR, toll-like receptor; MyD88, Myeloid differentiation primary response gene 88; TRAM, Toll- interleukin 1 receptor-domain-containing adapter-inducing interferon-β; TIRAP, Toll–interleukin 1 receptor domain–containing adapter protein; TRIF, Toll- interleukin 1 receptor -domain-containing adapter-inducing interferon-β

with CD, other investigators have reported presence of flagellin specific to Escherichia coli [73, 74] which was associated with compromised gut barrier. In the treatment of patients with HIV infection, anti-flagellin antibodies were used as biomarker of MT [75]. The use of this PAMP has been very narrow, and this warrants more studies to investigate its viability as a biomarker of MT in different diseases.

Lipoteichoic acid (LTA) is another PAMP that has been proposed as a diagnostic biomarker for MT. This is an equivalent of LPS in the Gram-negative bacteria, and it is shed during Gram-positive bacteria replication. It has been shown to induce the production of cytokines that are different from the ones observed when LPS stimulate transcription factors. If bacteria in the culture medium are exposed to antibiotics, LTA is secreted, and in human, its titers are reported to be higher in patients with chronic hepatitis C compared with healthy individuals [76]. Other studies have demonstrated that in patients with primary biliary cholangitis, LTA containing mononuclear cells were found in histological sections [77].

Other Biomarkers of Microbial Translocation

Indirect (surrogate) biomarkers are cellular biological molecules produced as a result of host immune response to MT. Biomarkers that have been reported to correlate with MT include sCD14 [31], LBP [35], intestinal-fatty acid binding protein [31, 78, 79] and EndoCab [79]. Other investigators have argued that sCD14 is not a biomarker of MT per se but rather a biomarker of monocyte activation but correlates well with LPS [80]. Another potential measure of direct biomarkers of MT is the use of plasma which stimulates a reporter cell line such as RAW-Blue mouse macrophages to express TLRs capable of detecting total PAMPs readout which are of microbial origin (Patrick Kaonga unpublished data). The total PAMPs activity can be measured by using detection reagent, QUANTI-Blue by spectrophotometer.

How immune system detects microbes and microbial products

After microbes and their components cross the intestinal barrier, innate immune system composed of unspecialized cells detect all non-self components from pathogen referred to as PAMPs through pathogen recognition receptors (PRRs) such as TLRs. TLR are germ-line encoded conserved receptors that are either expressed on the surface or endosomal that recognize various PAMPs [81]. PAMPs are essential for microbial survival and indispensable for microbial survival and fitness. Loss of patterns or even mutation can mean loss of life, so they have low major mutation rates. Second, they are not produced by host cells. Instead, they are produced by microorganisms, and this allows innate immunity to distinguish between non-self and self. Third, between microorganisms of a given class, PAMPs are invariant, meaning that not a lot of encoded PRRs are needed for microbial infection presence to be detected [82]. In humans, there are nine TLRs that have been described recognizing to interact with different PAMPs.

The main ligand for TLR1 is lipopeptide and for TLR6 are lipoteichoic acid and lipopeptides [81]. When these ligands are detected, they lead to secretion of pro-inflammatory cytokines by cells of the innate immune system including interferon-alpha (IFN-α), tumor necrosis factor-alpha (TNF-α) and interleukin-1-beta (IL-1β). Selected examples of PAMP-ligand interactions that have been studied are summarized (Table 1). TLR2 recognizes lipoteichoic acid and peptidoglycan which are major components of Gram-positive bacteria while TLR3 is only known to detect dsRNA [83, 84]. When LPS activates TLR4, its act together with membrane CD14 and Myeloid differentiation factor 2 (MD-2) proteins as co-receptors in recognition of LPS [85, 86]. Following recognition of these PAMPs, pro-inflammatory cytokines are produced which could worsen the inflammatory process and disease condition. Other receptors TLR5 recognize flagellin, TLR7 and TLR8 single stranded viral RNA in endosomal or lysosomal compartments [87] and TLR9 unmethylated CpG-DNA [86]. The feature of PAMPs detection by TLRs is followed by activation of transcription factor, NF-κB, leading to the production of pro-inflammatory cytokines.

Conclusions

From the literature reviewed, it is evident that MT in humans makes a significant contribution to several disease states, but its clinical significance is under studied. This is bound to change as more biomarkers become available. It is also likely to become possible to use these biomarkers to demonstrate the clinical significance of MT. Additionally, heightened and persistent immune activation which may originate from detection of PAMPs by TLRs which are expressed by immune cells and other organs may result in some clinical consequences.

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DENTAL CARIES ON PERMANENT DENTITION IN PRIMARY SCHOOL CHILDREN – NDOLA, ZAMBIA, 2017

RESEARCH ARTICLE

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Dental caries is a major oral health problem affecting 60-90% of children in developing countries [1]. This study aimed to determine the prevalence of caries and associated factors in permanent dentition among primary school children. A cross sectional study was conducted using a modified 2007 WHO questionnaire and a 1997 WHO oral health survey clinical examination tool. Ethical approval and permission to conduct the study were obtained from relevant authorities. The Chi-squared test was used to determine associations, with the level of significance set at the 5%. A total of 365 children were enrolled of which 48.5% were males. The age range was 5-17 years. The overall prevalence of caries in permanent teeth was 47(12.9 %). Geographical location (p=0.022) and family income (p= 0.014) were significantly associated with caries, although only family income was statistically significant (odds ratio [OR] = 0.65, 95% confidence interval [CI] = 0.46 - 0.92) in a multivariate analysis. The lower left first molar (9.0%) was the most often affected. None of the children had a tooth with a filled cavity. Less than half, 177 (48.5%), brushed their teeth for 2 or more minutes daily and only 71 (19.5%) had been for a dental check-up. Promotion of regular dental check-ups in schools and application of fissure sealants to children at high risk of developing caries is recommended.

Introduction

Dental caries is a progressive and irreversible microbial disease that affects calcified dental hard tissues. Cariogenic bacteria, fermentable carbohydrates, susceptible teeth, and time are the key etiological factors [2]. Carries occurs when organic acids resulting from metabolism of sugars by bacteria in dental plaque cause a loss of minerals in enamel and dentine resulting in a cavity [3]. Most decay is untreated in most developing countries [4,5], affecting the growth and wellbeing of millions of children [6,7]. Most African countries, including Zambia, have a poor dentist: population ratio of 1:150,000 compared with 1:2000 in most industrialized countries [8].

A study in West Bengal, India, showed a significant higher prevalence of caries on permanent dentition in girls (30.9%) than boys (25.4%) [9]. A similar study in India also showed 73.5% in girls and 26.2% in boys [10]. The higher prevalence in girls could be associated with earlier eruption of permanent teeth in females than males [11,12]. However, another study [13] reported a higher prevalence of caries in boys (45.9%) than girls (40.9%).

Occupational status, income, and education are related to dental caries. A study conducted in Ibadan, Nigeria showed that populations with the worst oral health are those with the highest poverty rates and the lowest education [14]. In another study done in Nigeria [15], a higher prevalence of dental caries was recorded among children of high social class (46.9%) compared with those from low social class (12.6%).

Some studies showed an association between family size and dental caries. A study done in Mexico showed that children in large families had a higher prevalence of dental caries than in small families [16].

Prevalence of dental caries and associated factors in Zambia are not well documented. A study done in 1996 reported an increase in caries among the youth and young adults [17]. Therefore, this study aimed to determine the prevalence of caries and associated factors in permanent dentition among primary schoolchildren in Ndola District, Zambia.

Methods

A cross sectional study involving 365 children in primary schools was conducted. A pilot study of 36 children from one urban and one peri-urban area was used to obtain information to calculate the sample size. Consent letters were given to 385 children, and out of this 365 (94.8%) presented a written parental consent to participate. This study had dental caries as the dependent variable while age, sex, and geographical location were independent variables.

Data were collected between January and March 2017 using a structured questionnaire. The questionnaire was administered to children by trained assistants. A convenience sample of three urban and three peri-urban primary schools in Ndola District were selected from the list of 57 primary schools obtained from the District Education Board Secretary's office (DEBS). Children were selected by systematic random sampling.

Permission was obtained from Copperbelt University School of Medicine administration, the DEBS office, and Principals of each school before commencing the research. Ethical approval was obtained from the Tropical Diseases Research Centre (IRB NO. 00002911, FWA NO. 00003729).

Table 1: Distributions of participants by demographic characteristics

	Total	Male	Female	
Demographic variable	n (%)	n (%)	n (%)	p value
Age (years)				
5- 10	251 (100)	125 (49.8)	126 (50.2)	0.458
11-17	114 (100)	52 (45.6)	62 (54.4)	
Geographical location				
Urban	184 (100)	81 (44.0)	103 (56.0)	0.085
Peri- Urban	181 (100)	96 (53.0)	85 (47.0)	

Table 2: Frequency distribution of participants according to caries experience by age

Age (years)	Total	With caries n (%)
5, 6	54	2 (3.7)
7	63	6 (9.5)
8	66	12 (18.2)
9	28	4 (14.3)
10	40	6 (15.0)
11	41	9 (22.0)
12	35	4 (11.4)
13 – 17	38	4 (10.5)

Table 3: Decayed, missing, and filled teeth among 365 children

	Total	(Minimum, maximum)	Mean
Decayed	47	(1, 7)	0.129
Missing	3	(0, 3)	0.008
Filled	0	(0, 0)	0
DMFT*	49	(0, 7)	0.134

*D- Decayed, M- Missing, F- Filling, T-Tooth

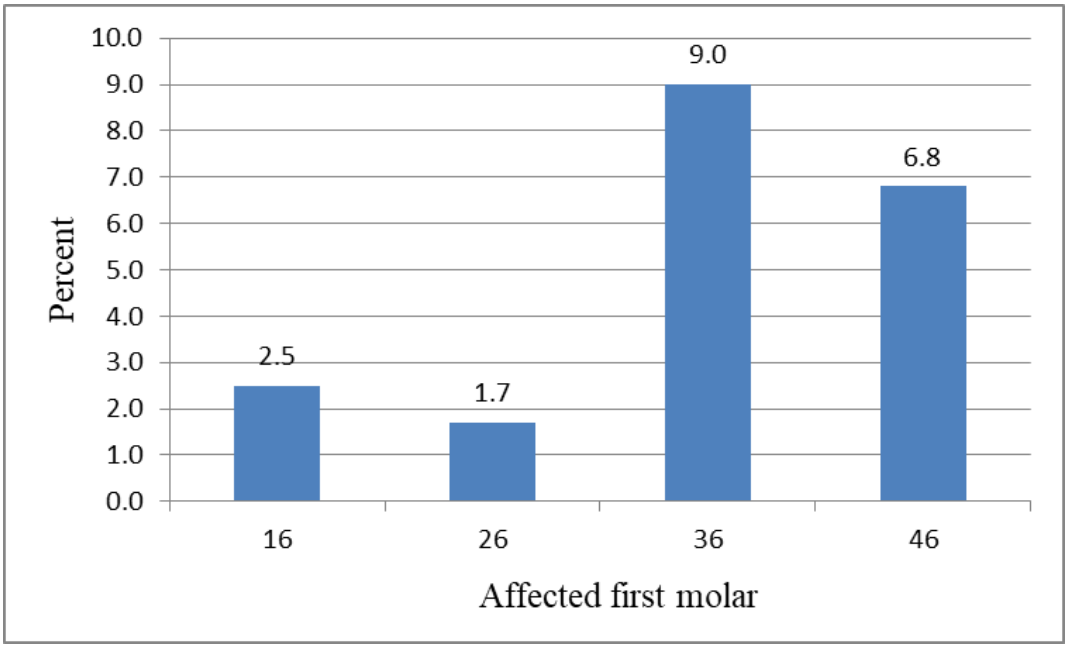
Table 4: Distribution of caries experience according to sex, geographical location, and family size

Variable	Total n (%)	Caries free n (%)	With caries n (%)	p value
Sex				
Male	177 (100)	153 (86.4)	24 (13.6)	0.706
Female	188 (100)	165 (87.8)	23 (12.2)	
School				
Urban	184 (100)	153 (83.2)	31 (16.8)	0.022
Peri-urban	181 (100)	165 (91.2)	16 (8.8)	
Family size				
Up to 5	302 (100)	262 (86.8)	40 (13.2)	0.646
More than 5	63 (100)	56 (88.9)	7 (11.1)	

Table 5: Distributions of dental caries according to family income, mother and father's level of education.

	Caries Status			
Demographic Characteristics	**Total n (%)**	**Caries free n (%)**	**With caries n (%)**	**p value**
Family income				
< K 600	153 (100)	137 (89.5)	16 (10.5)	0.014
K 600 +	107 (100)	84 (78.5)	23 (21.5)	
Mother education				
Up to primary	100 (100)	88 (88.0)	12 (12.0)	0.391
Secondary / Tertiary	171 (100)	144 (84.2)	27 (15.8)	
Father education				
Up to primary	55 (100)	51 (92.7)	4 (7.3)	0.097
Secondary / Tertiary	212 (100)	178 (84.0)	34 (16.0)	

Figure 1: Percentage distribution of Dental caries on first molars among participants



The modified WHO criterion (WHO, 1997) for caries diagnosis was used. The clinical examinations were carried out by four examiners in a classroom with wide open widows to provide natural light. Subjects leaned on a pillow placed on the lap of the examiner with the head facing upward and the mouth opened. To prevent transmission of infection, a new or disinfected round-ended probe, examination mirror, pair of examination gloves, and face mask was used for each child. Hand washing was exercised accordingly. The data was recorded on individual questionnaires and children with diagnoses of caries were given notes to take to their parents so that they could take them for treatment to nearby dental clinics.

Data were entered and analyzed using SPSS version 20 to generate frequencies and cross-tabulations. Chi-square test was used to compare differences of the outcome measure (dental caries) and was assumed significant when p value was ≤0.05. Multivariate analysis was done for variables that were significant (family income and geographic location) and associations were assumed when the 95% confidence intervals excluded 1.

Results

A total of 365 children aged 5 to 17 years were enrolled in this study, out of these 177 (48.5%) were males. Distributions of participants according to age and geographical location of the school by sex were statistically non-significant as shown in Table 1. Less than half 177 (48.5%) reported brushing their teeth for 2 or more minutes daily and only 71 (19.5%) had been for dental check-up.

Table 2 shows frequency distribution of participants according to caries experience by age. Altogether, 47(12.9%) of the participants had caries .The most affected age group was 11 years old; 22.0% of them had caries.

Mean decayed, missing, and filled teeth (DMFT) components are presented in Table 3. No subject had a tooth with a filled cavity.

Table 4 shows distributions of caries experience by sex, geographical location, and family size. School geographical location was significantly (p=0.022) associated with dental caries, as 31 of the 184 (16.8%) children living in urban areas were affected compared with 16 of 181 (8.8%) of those from peri-urban schools.

The lower left first molar (9.0%) was the most frequently affected tooth by caries, followed by the lower right first molar (6.8%); Table 5 shows distributions of dental caries according to family income, mother's education, and father's education. Family income was significantly (p= 0.014) associated with caries experience with more children from families with a monthly income of >K 600 were found with caries than those from low income families (21.5% versus 10.5%).

Geographical location and family income were included in logistic regression model. Geographical location (OR = 1.22, 95% CI = 0.85-1.75) was not independently associated with dental caries but family income was significantly associated with dental caries (OR = 0.65, 95% CI = 0.46 - 0.92). Children from families with an income of <K 600 were 35% less likely to have dental caries compared with children from families with income of K 600 or more.

Discussion

The overall prevalence of dental caries in the current study was 12.9%, 13.6% in boys, and 12.2% in girls. Geographical location was statistically associated with dental caries, as children living in urban areas were more affected than those in peri-urban areas (16.8% compared with 8.8%). These results are consistent with a study done in Burkina Faso that revealed a higher prevalence in urban (46%) than rural (32%) areas [18]. Similarly, a study in Zimbabwe [19] showed more caries in urban schoolchildren (59.5%) than in rural schoolchildren (40.8%). The results also showed a mean DMFT of 1.29 for urban schoolchildren and 0.66 for rural schoolchildren. The higher prevalence of caries in Ndola urban areas could be due to inadequate oral hygiene combined with easy access to cariogenic foods and sugary drinks [17].

The current study found a positive relationship between higher family income and more dental caries. This finding correlates with a study done in Nigeria [15] where the prevalence of caries was higher among children of high (46.9%) than low (12.6%) social class. In contrast, in the United States, children from high income families had a lower caries experience (16.3%) compared with those in lower income groups (24.1%) [20].

The current study did not reveal a significant association between family size and dental caries. The findings are contrary to a study done in Mexico which revealed a significant association between family size and dental caries [16] on permanent dentition. In a study done in Argentina, low parental level of education was associated with the high level of caries experience [21]. However, the current study showed no statistically significant association between mother's level of education or father's level of education and dental caries.

The occurrence of dental caries showed the lower left first molar (9.0%) to be the most often affected tooth, followed by the lower right first molar (6.8%). These findings could be attributed to the early eruption of these teeth [22]. These results agree with the results of a study in South Africa [23] that found that the lower molar teeth experienced a higher incidence of caries than upper molars. In contrast, in a study done in Nigeria, a higher incidence of dental caries was found in second molars compared with first molars [24].

The highest mean DMFT in this study was found in children aged 11 years; 22.0% of them had missing or decayed teeth, while the F component was zero.

One of the limitations of the study was that the sample was not randomly selected. Furthermore, the participants were those

that were present at school during data collection. Those absent could have been different from those present and the results may not be generalizable to the rest of the children who did not take part in the study.

Conclusions and Recommendations

Dental caries prevalence among primary schoolchildren in Ndola district was low. However, dental caries prevalence was higher in urban and high-income families than in rural and low income families. It was also noted that there were few participants that had dental check-ups, and among these, none had fillings. Regular dental check-ups should be conducted more in urban schools and fissure sealants applied to children at high caries risk.

Competing Interests

The authors declare that they have no competing interests.

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