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Relationship between health funding and detection of infectious diseases

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Abstract
Background: In Kenya, the County Governments manage most health facilities that handle, store and transfer biological agents in response to potential health threats with limited information including biosecurity and biosafety. The County Government facilities include level 1, 2, 3, 4, 5 and the National Government manages level 6 facilities, national referral hos-pitals. The variables: infectious diseases; health development expenditure 2014/2015, and health current expenditure 2014/2015 indicate concern to achieve and maintain sustainable national health security. This study exam-ines the relationship between health funding and capacity of county level fa-cilities to report infectious human diseases between 2014 and 2015 in Kenya.
Results: The MLR model developed revealed that when annual develop-ment and recurrent health expenditure are held constant, the detection of new infection would remains at 78:017% (95% CI 78.4-79.4); that 1% in-crease on health development expenditure increases detected infectious dis-eases by 23,180 cases per county; 1% increase in recurrent health expenditure increases detected infections by 286,639 cases per county.
Conclusion: Timely disbursement of funds to county governments could prevent emerging, re-emerging or deliberately exposed populations to viruses and other microbes that they otherwise would not have encountered. Fund-ing for budget activities on biosecurity and biosafety facilitates e ective compliance to biological threat reduction. Creating awareness among policy decision makers on critical health security funding gaps and marginalized communities to seek healthcare may achieve and sustain disease reporting rate by 80.01%.

Keywords: Infectious diseases, detection, budgeting

Introduction

Global burden of emerging infectious diseases (EIDs) has been signi cantly reduced, however developing countries including Kenya constantly face new challenges. A major need is support to sustain national capacities for diagno-sis, improve research and respond to disease outbreaks and to pool resources ensuring risk-based policies are implemented (Ndhine *et al.*, 2015 and Hans *et al.*, 2016, Gebreyes *et al.*, 2014) [4, 5]. Unfortunately, health security funding consistently remain missing from estimated county expenditure on health development. This necessitates support especially to the county health fa-cilities, research institutions and universities with a wide array of activities on infectious pathogens to pinpoint funding gaps for research, prevention, preparedness (Ndhine *et al.*, 2015) [4] to prevent sporadic incidents of large scale risks and threats (Sifuna *et al.*, 2013) [14]. Diagnostics and Laboratory Systems Program (DLSP) received funding to establish next generation sequencing and bioinformatics analysis in Kenya (CDC Annual Report, 2014). Addi-tional funds are needed to bolster response during important epidemic or pandemic events. Funding does not only cover acquisition of equipment but select capacity building of laboratory sta. The development of a sustain-able national interagency response mechanism based across all counties with sustainable DLSP trained and laboratory sta competent in molecular tech-niques (real-time PCR) in pathogen detection, response and preparedness is yet to be realized (CDC Annual Report, 2014). This is an intervention not foreseen in national health budgeting. Few studies have been conducted in Kenya to establish relationship between funding and identi cation of critical health security gaps and, areas of need. Both with outdated and vulnerable equipment; funding imbalance exist in health security training and reinforce-ments; antiquated laboratory

capacity; lack of real-time surveillance and epidemiological systems; incomplete domestic preparedness and emergency response capabilities; ine ective and fragmented communications networks and, hurdles to approval processes, accessibility and linkage of data and samples create further evidence of barriers (Wellcome Trust, 2004) [20].

The purpose of this manuscript is to determine if there is a statistical re-lationship between nature of health funding (and expenditiure) at county level and incidence of infectious disease by county. We furthermore intend to see how the funding is used, and what e ect these have on the level of infectious disease.

Method

Data can be found in Statistical Abstract for Kenya (https://www.knbs.or.ke/publications/). The paper is partly based on data from the study by Ndhine *et al.*, (2015) [4], Slotved *et al.*, 2017) [10], and national data on nancial year 2014/2015 Annual County Governments Budget Implementation Review Report, National and County Health Budget Analysis Report and, Statistical Abstract, 2014. The variables: new infections (both under ve and ve and above summed), health development expenditure 2014/2015, and health current expenditure 2014/2015, were disaggregated per county. From this data descriptive statistics was deducted, normalized and MLR estimated using R software and results interpreted. FY 2014/15 marked one year after devolving health services to county governments.

Statistical modeling

The study sought to determine the statistical relationship between health funding and incidences of infectious disease reporting by county with pathogens readily available in nature, natural pathogens characteristic to spread of large-scale threats. As such, the study focuses on new cases of infectious diseases reported in 2014 per county as dependent variable, county health de-velopment expenditure, and county health recurrent expenditure, per county as explanatory variables. Health recurrent expenditure was considered for the reasons that it feeds into the availability of human resources, subjected to incessant medical practitioners' strikes over remuneration packages, promo-tion, among other labour related issues. The incidence of infectious diseases reported gives insights into tendency of county residents to seek medical at-tention from health facilities. This argument is bolstered by (Gibbons *et al.*, 2014) [4] observation that not all cases seek healthcare (under-ascertainment), and at the healthcare level, represent a failure to adequately report symp-tomatic cases (under-reporting).

These variables were estimated using multiple linear regression (MLR) model to give ceteris paribus e ect of each variable on reported new cases. The cross-sectional data representing the variables were tested for normality before being subjected to logarithm transformation. Logarithm transforma-tion enables interpretation of elasticity in terms of percentage and reduces e ects of outlier data points. The data variables being in di erent scales are normalized and tested for normality to ensure that it follows normal distribution in line with central limit theory. For statistical modeling, the study uses and R software to develop and estimate MLR model.

Generally the MLR model formula is,

Normalization of Data

The data is normalized between 0 and 1

$$K_i = \frac{y_i \quad \min(y)}{\max(y) \quad \min(y)} \tag{1}$$

The MLR model used

$$Y = {}_0 + {}_1X_{i1} + {}_2X_{i2} + {}_1 \quad i = 1; 2; 3; \quad n \tag{2}$$

The values of $_0$, $_1$ and estimate parameters of regression line and unite ects predictor variables on Y. ln our case the MLR model is (3), Where ln N IN F ECT, is log of total new infections; ln DEV EXP, is log of health development expenditure; ln RECEXP, is log of recurrent health expendi-ture.

$$\ln N \text{ IF ECT} = {}_0 + {}_1 \ln \text{DEV EXP} + {}_2 \ln \text{RECEXP} \tag{3}$$

Results

Upon submission of county budgets to Controller of Budgets (COB) and the National Treasury (TNT), the exchequer issues its own budget lines with caps lower than county allocations (Figure 1). In all counties exchequer is-sues are less than county allocations on health development. The average development budg *et al.* location across all counties was KES 365.8136 million and that issued by exchequer was KES 168.45 million which is only 46.48% of what is required by the counties. On average, this implies that the exche-quer issue on health development is 46.48% of what is required by counties. The average county expenditure on health development for FY2014/2015 was KES 135.055 million while average exchequer issue on the same stood at KES 168.5619 million, which account for 80.12% budget uptake. Figure 2 show the pattern of health development expenditure revealing that counties dominated by marginalized pastoralist communities like Garissa, Samburu, Mandera, Turkana, Marsabit, and Tana River have higher exchequer issues on health development and reported to spend more on building facilities, acquire medical equipment and training medical practitioners. Counties dominated by pastoralist communities experience the lowest incidence of disease reporting rate: Garissa 84%, Samburu 81%, Isiolo 79%, Turkana 77%, Marsabit 75%, and Mandera 75% Figure 4. Some counties experience higher incidence of disease reporting rate. They include Kirinyaga 100%, Lamu 100%, Siaya 97%, Kericho 95%, Nyamira 95%, Kili 95%, and Taita Taveta 95% Figure 4. Averagely they spend 95.34% of exchequer issues on recurrent and 80.12% on development.

Statistical modelling

At 95% Con dence Interval, the model developed from the analysis is:-

$$\ln N \text{ IF ECT} = 78{:}017_{0{:}03473} + 2{:}772_{0{:}0093} \ln \text{DEV EXP} + 34{:}277_{0{:}8785} \ln \text{RECEXP} \tag{3}$$

The model estimated revealed that when annual development and re- current health expenditure are held constant, the detection of new infec- tions would increase by 78.017% (95 % CI. 78.4-79.4). Also, 1% increase in health development expenditure, increases detection of infectious diseases by 2.772 %.Given that the average annual infection stands at 836,242, the implication is that 1% increase on health development expenditure in- creases detected infectious diseases by 23,180 cases per county. In addition, 1% increase

in recurrent health expenditure increases detection of infec-tious diseases by 34.277% (95% CI. 33-36). This implies that 1% increase in recurrent health expenditure increases detected infection by averagely 286,639 cases per county. The nding is consistent and signicant given that, it takes remunerated human resource to diagnose and detect infectious diseases. Increasing recurrent expenditure translates in increased quali ed and well remunerated medical practitioners with uninterrupted hours at work because of elimination of incessant strikes resulting from comprehen-sive bargain agreement demands. We take total new infections as the number of incidence diagnosed and reported in medical facilities.

Discussion

From the budgetary data on health, the gaps in funding start manifesting at the point of budgeting. The county governments prepare budg *et al.* locations for recurrent and development health expenditure based on assessed needs. Upon submission to Controller of Budgets (COB) and the National Trea-sury (TNT), the exchequer issues budget lines with caps lower than county allocations as illustrated in Figure 1. In all counties, exchequer issues are lower than county allocations on health development. The study focuse more on health development and recurrent allocations, exchequer issues, and expenditure for the reasons that this funding includes surveillance and detection of both new and emerging infectious diseases for the bene t of citi-zens and national health security. The reasons for not fully executing health development budget are, bureaucracy in government procurement processes, late quarterly disbursement from National Treasury, and diversion of funds to pay backlog of doctors, nurses and public health o cers salaries. It is also important to note that arid and semi arid counties, characterized by low rainfall and pastoralist activities also experience low disease incidence reporting rates because they lack facilities/laboratories including relevant medical practitioners in areas of surveillance, prevention and detection of infectious diseases. Their normad way of life makes it di cult to establish fully functional mobile clinics and laboratories. According to data analyzed in Figure 3 the counties spend higher percentage of their exchequer issue on recurrent than health development expenditure. Salaries for medical prac-titioners are paid monthly, health development budget uptake is dependent on protracted procurement processes. Averagely, counties spend 95.34% of exchequer issues on recurrent and 80.12 % on development. It's important to note that collaboration with partners that support biosecurity training programs to in-country health facilities results in research, purchase or leas-ing of medical equipment most useful in diagnosis. The model estimated reveals that without enhanced biosecurity and biosafety budget to annual development and recurrent health expenditure, the detection of new infec-tion may remain at 78.017%. This paints a wanting situation in the absence of collaborative health security funding. Also, 1 % increase in health de-velopment expenditure, increases detection of infectious diseases by 2.772%. This is signi cant going by the value of standard error. Given that the aver-age annual infection stands at 836,242, the implication is that 1% increase on health development expenditure increases detected infectious diseases by 23,180 cases per county. Most importantly, 1% increase in recurrent health expenditure increases detection of infectious diseases by 34.277%. This im-plies that 1% increase in recurrent health expenditure increases detected infection by 286,639 cases per county. The nding is very consistent and signi cant given that, it takes constant supply of skilled human resource to diagnose, detect and e ectively respond to disease outbreaks of large-scale threat. The total new infections are taken as the number of incidence of disease reported in health facilities. It is important because not all incidents of disease are reported in health facilities by the infected. Some victims do not seek medical care leading to disparity between reporting and actual morbidity.

Conclusion

It is necessary to analyze funding categories if annual budget is to protect the Kenyan citizens from intended and/or unintended infectious disease out-break of large-scale threats. This necessitates substantial increase and timely transfer of funds to directly acquire materials and equipment, improve in-frastructure, build competence for diagnostics, detection, preparedness and response, create public awareness, and support implementation of national law and regulations dedicated to biosecurity actions for health security.

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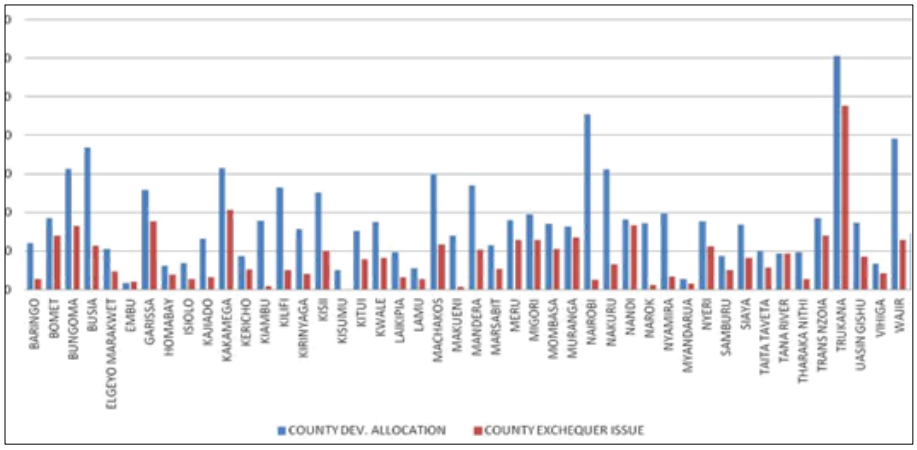

Fig 1: County health development allocation and exchequer issues in million KSH

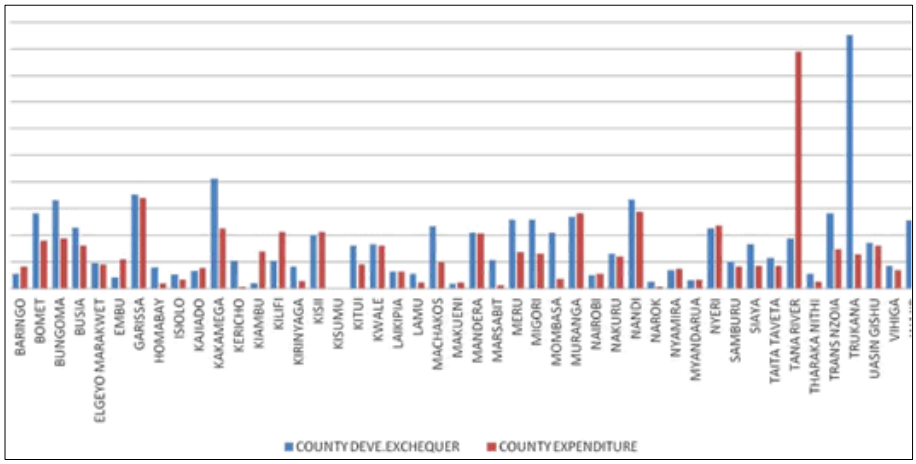

Fig 2: Comparing county health development expenditure and exchequer issues (in million KSH)

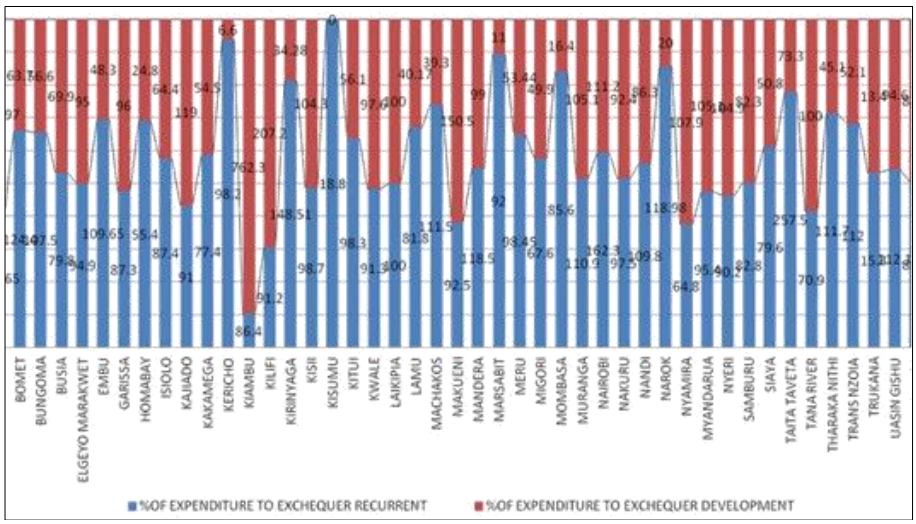

Fig 3: Counties health expenditure on recurrent and development as % of exchenquer isseus

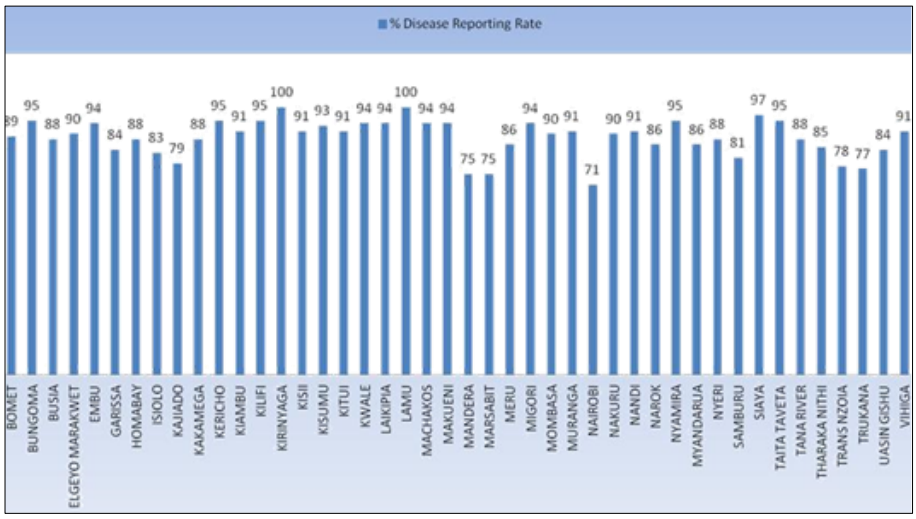

Fig 4: % incidence of disease reporting rate by county

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