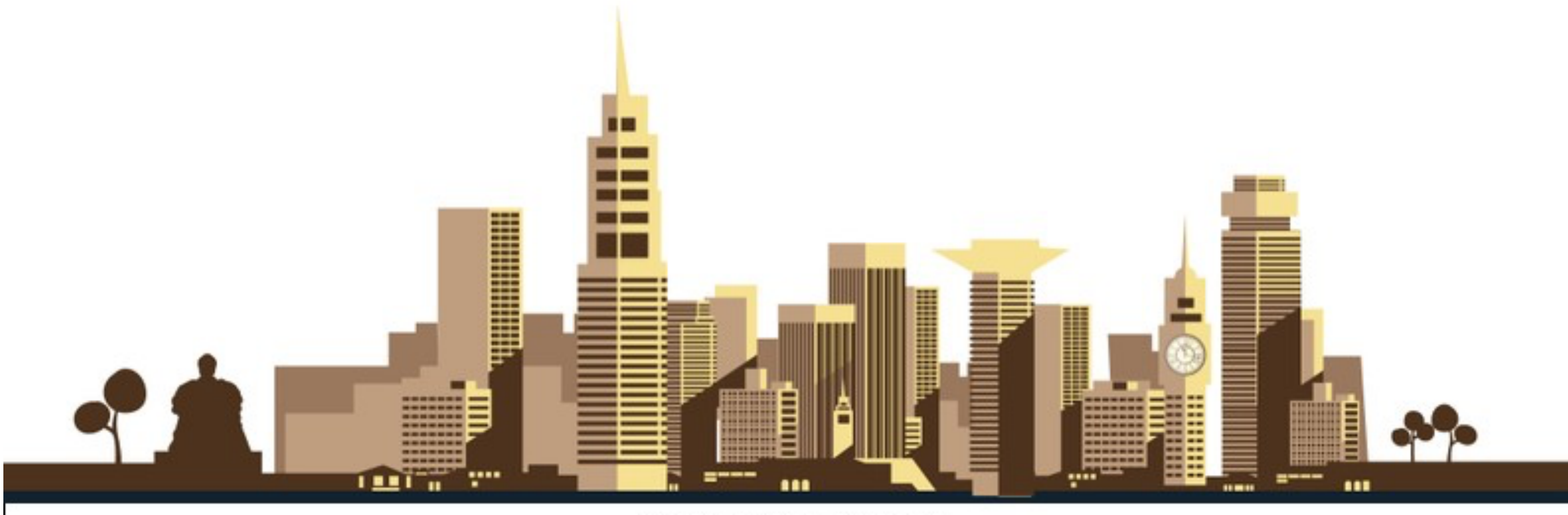
Tuberculosis in Nairobi, Kenya

Policy Brief

Daniela Shuman
Spring 2024

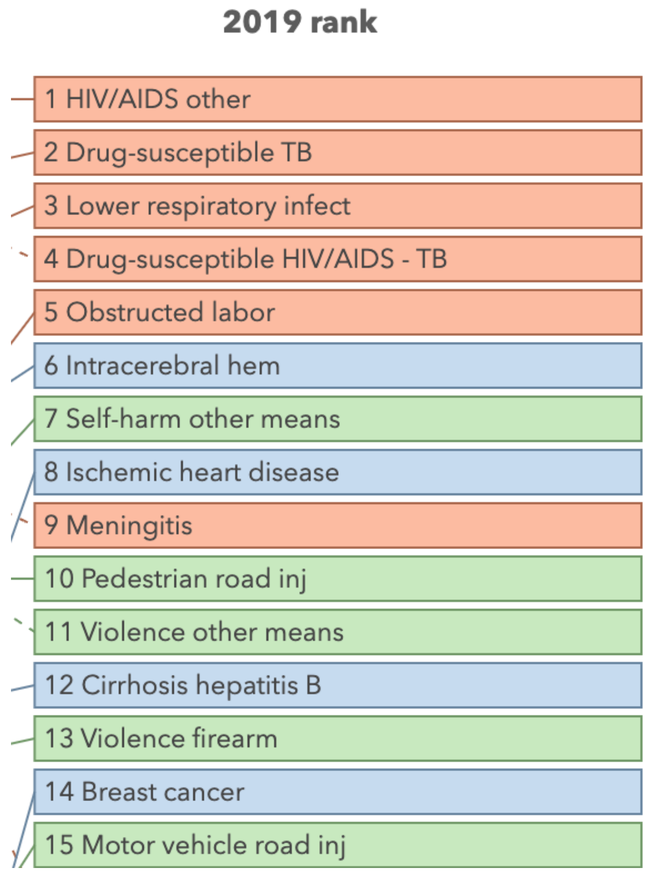


Summary

Tuberculosis (TB) in Nairobi, Kenya is one of the leading causes of death and DALYs (after HIV). TB and respiratory infections cause over 2000 DALYs per 100,000 in Nairobi alone, 83% of which affect 15-49 year olds.

Approximately 60% of residents in Nairobi live in urban slums and lack critical health infrastructure to prevent, test, and treat TB. HIV rates in the city are also high. HIV is the leading risk factor for TB-related deaths because of the higher fatality rate of immunocompromised and TB-infected individuals.

Existing efforts have had difficulty replicating effectiveness, largely due to the lack of necessary health infrastructure to maintain any progress. This policy brief argues that TB-related philanthropic organizations such as the World Health Organization, Bill and Melinda Gates Foundation, and Open Philanthropy should invest in health system infrastructure, particularly in Community Health Worker centric health systems, in order to reduce TB-caused deaths in dense, informal, growing cities like Nairobi, Kenya.



Establishing the Problem

HIV / AIDS & TB

HIV/AIDs and sexual diseases rate is very prevalent in Nairobi, contributing to over 4,161 DALYs per 100,000. HIV/AIDs contributes to over 3,300 DALYs per 100,0000, at 79% of all sexually transmitted diseases (*GBD Compare*, 2019). The high prevalence largely due to unsafe sexual practices (*IHME*, 2023). Nearly all individuals with HIV and TB die early (*Tuberculosis (TB)*, 2023).

The HIV/AIDS epidemic is a serious risk factor for TB.

Tuberculosis is a form of typically respiratory bacteria that is mostly transferred through the air. Most people infected with TB have latent bacteria, but those with the “active disease” are approximately 50% likely to die if untreated. The symptoms include typical respiratory infection symptoms including coughing and fever.

Tuberculosis and Respiratory Infections cause 2,878 DALYs per 100,000 in Nairobi alone. The majority of these DALYs are concentrated in the 15 – 49 year old age range, consisting of 2,405 DALYs per 100,000, or 83% (*GBD Compare*, 2019). For context, in the US, cardiovascular disease accounts for 233 DALYs per 100,000 (*GBD Compare*, 2019).

Drug-susceptible TB, lower respiratory infections and drug-susceptible HIV/AIDS-TB are the top three contributors to DALYs due to respiratory infections (*GBD Compare*, 2019). Drug-susceptible TB has a much higher prevalence than drug-resistant TB in Nairobi. Drug susceptible TB contributes to 2 out of 3 DALYs approximately due to TB and respiratory infections.

Risk Factors

Undernourishment: Undernourishment is considered a significant risk factor for TB. Unfortunately, malnutrition is listed as the #1 risk factor for health-related issues in Nairobi, according to the Institute for Health Metrics and Evaluation (*Kenya - Nairobi | Institute for Health Metrics and Evaluation*, 2023). A study on malnutrition in informal settlements in Nairobi found stunting due to malnutrition in 47% of children (*Nutritional Status of Under-Five Children Living in an Informal Urban Settlement in Nairobi, Kenya*, 2011). Individuals have a harder time fighting the virus if they are undernourished and are more likely to have latent TB turn into active TB (Padmapriyadarsini et al., 2016).

HIV: People living with HIV are 16 times more likely to fall ill with TB than people without HIV. The combination of the two has detrimental effects to individual lives. Only 54% of people in Africa who have TB and HIV are on antiretroviral therapy (ART) (*Kenya - Nairobi | Institute for Health Metrics and Evaluation*, 2023), a set of medications that treat HIV. Thus, the risk is higher for immunocompromised individuals and there is less treatment available for said individuals.

Other Risk Factors: While alcohol-use disorder is also considered generally a risk factor, this isn't a common behavioral risk in Nairobi. It is considered the 4th ranked risk factor and has decreased by 200 DALYs per 100,000 between 2009 and 2019 (*Kenya - Nairobi | Institute for Health Metrics and Evaluation*, 2023).

Social Determinants

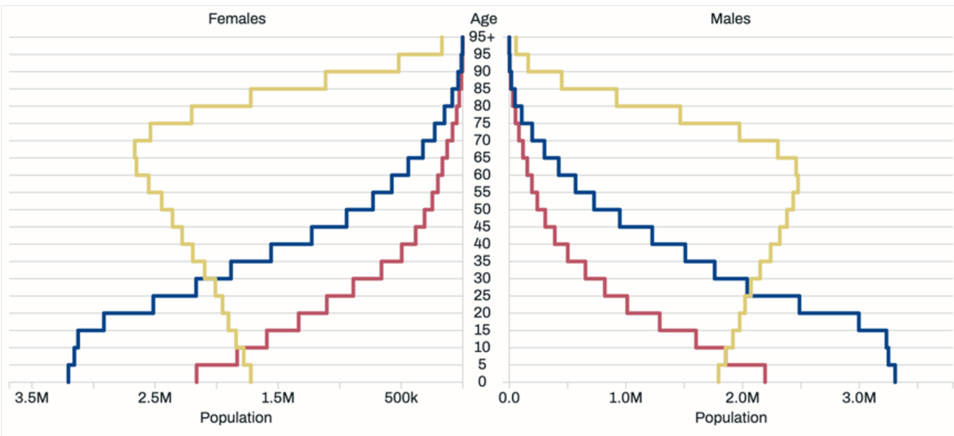
Inadequate WaSH Infrastructure: Settlements within Nairobi are characterized by a lack of proper WaSH infrastructure (Pessoa Colombo et al., 2023). Unsafe defecation practices are common in the informal settlements within Nairobi. Only 40% of residents in Nairobi have access to a sewage system (*World Bank*, 2020). Only 40% of residents in Nairobi have access to a sewage system[8]. Further, only 20% of residents in Nairobi have access to piped water. Even the water that is piped is subject to contamination. WaSH is listed as the 3rd highest risk factor (*IHME*, 2023) in all of Kenya but only the 9th in Nairobi (*IHME*, 2023). This may be because Nairobi is more developed, on average, than the rest of Kenya. Many rural towns will have less access to proper water and sanitation. Within the poorer neighborhoods, 49% of water distribution sites don't reliably function (Chaffinch, 2017).

High Density: Nairobi is a very dense city with over 60% of residents living in informal settlements (Pepela et al., 2017). Density in informal settlements in the city reaches 63,000 people per square kilometer (Ren et al., 2020). The average home in Kibera, one of the larger informal settlements in Nairobi, is 12ft by 12ft and fits more than 8 people (UN-Habitat, 2020). Infection rates are high amongst households.

Unsafe Sex: Further, behavioral risk factors are a contributor to TB deaths. Unsafe sex is listed as the second greatest risk factor to health by the IHME (*IHME*, 2023). This leads to higher HIV/AIDS rates and thus, higher rates of TB deaths.

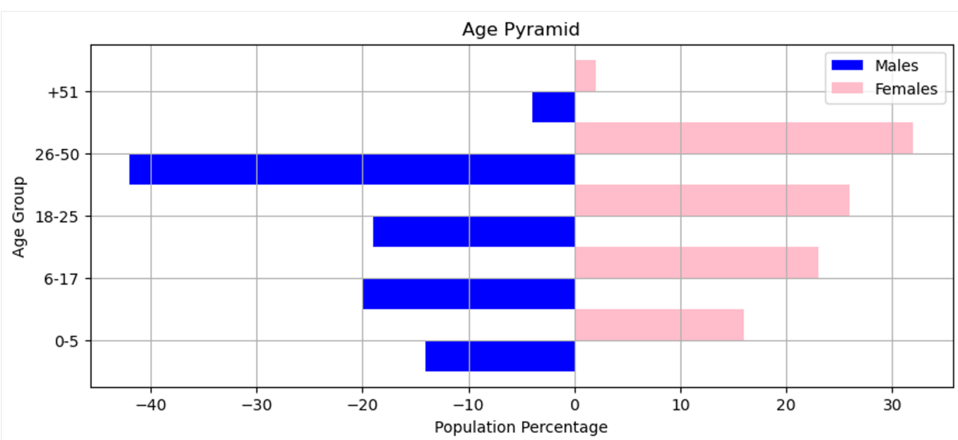
Context

Nairobi is in a country that is early in its demographic transition. Nairobi has a growing population of approximately 5.5M (World Population Review, 2024). The population is growing quickly at a rate of 4.06% and expected to continue to rise as the population of Kenya increases and people seek economic opportunity in the denser population hubs.



Kenya Age Pyramid (*IHME*, 2023)

Many of the individuals in Informal Settlements in Nairobi are concentrated around middle age, but rarely live past 50 years old. This is in sharp contrast to the demographic pyramid of Kenya. There is a lower number of people that are 0-17 years old likely because of the high infant mortality rate, at 19% (*Kibera | Chaffinch*, 2017).



Informal Settlements in Nairobi Age Pyramid (*Chaffinch*, 2017)

The overall Kenyan age pyramid is skewed towards younger, suggesting Kenya is early in its demographic transition (*IHME*, 2023).

Quick Facts

<u>HEALTH</u> (IHME, 2023)

Life Expectancy (Nairobi): 67.6

Life Expectancy (Kenya): 66

7.5 Health Posts, 6 Centers, 1.4 Hospitals per 100,000 in Kenya

Fertility Rate (Nairobi): 1.8

Fertility Rate (Kenya): 3.0

<u>ECONOMIC</u> (IHME, 2023) (USAID, 2021)

43% of Health Costs are provided by the Government.

17% of Health Costs are from Developmental Assistance

Poverty Headcount (Kenya): 36%

Human Capital Index: 0.5

GDP per Capita: $2,099

Average Daily Income: $3.02

Bottom 20th Percentile Monthly Income (Nairobi): $128

Bottom 20th Percentile Monthly Income (Kenya): $90

<u>SOCIAL</u> (WHO, 2022)

Population (Nairobi): 5.5M

Growth Rate (Nairobi): 4.06%

Access to Electricity: 76.5%

Access to Proper Sanitation: 31%

Access to Fresh Water: 19%

Average 95th Percentile Household Size (Nairobi): 4

Average 95th Percentile Household Size (Kenya): 4.

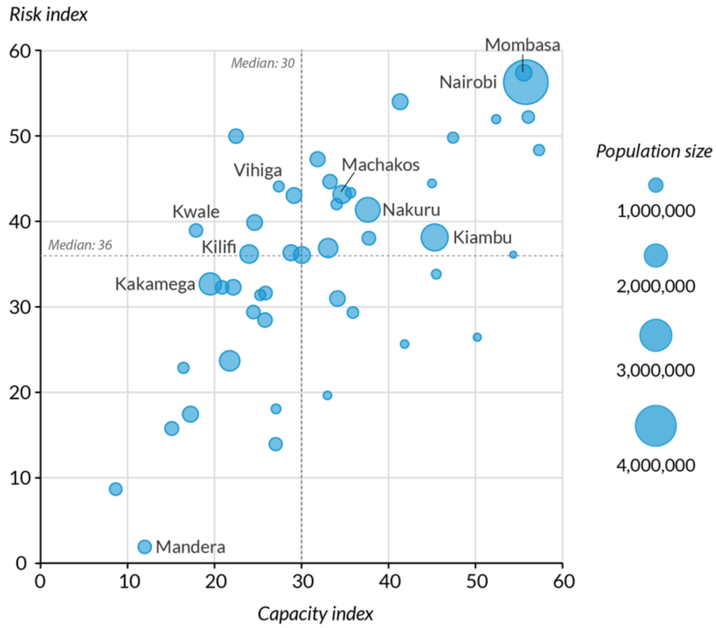
Health System Capacity

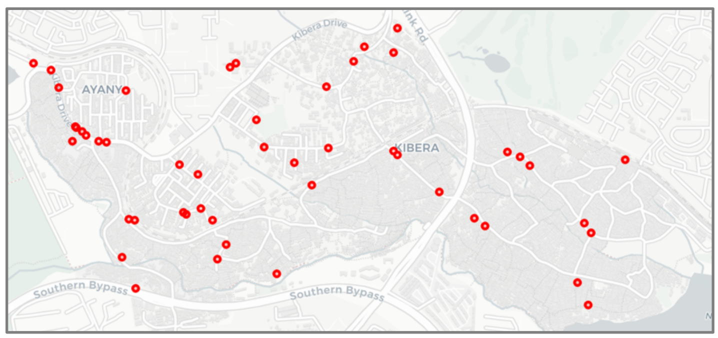
There are only 49 known health clinics in Kibera, which puts the health facilities per 10,000 at only 1.96 health facilities per 10,000 people. For comparison, other states in Kenya surpass 5 health facilities per 10,000 (Pepela et al., 2017). For illnesses such as TB, health facilities are critical in order to ensure the regular medication is taken for a regular period of time for 4-6 months (*Tuberculosis (TB)*, 2023). Most of the health facilities are concentrated around main streets, likely because they are more easily accessible for suppliers.

HIV/AIDs and sexual diseases rate is very prevalent in Nairobi, contributing to over 4,161 DALYs per 100,000. HIV/AIDs contributes to over 3,300 DALYs per 100,0000, at 79% of all sexually transmitted diseases (*GBD Compare*, 2019). The high prevalence largely due to unsafe sexual practices(*IHME*, 2023). Nearly all individuals with HIV and TB die early(*Tuberculosis (TB)*, 2023).

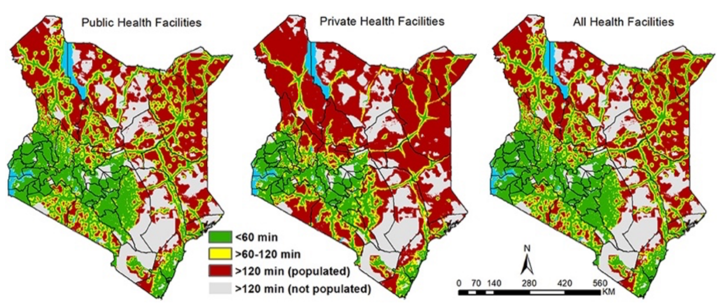
The health system in Kenya is relatively lacking. On average, there are approximately 7.5 Health Posts, 6 Centers, 1.4 Hospitals per 100,000 in Kenya (WHO, 2022). There is a solid government run healthcare system. Approximately 43% of Health Costs are provided by the Government (IHME, 2023). Further, the country of Kenya receives developmental assistance from organizations such as the WHO. Approximately 17% of all Health Costs are from Developmental Assistance.

How Kenyan Counties Perform on the Health Care Capacity and Population Risk Indexes





Health Clinics in Kibera (Map Kibera, 2017)



Travel Time to Nearest Health Clinic (Moturi, 2021)

Tackling the Problem

Laying out the Alternatives

Global efforts in developmental assistance have prioritized investing in TB, given it is the leading cause of death in 2022 after COVID-19 (WHO, 2023). Organizations such as the World Health Organization and the Bill and Melinda Gates Foundation have invested efforts in funding Vaccines, Drug Regimine Programs, Testing systems, and TB Drug Treatment Therapy.

Distribution of the Bacille Calmette-Guerin (BCG) vaccine: *(CDC*, 2022).
The BCG vaccine was developed as a solution for children with TB. However, BCG is not recommended for use in the United States because of its variable effectiveness. Evidence suggests the vaccine is only 37% effective in children younger than 5 years of age(Andersen & Doherty, 2005). A new vaccine(Scriba et al., 2020) has demonstrated a 50% efficacy in third stage clinical trials. For context, the measles, smallpox, and polio vaccines are 93, 95, and 90 percent effective, respectively (*Vox*, 2024). Kenya is currently 97% covered with the vaccine (GHO, 2022).
Strengths:
- This vaccine could have a significant improvement in reducing the number of people infected with TB.
- Vaccine distribution channels exist across Nairobi, including in the informal settlements that have health centers.
- This solution is endorsed by well-vetted agencies such as Open Philanthropy, who gave $40M to develop a better vaccine in partnership with the Bill and Melinda gates foundation (Gates Philanthropy Partners, 2023).

Limitations:
- A new vaccine will still take several years to be approved. TB deaths in Nairobi are 56 per 100,000 (*GBD Compare*, 2019), so any year waiting for a vaccine to be released results in more residents passing away.
- The number of health centers in Nairobi, particularly in Kibera, are still low compared to the peer cities and countries. A concentrated vaccine distribution effort would require a lot of upfront costs and planning because of the lack of existing health infrastructure.

Drug-regimen programs to prevent infection in immunocompromised groups (Fraser et al., 2006)
Drug-regimen programs are specifically designed to treat individuals regularly who are immunocompromised (i.e. infected with HIV/AIDS)
Strengths:
- Could dramatically reduce TB deaths that are caused by multiple diseases, particularly in immunocompromised people.

Limitations:
- Any regular program introduces risks of no-show, which can result in drug-resistance. In this environment, there are many reasons why an individual would not be able to show up to a drug-regime program or regularly take their medication on-time including job insecurity, natural disasters, or generally more immediate concerns such as hunger.

Frequent testing:
Frequent Testing allows for early detection of latent disease becoming active. There are two types of tests for TB 1) a skin test, and 2) blood test. Latent TB will not be detected on a skin test, but the skin test is significantly less invasive. Proper safety protocols can be encouraged once TB is detected.
Strengths:
- Frequent testing allows for the community to prepare in-case of an outbreak.

Limitations:
- In health-site limited areas, frequent testing can be easily above the capacity of the health system. Further, since latent TB cannot be detected on a skin test, the TB can continue to transfer between people and increase the incidence of the disease in the population.

TB Drug Treatment:
For those with TB, the typical treatment is Anti-Retroviral Therapy (ART), which can take up to 6 months of treatment. This involves regularly taking pills for up to 6 months.
Strengths:
- Treatment success is up to 88%, if completed *(PAHO*, 2020).

Limitations:
- Missing a pill one day can result in the development of drug-resistant TB, leading to an ineffective ART.
- Given the unstable nature of many of these communities, attending a health center regularly is difficult, particularly when there are other more immediate concerns such as food insecurity.

Evaluating the Outcomes

Vaccine distribution increase seems only marginally effective because of the high existing vaccination rate, and the marginal improvement in effectiveness with the new vaccine. A more systems-based approach would be critical.

A successful intervention would have a statistically significant reduced number of deaths due to TB. Since the rate of TB infections is already decreasing in the region, a randomized control trial would be necessary to demonstrate significant effects.
The criteria to assess the strategies would be: Active TB rates have declined faster, provably because of the intervention. Additionally, there is a reduced rate of new infections due to interventions that improve general sanitation and reduce the spread of disease.

Recommendation

Increase the health system capacity in Nairobi. A common thread in the failure of existing solutions is the lack of consistent health infrastructure. While this is a time and resource intensive solution, it would create systems that support an overall better health system that could prevent, test, and treat more individuals for TB.

Particularly, Nairobi should invest in Community Health Workers (CHW). CHWs can help with regular testing and regular treatment. CHW-centric health systems have theoretically and empirically reduced the deaths in communities across the world, especially for more chronic diseases with regular required treatment.

Theoretical: Some theoretical estimates of cost-effectiveness have calculated that the cost of saving one life via CHW mechanisms is approximately 847 USD. This is higher than some of the estimates of the effectiveness of other solutions. By a similar method, investment in a new vaccine could range from 149 USD – 1692 USD per DALY recovered depending on some assumptions about the efficacy of the new vaccine.

Empirical: The Costa Rican health system is a CHW based system that has provably increased the life expectancy of the country. Further, this method was tested in slums in India by Potty et. al. and it was found to have an 89.9% success rate (Potty et al., 2021).

One problem with this mechanism is that it has a high upfront cost. Organizations such as Open Philanthropy can circumvent this issue by redirecting the $40M funds from vaccine development to a CHW system.

References

Andersen, P., & Doherty, T. M. (2005). The success and failure of BCG — implications for a novel tuberculosis vaccine. *Nature Reviews Microbiology*, *3*(8), 656–662. https://doi.org/10.1038/nrmicro1211

Antiretroviral Therapy—PAHO/WHO | Pan American Health Organization. (2020, July 21). https://www.paho.org/en/topics/antiretroviral-therapy

Fact Sheets | Infection Control & Prevention | Fact Sheet—BCG Vaccine | TB | CDC. (2022, August 16). https://www.cdc.gov/tb/publications/factsheets/prevention/bcg.htm

Fraser, A., Paul, M., Attamna, A., & Leibovici, L. (2006). Drugs for preventing tuberculosis in people at risk of multiple-drug-resistant pulmonary tuberculosis. *The Cochrane Database of Systematic Reviews*, *2006*(2), CD005435. https://doi.org/10.1002/14651858.CD005435.pub2

Gates Philanthropy Partners—Tuberculosis Vaccine Candidate. (2023, February). *Open Philanthropy*. https://www.openphilanthropy.org/grants/gates-philanthropy-partners-tuberculosis-vaccine-candidate/

GBD Compare. (n.d.). Institute for Health Metrics and Evaluation. Retrieved February 27, 2024, from http://vizhub.healthdata.org/gbd-compare

GHO | By category | BCG - Immunization coverage estimates by country. (2022). WHO; World Health Organization. https://apps.who.int/gho/data/node.main.A830?lang=en

Is there a tuberculosis vaccine? Yes, but it's not as good as it could be. It's time for a new one. - Vox. (2024, April 14). https://www.vox.com/future-perfect/24128530/tuberculosis-vaccine-efficacy-solutions-tb-bcg?mc_cid=c640ff9ccc&mc_eid=63a6193db5

Kenya | Institute for Health Metrics and Evaluation. (n.d.). Retrieved April 12, 2024, from https://www.healthdata.org/research-analysis/health-by-location/profiles/kenya

Kenya—Nairobi | Institute for Health Metrics and Evaluation. (2023). https://www.healthdata.org/research-analysis/health-by-location/profiles/kenya-nairobi

Kibera | Chaffinch. (2017). https://www.chaffinch.org.uk/kibera-slum/

Nutritional Status of Under-five Children Living in an Informal Urban Settlement in Nairobi, Kenya—PMC. (2011). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3190366/

Padmapriyadarsini, C., Shobana, M., Lakshmi, M., Beena, T., & Swaminathan, S. (2016). Undernutrition & tuberculosis in India: Situation analysis & the way forward. *The Indian Journal of Medical Research*, *144*(1), 11–20. https://doi.org/10.4103/0971-5916.193278

Pepela, W., David, N., Bartilu, P., & Okoro, D. (2017). *Pathways to optimal health infrastructure in Kenya*.

Pessoa Colombo, V., Chenal, J., Orina, F., Meme, H., Koffi, J. d'Arc A., Koné, B., & Utzinger, J. (2023). Environmental determinants of access to shared sanitation in informal settlements: A cross-sectional study in Abidjan and Nairobi. *Infectious Diseases of Poverty*, *12*(1), 34. https://doi.org/10.1186/s40249-023-01078-z

Potty, R. S., Kumarasamy, K., Adepu, R., Reddy, R. C., Singarajipura, A., Siddappa, P. B., Sreenivasa, P. B., Thalinja, R., Lakkappa, M. H., Swamickan, R., Shah, A., Panibatla, V., Dasari, R., & Washington, R. (2021). Community health workers augment the cascade of TB detection to care in urban slums of two metro cities in India. *Journal of Global Health*, *11*, 04042. https://doi.org/10.7189/jogh.11.04042

Ren, H., Guo, W., Zhang, Z., Kisovi, L. M., & Das, P. (2020). Population Density and Spatial Patterns of Informal Settlements in Nairobi, Kenya. *Sustainability*, *12*(18), Article 18. https://doi.org/10.3390/su12187717

Scriba, T. J., Netea, M. G., & Ginsberg, A. M. (2020). Key recent advances in TB vaccine development and understanding of protective immune responses against Mycobacterium tuberculosis. *Seminars in Immunology*, *50*, 101431. https://doi.org/10.1016/j.smim.2020.101431

Tuberculosis (TB). (2023). https://www.who.int/news-room/fact-sheets/detail/tuberculosis

UN-Habitat. (2020). *Informal settlements' vulnerability mapping in Kenya*. https://unhabitat.org/sites/default/files/2021/08/the_case_of_kibera_edited.pdf

World Bank. (2020, February 19). *Providing Sustainable Sanitation and Water services to Low-income Communities in Nairobi* [Text/HTML]. World Bank. https://www.worldbank.org/en/news/feature/2020/02/19/providing-sustainable-sanitation-and-water-services-to-low-income-communities-in-nairobi

World Population Review. (2024). *Nairobi Population 2024*. https://worldpopulationreview.com/world-cities/nairobi-population