Transforming Rural TB Surveillance with *Mycobacterium tuberculosis* Fingerprinting

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DESCRIPTION

Rural areas often face unique challenges in Tuberculosis (TB) control, including resource limitations and geographical barriers to healthcare access. One encouraging strategy to enhance TB surveillance and control is fingerprinting-the use of molecular techniques to track and analyze *Mycobacterium tuberculosis* (*M. tb*) strains. This tool is particularly effective in identifying outbreaks, mapping transmission patterns, and guiding public health interventions. Fingerprinting refers to molecular techniques used to analyze the genetic makeup of *M. tb* strains. This process identifies unique patterns or fingerprints in the bacterial DNA, enabling public health officials to distinguish between strains. Common fingerprinting methods include, analyses specific DNA regions called direct repeat loci to identify strain-specific patterns. Mycobacterial Interspersed Repetitive Unit-Variable Number Tandem Repeat (MIRU-VNTR) examines the number of repetitive DNA sequences in various loci of the bacterial genome. Whole Genome Sequencing (WGS) provides comprehensive data on the genetic structure of the bacterium, offering the highest resolution for strain differentiation.

Importance of fingerprinting matters in rural states

Within the limited healthcare infrastructure, delayed diagnosis, and high rates of undiagnosed or untreated cases fingerprinting can address these issues by identifying, whether TB cases in a community are due to recent transmission or reactivation of latent infections. This information is essential in directing resources toward breaking chains of transmission. When multiple cases occur in a small region, fingerprinting can determine if they are part of a single outbreak caused by a common strain. This enables swift public health interventions. In rural states bordering other regions or countries, fingerprinting can track cross-border TB transmission, guiding collaborative control efforts. By analysing the genetic makeup of strains before and after treatment, fingerprinting can help identify cases of drug resistance or reinfection. With precise data on the spread and nature of TB strains, rural health departments can optimize limited resources for targeted interventions. In

several rural states, fingerprinting has already demonstrated its value to identify a cluster of TB cases in a rural county, leading to targeted screening and prevention programs that curtailed the outbreak. MIRU-VNTR analysis revealed a previously undetected link between TB cases in two distant rural communities, prompting a coordinated public health response. Whole-genome sequencing identified a drug-resistant strain circulating in remote villages, allowing for tailored treatment regimens and infection control measures.

Advantages of molecular fingerprinting

Fingerprinting enables rapid identification of TB outbreaks by distinguishing between clustered cases and unrelated ones. By analysing genetic data, public health officials can trace the movement of strains within and between communities, identifying high-risk areas for intervention. Insights from fingerprinting inform targeted control measures, such as focused screening campaigns and resource allocation to specific hotspots. The genetic data generated contribute to larger databases, fostering collaboration and advancing global efforts to combat TB. Furthermore, molecular fingerprinting helps monitor drug-resistant TB strains, enabling timely interventions to prevent their spread. By integrating fingerprinting with traditional epidemiological tools, public health programs can achieve a more comprehensive approach to TB control. This synergy ensures efficient use of resources and enhances the effectiveness of prevention strategies. Ultimately, fingerprinting serves as a cornerstone for both local and global TB elimination efforts.

Challenges and solution in implementing fingerprinting in rural areas

Advanced techniques like WGS require significant financial investment, which may strain the budgets of rural health departments. Fingerprinting requires trained personnel and specialized equipment, which may not be readily available in resource-limited settings. Effective use of fingerprinting data relies on collaboration between local, state, and national health agencies, which can be challenging in rural areas. To address

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these challenges, rural states can adopt the following strategies by collaborating with academic institutions and federal agencies can provide access to technical expertise and advanced technologies. Training local healthcare professionals in molecular techniques can build sustainable expertise. Advocating for federal and state funding can help offset the costs of fingerprinting technologies. Developing centralized databases for fingerprinting results can improve data sharing and analysis.

CONCLUSION

Fingerprinting *M. tb* is a powerful tool that enhances TB surveillance and control, particularly in rural states where resources are limited, and geographical challenges complicate healthcare delivery. By tracking transmission patterns, detecting outbreaks, and guiding targeted interventions, fingerprinting enables rural health departments to address TB more effectively. With adequate funding, training, and collaboration, this innovative approach can significantly improve public health outcomes in rural communities.