A Retrospective Cohort Comparing the Tuberculosis Diagnosis Related Costs and Health Resource Use (HRU) Using a Rapid Nucleic Acid Amplification (NAA) Test Vs. Conventional Tests in China, Followed By a Budget Impact Model
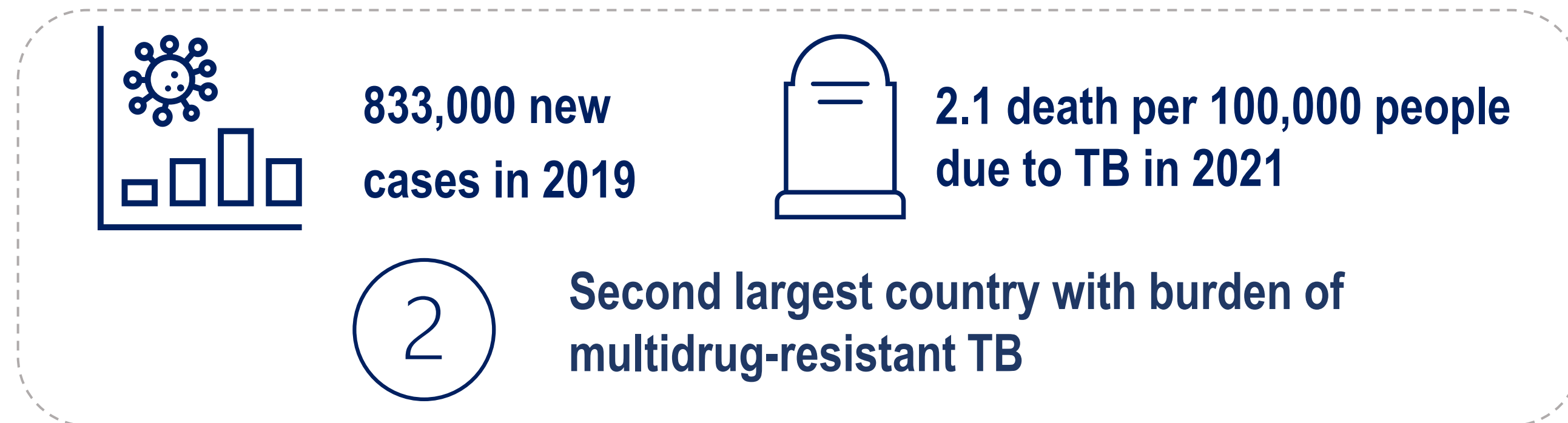
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BACKGROUND AND AIM

- Approximately 19 million new tuberculosis (TB) cases were reported in China from 1997 to 2018. Although TB incidence and mortality rates have decreased in recent years, TB is still an urgent public health issue in China. [1,2]

  - **833,000 new cases in 2019**
  - **2.1 death per 100,000 people due to TB in 2021**
  - **2** **Second largest country with burden of multidrug-resistant TB**

- The WHO has recommended using nucleic acid amplification (NAA) tests for diagnosis of TB and drug-resistant TB, mainly due to the high accuracy.[3]
- Combined with computed tomography (CT), a NAA test was recently introduced to China, which can simultaneously detect Mycobacterium tuberculosis complex (MTBC) and resistance to rifampin (RIF) in less than 2 hours.
- We aimed to compare the healthcare resource utilization (HRU) and costs associated with TB diagnosis using the NAA test vs. conventional tests and to estimate the budget impact of introducing the NAA test for patients with TB symptoms from a hospital's perspective in China.

METHODS

Retrospective cohort study

- **Population**: TB patients from 11 hospitals in China with suspected TB symptoms
- **Exposure**: the NAA test vs. conventional tests for TB diagnosis
- **Main outcomes:** hospital length of stay (LOS), costs for diagnostic anti-inflammatory therapies, and TB diagnosis costs.
- **Statistical analysis method**: the outcomes were compared using linear regressions controlling for potential confounders based on a *prior* (i.e., patient demographic and social economic status, TB symptoms, TB drug-resistant status)

Budget impact model

- **Overview**: the model assessed the differences in total hospital costs before and after adding the NAA test to the TB diagnostic methods from a hospital's perspective
- **Comparators**: CT + NAA test; CT + sputum smear (SS) + Interferon-gamma (IG)/solid culture (SC)/liquid culture (LC)
- **Healthcare costs associated with TB diagnosis were calculated based on:**

  - *Epidemiology of TB*
  - *Labor costs of laboratory technicians*
  - *Other hospital operating costs*

- **Model inputs**
  - Epidemiology inputs from the published literature were used to estimate the number of patients with TB symptoms, and patients with drug-resistant TB.
  - The test handling time was based on the published literature.
  - Labor costs of doctors and nurses were based on literature, while other hospital costs were based on assumptions. (**Table 1**)

Table 1. Model inputs[4-6]

Parameters	Model inputs	Notes & reference
Patients with TB symptoms	20.0%	Assumption + expert opinion
Prevalence of TB drug resistant	11.4%	Mingxia, J., et al 2022[4]
The test handling (hour) and sensitivity of each method	• CT + NAA: 0.5; 84.0% • CT + SS + LG: 1; 62.7% • CT + SS + SC: 3; 65.5% • CT + SS + LC: 3; 65.5% • Drug resistance testing: 1; 100%	• Handling time: expert opinion; averaged of each participating hospitals • Sensitivity: CDC, 2023[5]; assumption for CT + SS+ LG
Labor costs of technician (per day)	¥350	Dang, W., et al 2020[6]
Other hospital operating costs (per day)	¥2,000	Expert opinion

RESULTS

Retrospective cohort study

- Among 991 TB patients, 370 and 621 patients were diagnosed with and without the NAA test, respectively. Patient characteristics were shown in **Figure 1.**
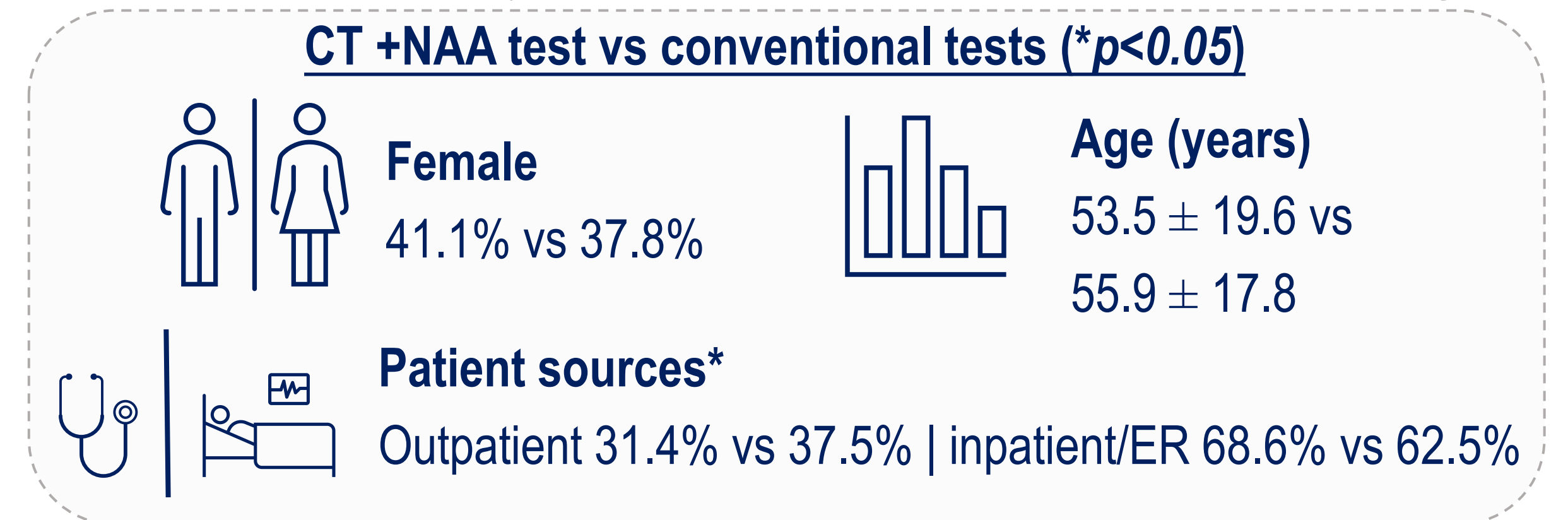
CT +NAA test vs conventional tests (*p<0.05*)

- **Female** 41.1% vs 37.8%
- **Age (years)** 53.5 ± 19.6 vs 55.9 ± 17.8
- **Patient sources*** Outpatient 31.4% vs 37.5% | inpatient/ER 68.6% vs 62.5%

Figure 1. Patient characteristics (n = 991)

- Compared to the conventional tests, TB patients diagnosed with the NAA test had (**Figure 2**)
  - 0.7 days shorter adjusted average LOS;
  - ¥1,592 lower adjusted average costs of diagnostic anti-inflammatory therapies;
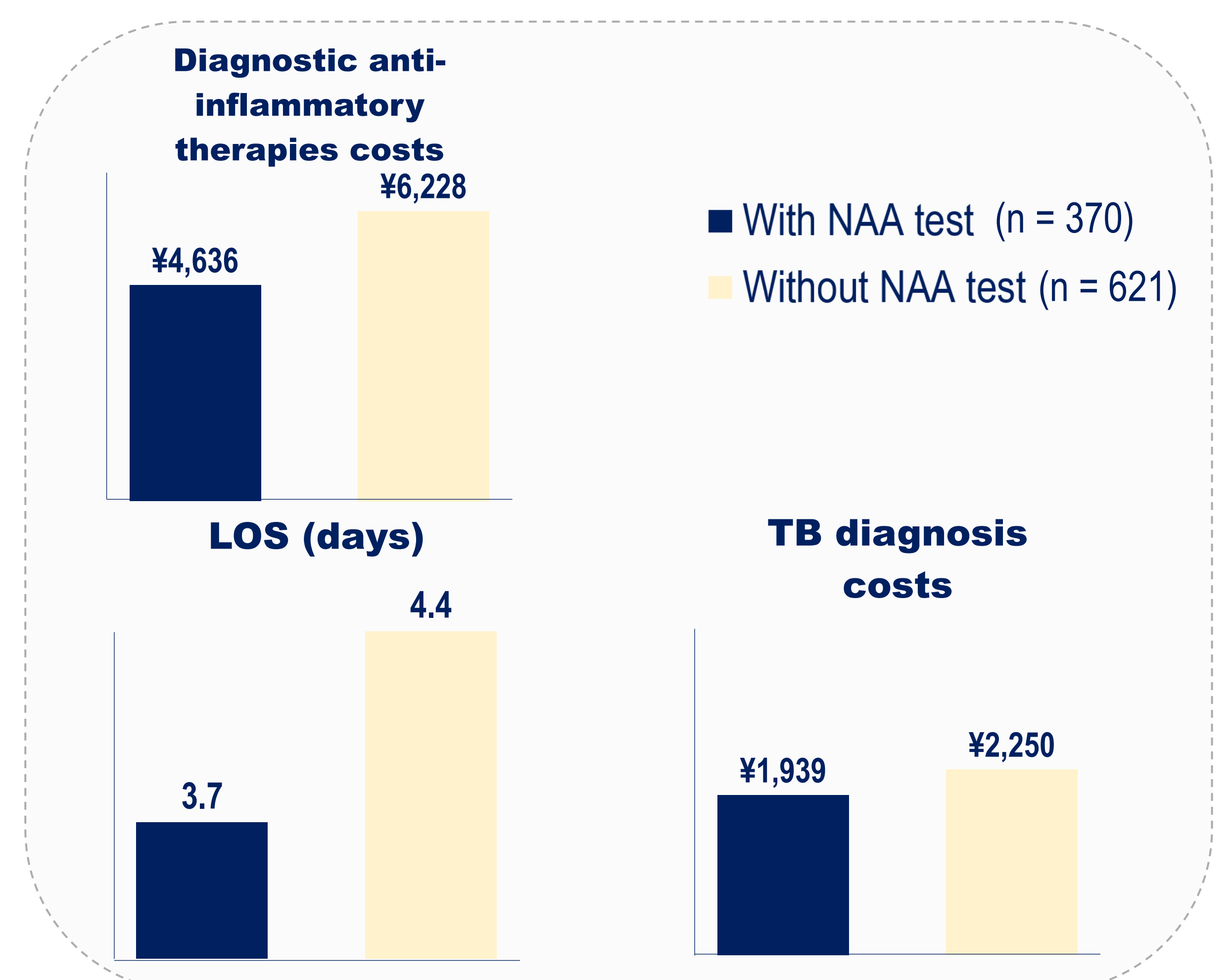 - ¥311 lower adjusted average TB diagnosis costs.

Diagnostic anti-inflammatory therapies costs: ¥4,636 / ¥6,228

With NAA test (n = 370)
Without NAA test (n = 621)

LOS (days): 3.7 / 4.4

TB diagnosis costs: ¥1,939 / ¥2,250

Figure 2. Diagnostic anti-inflammatory therapies, LOS, TB diagnosis costs comparing NAA test with conventional tests (n = 991)

Budget impact model (Figure 3)

- In the base case, 60,000 patients with TB symptoms were eligible for TB tests in a hypothetical hospital population of 300,000 patients.
- Adding the CT + NAA test decreased hospital costs by ¥ 5.3 million per year. The hospital budget decrease was mainly due to the shorter time to process the CT + NAA test (total time used per year before vs. after market entry: 180,000 hrs vs. 135,411 hrs [Δ= 44,588 hrs]).
- The total hospital costs were most sensitive to hospital operating costs.

With CT + NAA test: ¥6,295.75 / ¥11,250.00 — Δ = ¥5,329
Without CT + NAA test: ¥7,875.00 / ¥15,000.00

¥0 ¥5,000 ¥10,000 ¥15,000 ¥20,000 ¥25,000
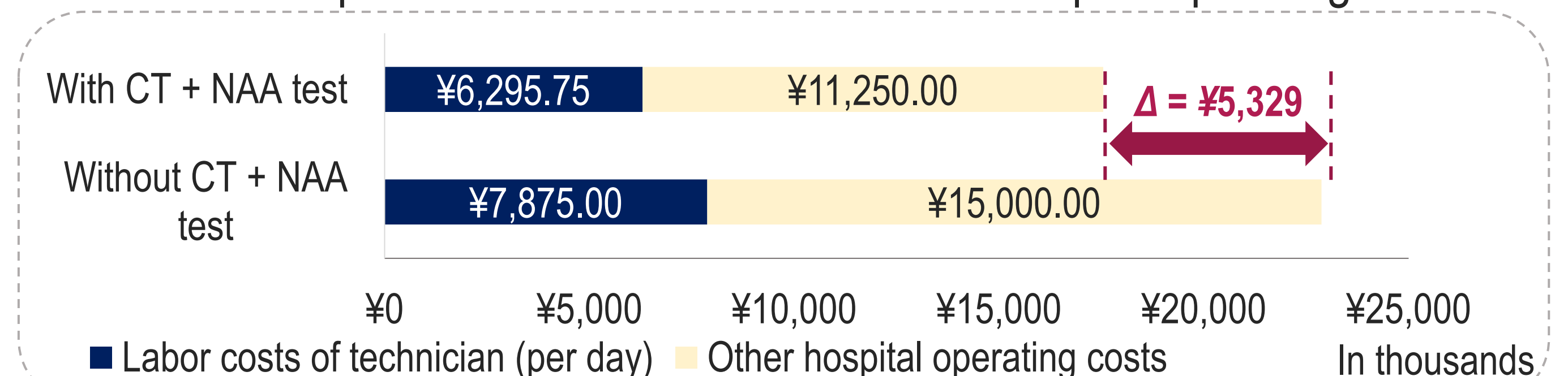■ Labor costs of technician (per day) Other hospital operating costs In thousands

Figure 3. Budget Impact Results – Total Hospital Costs per Year (n = 60,000)

CONCLUSION

Introducing the NAA test for TB diagnosis may reduce HRU and total costs for each patient. It may also offer a budget-saving option from a hospital's perspective in China.

REFERENCE

1. Wang, Y.S., Zhu, W.L., Li, T., Chen, W. and Wang, W.B., 2021. Changes in newly notified cases and control of tuberculosis in China: time-series analysis of surveillance data. Infectious Diseases of Poverty, 10, pp.1-10.
2. Yu, S., Ma, J. and Jia, Z., 2020. Estimating the Incidence of Tuberculosis—Shanghai, China, 2025– 2050. China CDC Weekly, 2(52), p.995.
3. Update on the use of nucleic acid amplification tests to detect TB and drug-resistant TB: rapid communication. Geneva: World Health Organization; 2021. Licence: CC BY-NC-SA 3.0 IGO.
4. Mingxia, J., Zhaofen, W., Binzhong, M., Xiuzhen, C., Rong, W., Yongcheng, M., Bin, L., Chaocai, W., Erchen, L., Yujia, W. and Yongxue, L., 2022. Epidemiological characteristics of rifampicin-resistant and multidrug-resistant tuberculosis in Qinghai. 疾病监测, 37(3), pp.1-4.
5. Zhao, YL, 2006. Tuberculosis control and diagnostic guide. China Centers for Disease Control and Prevention
6. Dang Wangwang, & Wang Zhen. (2020). A Comparative Study of Doctors' Income Gap between OECD Countries and China. China's Health Economy.