Impact of interventions for tuberculosis prevention and care in South Africa - a systematic review of mathematical modelling studies

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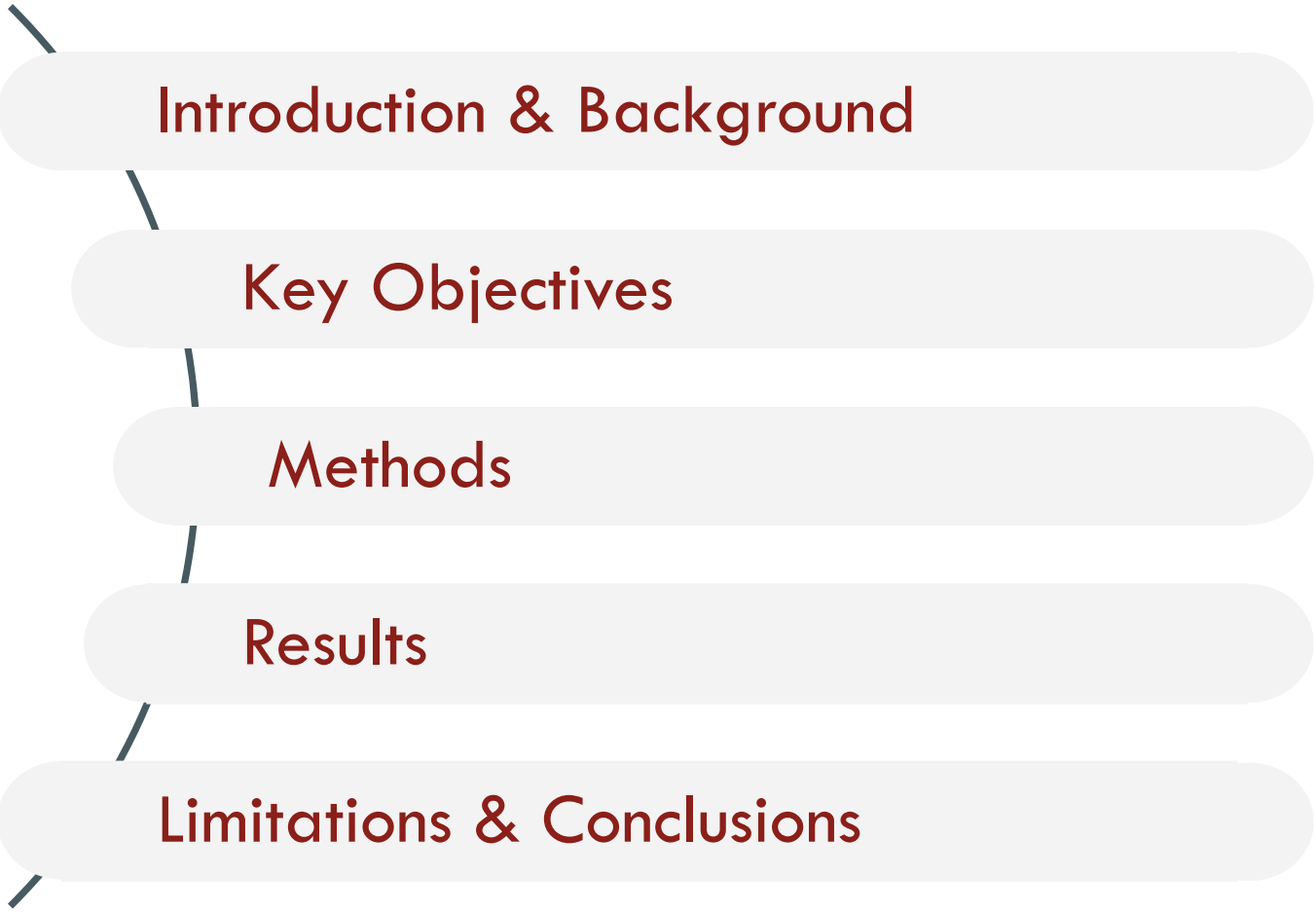
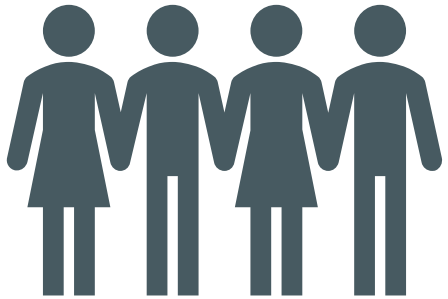
Overview


Introduction & Background
Key Objectives
Methods
Results
Limitations & Conclusions

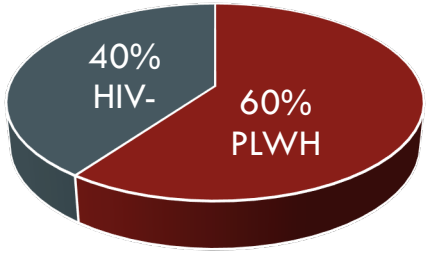
South Africa's ongoing TB epidemic



In 2021 ~**304,000** people developed TB and ~**55,000** people died from the disease

HIV

~60% TB deaths were PLWH in 2021



COVID-19

Diversion of key resources & lack of patient access to care

WHO's End TB Strategy

* Source: WHO End TB Strategy Framework

End TB Strategy Targets*

Countries should aim to reach the targets by 2035.

1

90%

Reduction in TB incidence.

2

95%

Reduction in number of TB deaths.

3

0%

Threshold for TB-affected households facing catastrophic costs.

* Source: WHO End TB Strategy Framework

Introduction

- South Africa reduced the TB incidence rate by 20% in 2020, but the country is **unlikely to reach the 2035** goals.
- Substantial efforts are needed to **prevent, find and successfully treat TB** in South Africa
- Evidence from **mathematical modelling** research on **interventions** to reduce TB **incidence, mortality** and TB-related **costs** in South Africa had not been systematically assessed prior to this paper.

Key objectives

1. Systematically review **TB transmission-dynamic modelling** studies that estimated the **impact of interventions** on population-level TB **incidence and/or mortality** in **South Africa.**

2. Determine which **interventions** had the **most promising** estimated impact on population-level outcomes linked to the **WHO's End TB Strategy.**

3. **Highlight gaps** in TB modelling research.

Methods

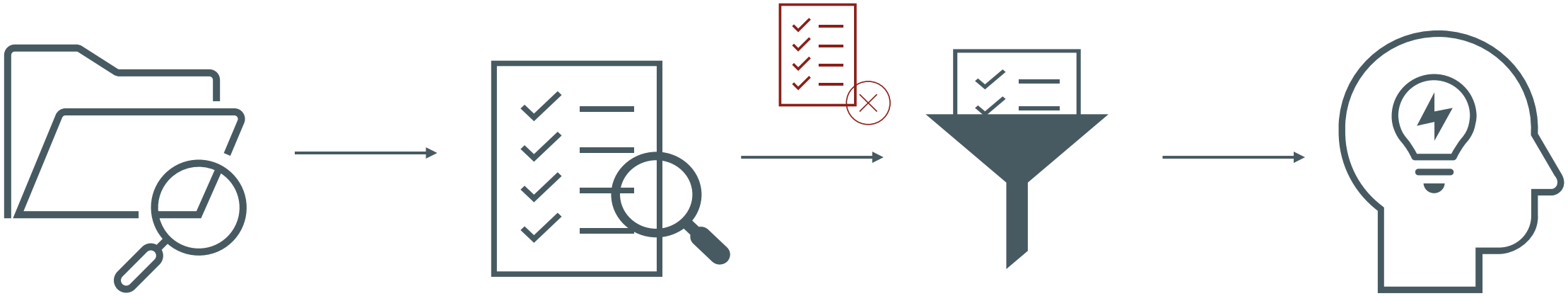
Inclusion criteria

- Transmission dynamic model of TB
- Population-based model
- South African population at country or sub-country level
- Model the impact of an intervention(s)
- Estimate reductions in TB incidence and/or mortality
- Estimate impact towards WHO's End TB strategy targets

Exclusion criteria

- Model type other than transmission dynamic
- Non-South African population
- No intervention
- Review/ commentary

Methods



Literature search

- Web of Science
- PubMed
- Scopus
- TB MAC
- Global Index Medicus
- African Index Medicus

Abstract and full-text screening

Two reviewers

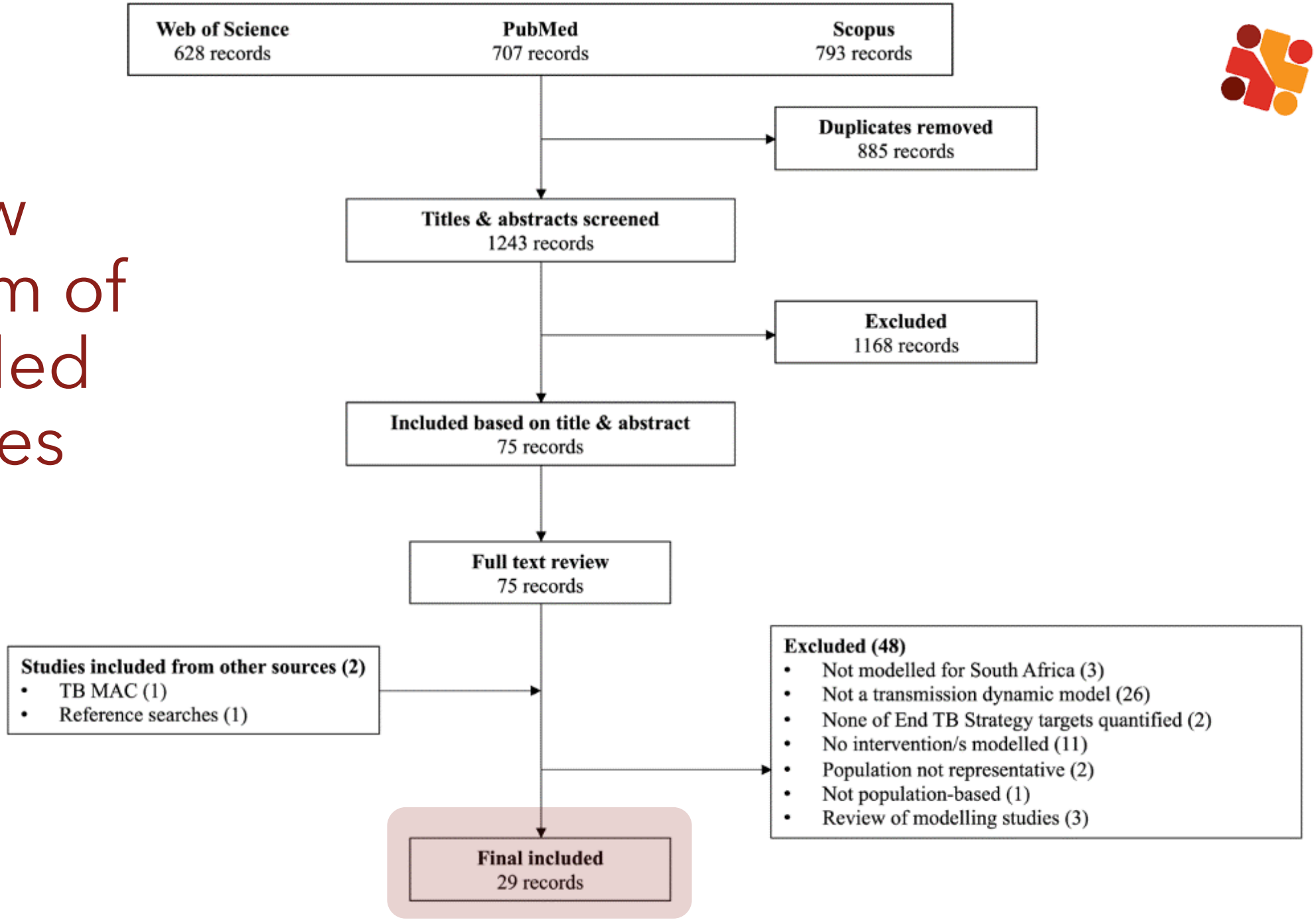
Data extraction

Narrative synthesis of findings

Summarize and compare results from final studies

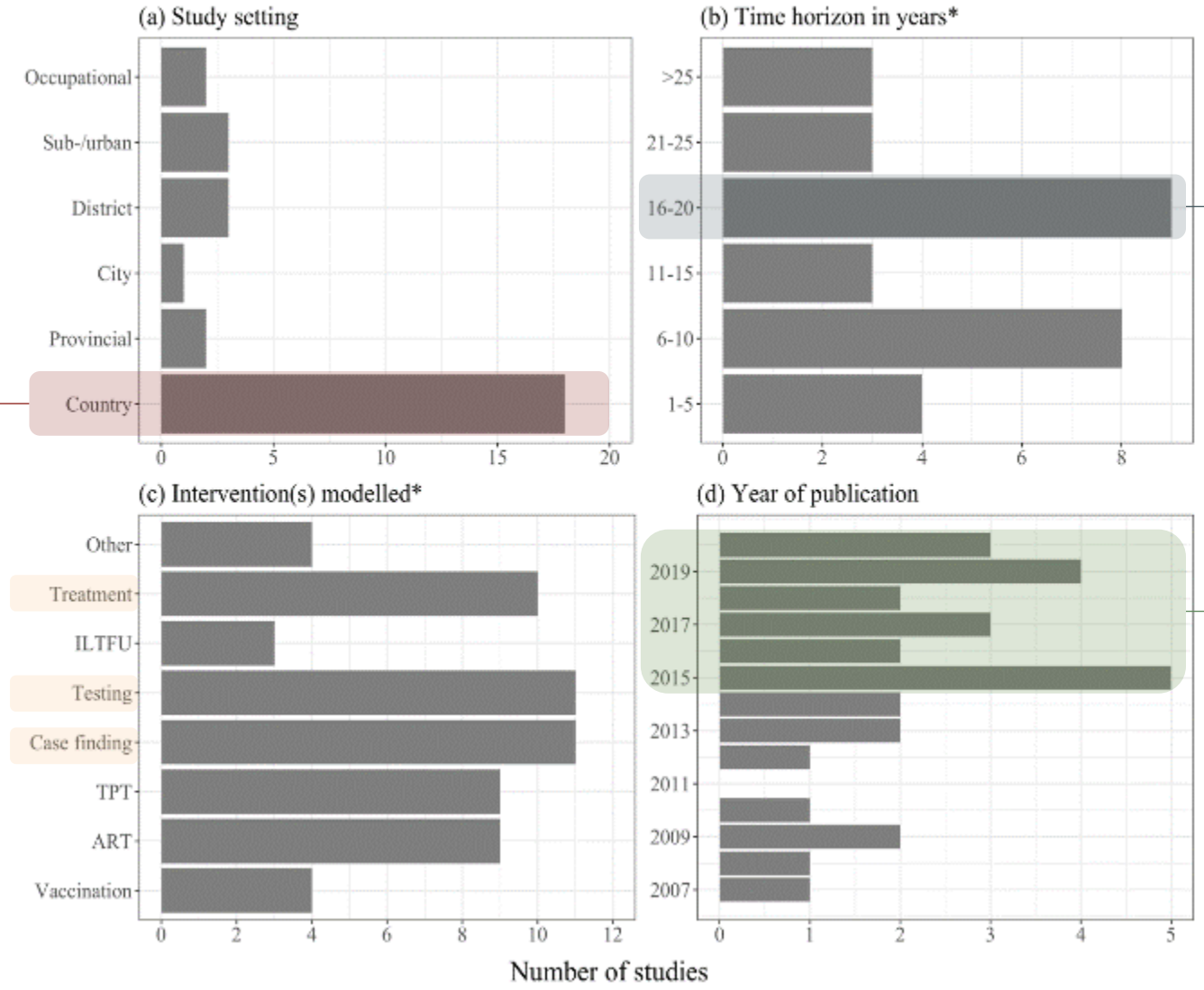
RoB Assessment

Flow diagram of included studies



Data extraction summary

Eighteen studies modelled at **country-level**



Nine had time horizons between 16 and 20 years

Majority published in the last 6-7 years

Risk of Bias Assessment

Study	Risk of Bias item														Final Score	Quality Grading
	Aims & Objectives	Setting & Population	Interventions & Comparators	Outcome measures	Model structure & Time horizon	Modelling methods	Parameters, Ranges & Data sources	Assumptions	Quality of data & Exploration of uncertainty	Methods of fitting	Model validation	Results	Interpretation & Discussion of results	Funding sources & Conflicts of interest		
Azman *et al.* (58)	2	1	1	2	2	2	1	1	2	1	0	2	2	2	21	High
Basu *et al.* (59)	2	1	1	2	2	2	2	2	2	2	2	2	2	2	26	Very High
Basu *et al.* (60)	2	2	2	2	2	1	2	2	2	2	0	2	1	1	23	Very High
Chindelevitch *et al.* (61)	2	2	2	2	2	2	2	1	2	2	1	2	2	2	26	Very High
Dowdy *et al.* (62)	2	2	2	2	2	1	1	2	2	1	0	2	2	1	22	High
Dye *et al.* (63)	2	2	2	1	2	1	1	1	1	2	0	1	1	2	19	High
Dye *et al.* (64)	2	2	2	2	1	2	2	2	1	2	0	2	1	1	22	High
Gilbert *et al.* (65)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	28	Very High
Gilbert *et al.* (66)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	28	Very High
Harris *et al.* (67)	2	2	2	2	2	2	2	2	2	2	0	2	2	2	26	Very High
Hippner *et al.* (45)	2	2	2	2	2	2	2	1	1	1	0	1	1	2	21	High
Houben *et al.* (40)	2	2	2	1	2	2	1	1	1	1	0	1	2	2	20	High
Kendall *et al.* (68)	2	2	2	2	2	2	2	2	2	2	0	2	2	2	26	Very High
Kendall *et al.* (69)	2	2	2	2	2	2	2	2	2	2	0	2	2	1	25	Very High

...

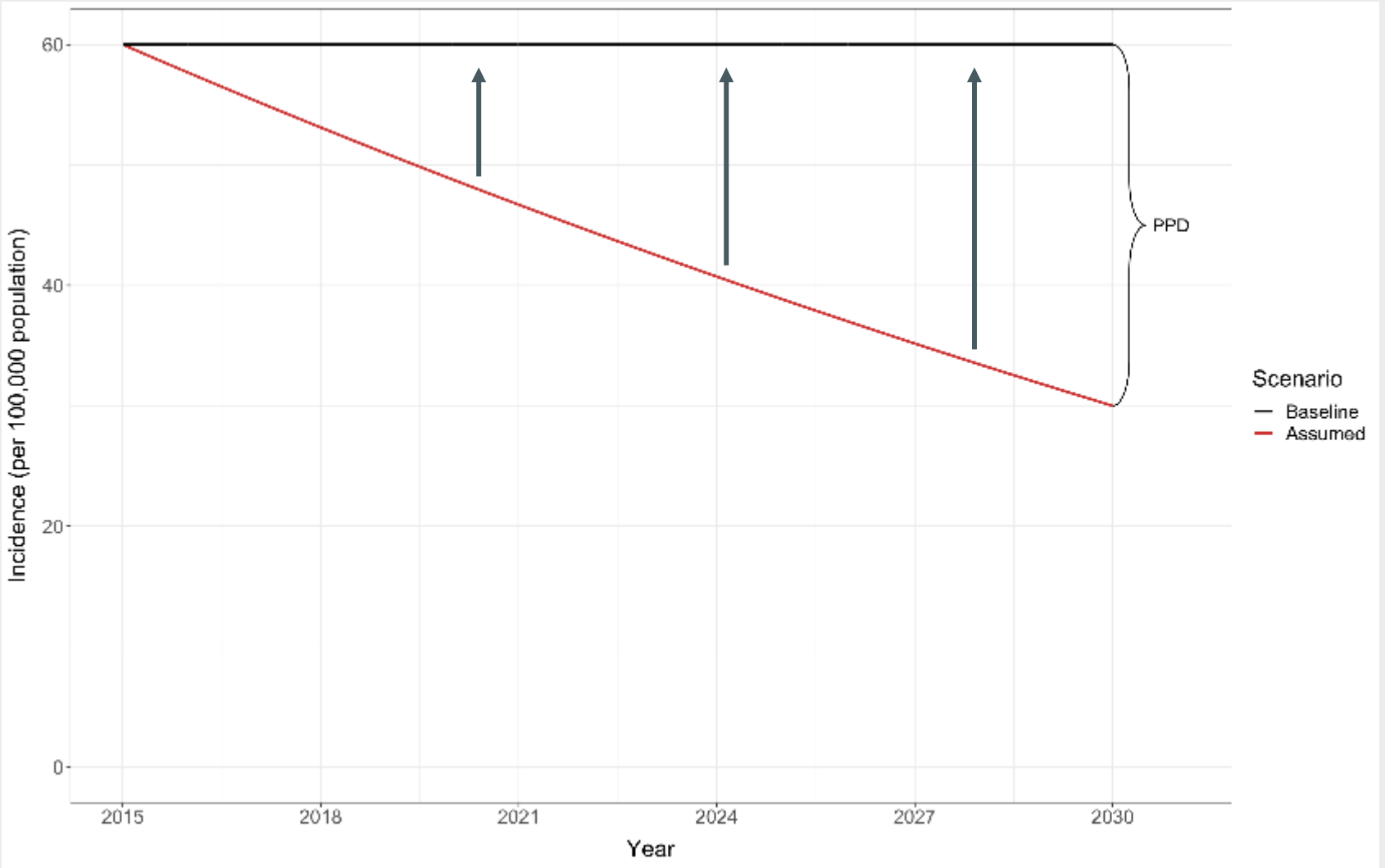
16 studies were of **very high quality,** and 13 of **high quality.**

Calculating AAPDs for comparison of intervention impact

Assumed Scenario

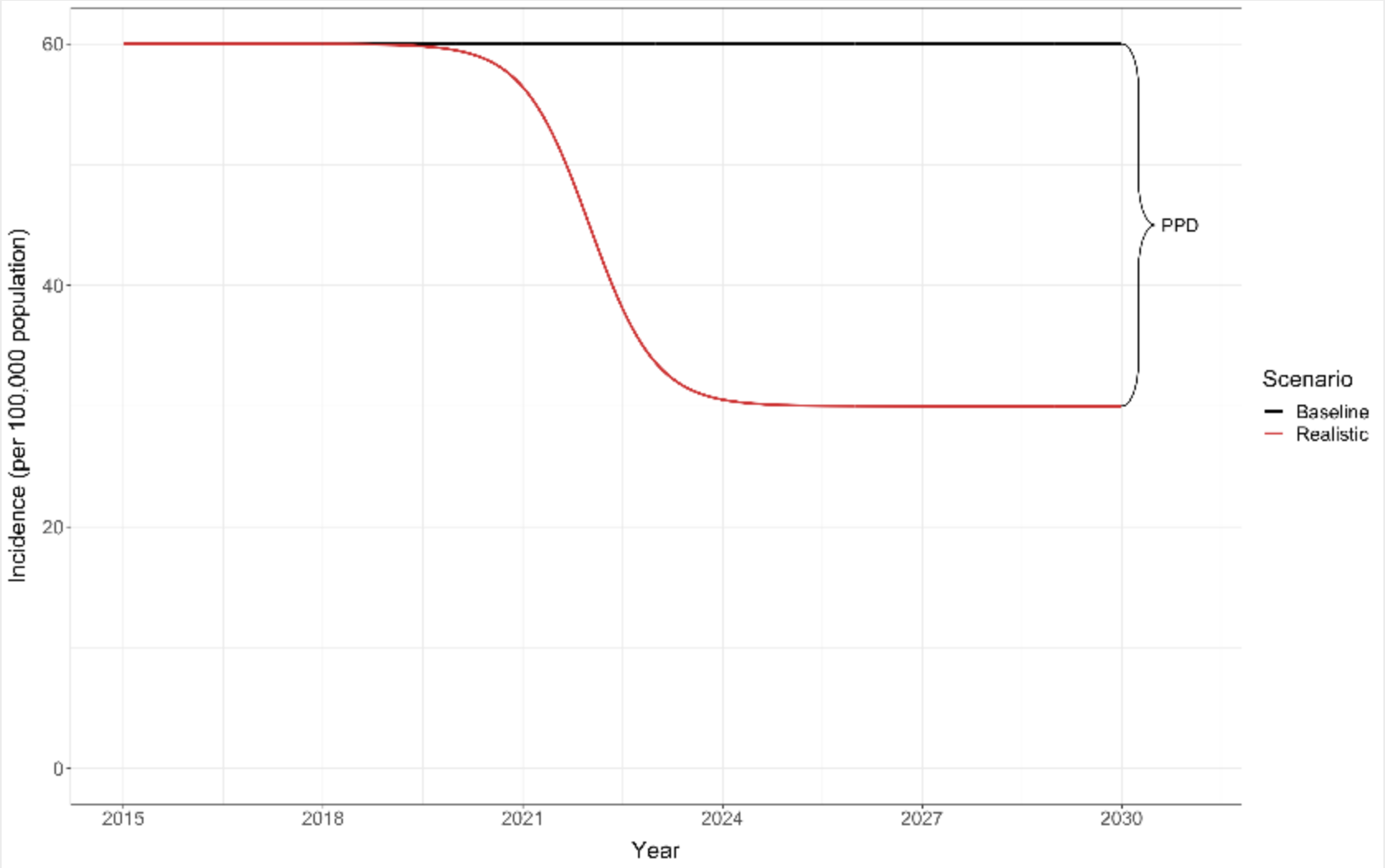
PPD: Period % decline = 30%
t: time horizon = 15 years
$AAPD$: Average annual % decline = 2.35%

$$\boldsymbol{AAPD = \left(1 - \sqrt[t]{1 - \frac{PPD}{100}}\right) \times 100}$$

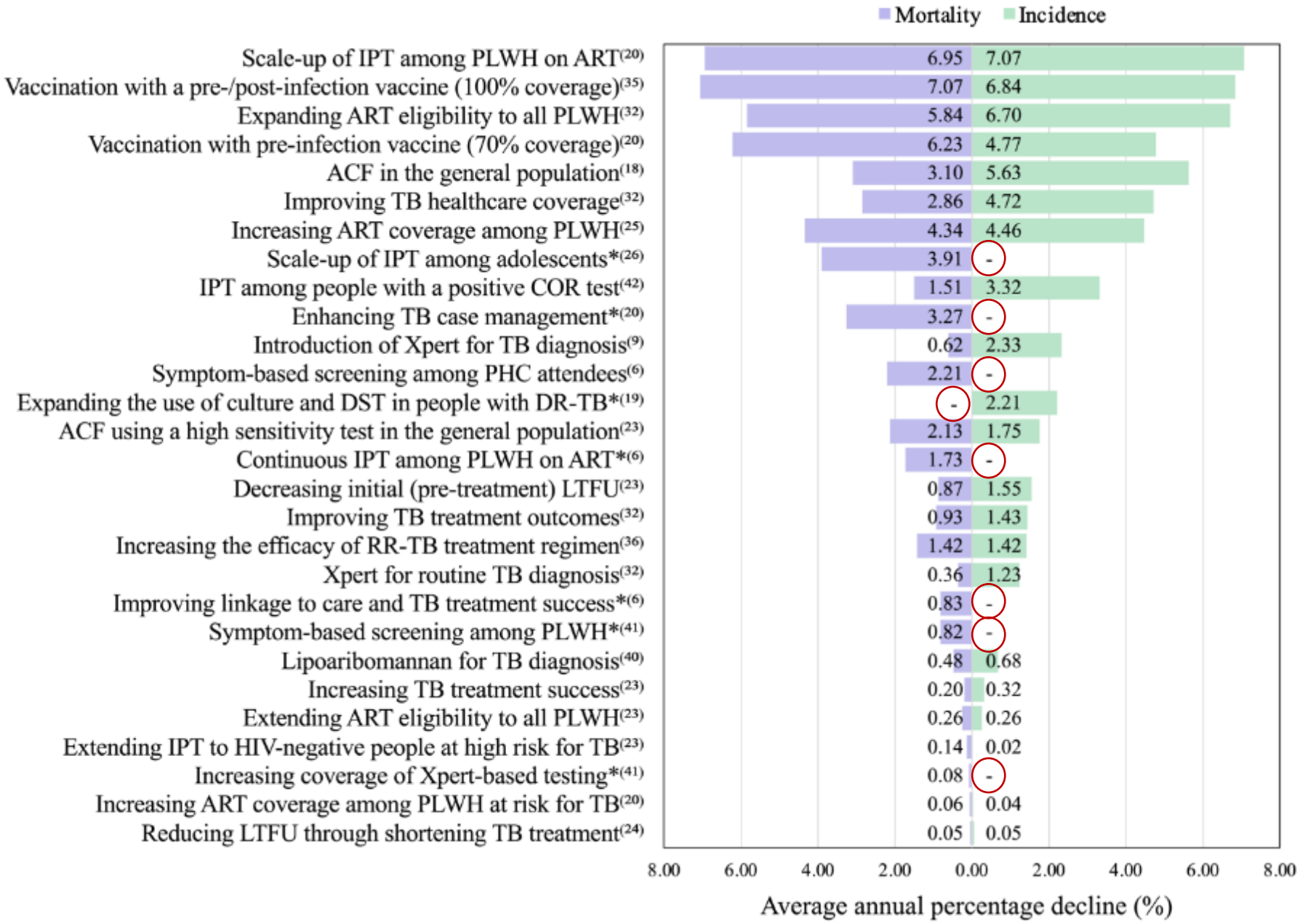


Calculating AAPDs for comparison of intervention impact

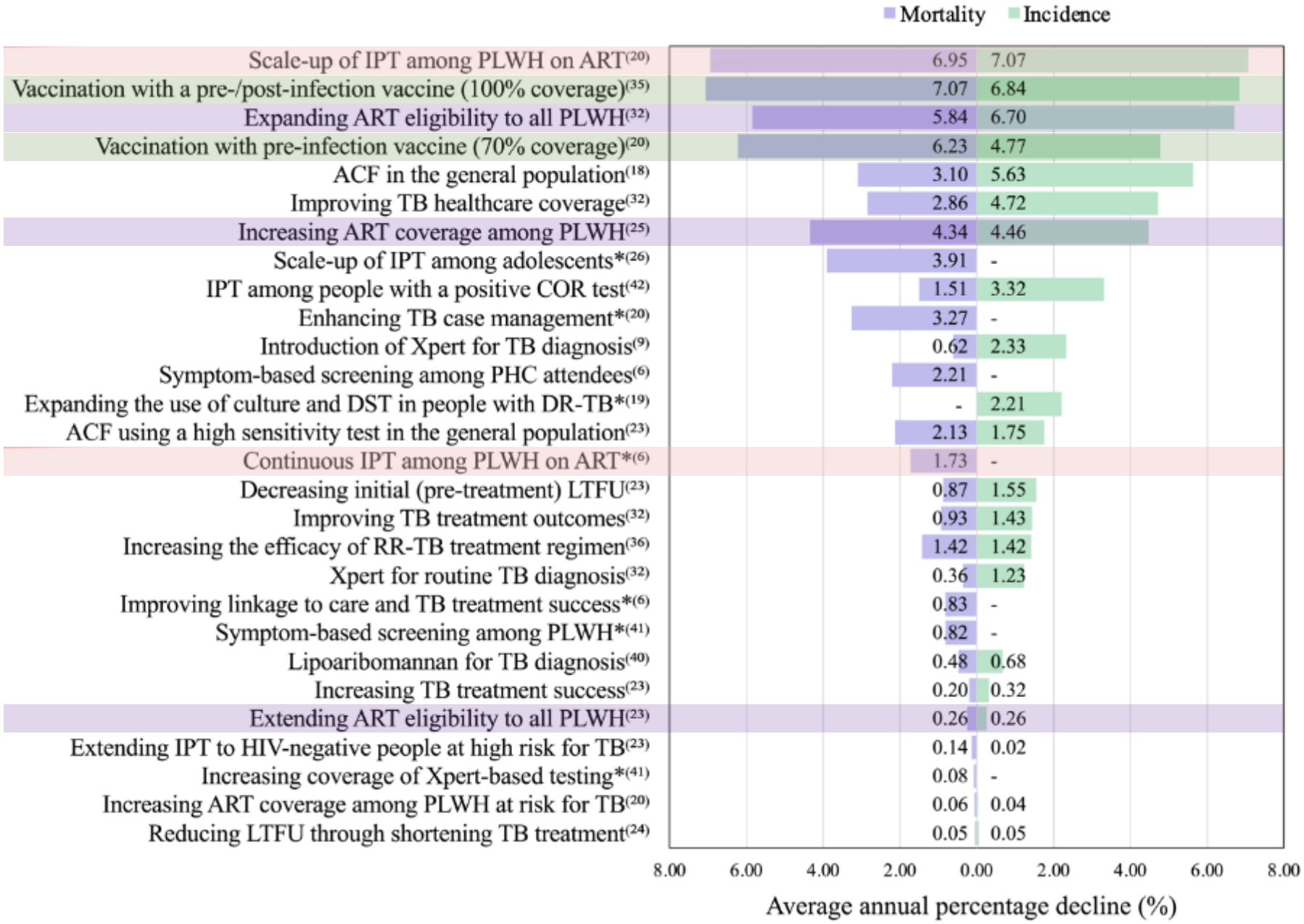
“Realistic” Scenario



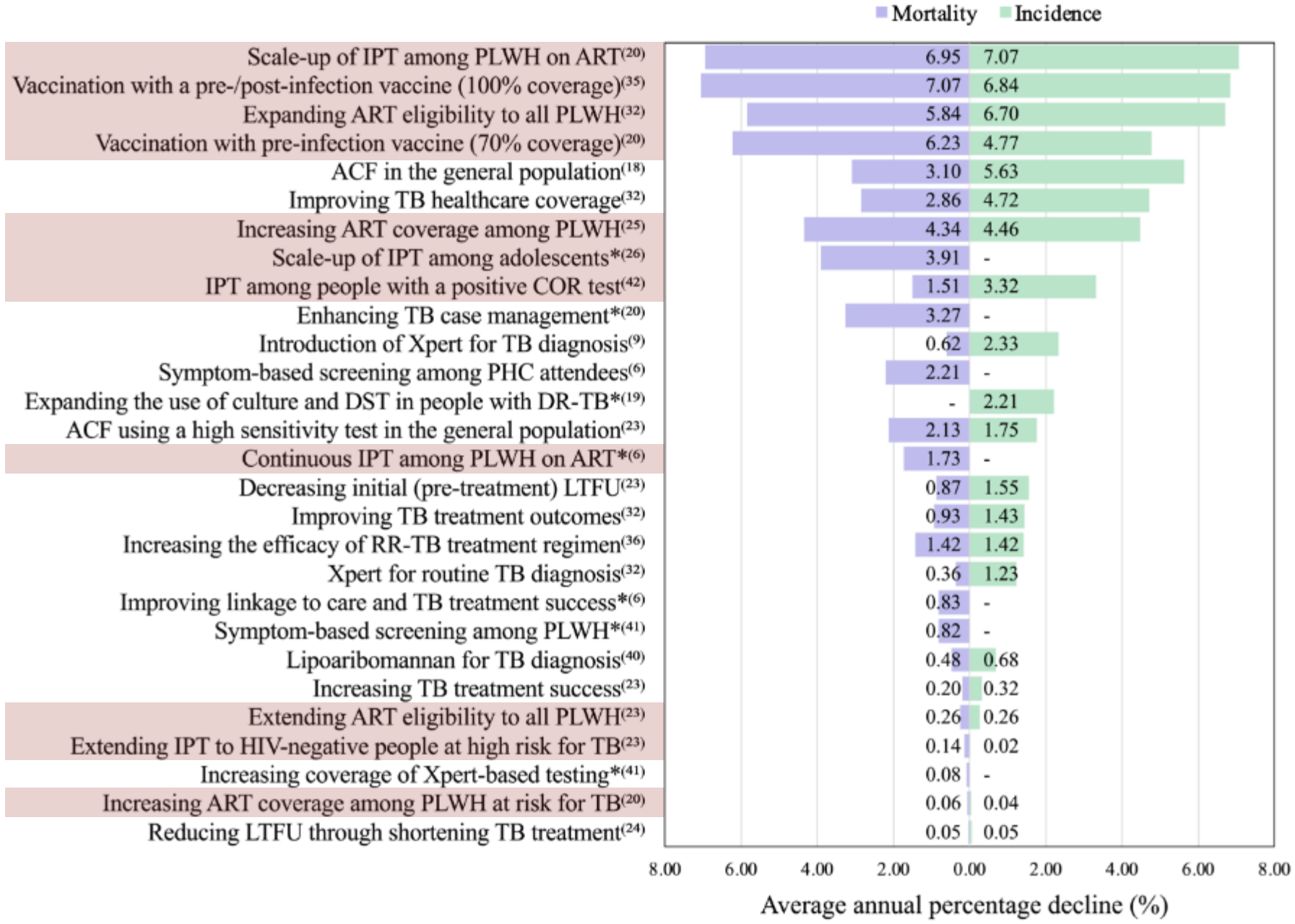
Impact of interventions on TB outcomes at **country-level**



Most impactful interventions estimated



Preventive
interventions
vs
care cascade
interventions



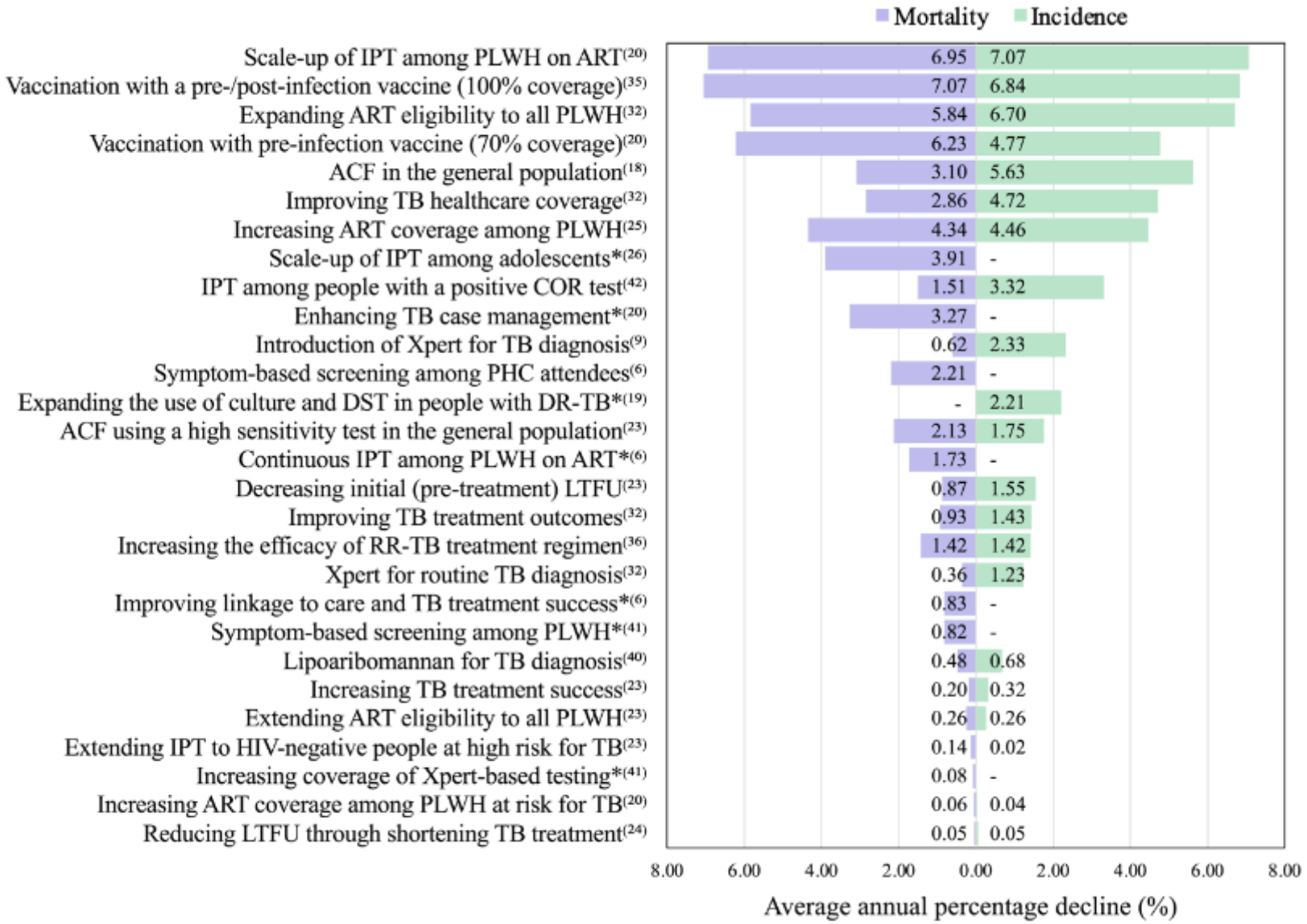
AAPDs required to meet **incidence** and **mortality** targets for South Africa

Incidence

12%

Mortality

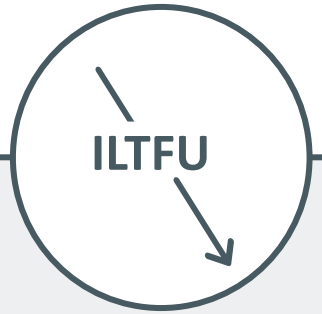
19%



Modelling gaps identified

Vulnerable groups for **case finding** initiatives

Novel diagnostic tests and **treatment regimens**



Reducing **ILTFU**

Cost-effectiveness of interventions

Reducing **catastrophic costs due to TB** - 3rd goal of the End TB Strategy

Limitations

- Restricted to **South African** population
- Findings from sub-country level studies may not be readily **generalizable** to the national level
- **Heterogeneity** in model structure, study design and reported outcomes
- Reported impact with **crude measures of AAPDs for single interventions,** many studies considered **combinations**
- If multiple scenarios were modelled, we chose the scenario resulting in the **highest impact**

Interventions to tackle TB in South Africa

Strategic focus on preventive interventions

Vaccination, TPT among PLWH and scaling-up ART were **most promising** to reduce TB incidence and mortality.

Consideration of care cascade interventions

Case finding initiatives and improving testing and treatment estimated to be of **lower impact** but does not negate significance.

Combinations of interventions

Needed to meet **WHO's End TB Strategy targets** in South Africa.

Thank you!

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