Largest Micronutrient Survey ever conducted: CNNS 2016-

112,316
Children and adolescents interviewed

51,029
Blood, stool and urine samples collected

360
Anthropometric measurers

30
Microscopists
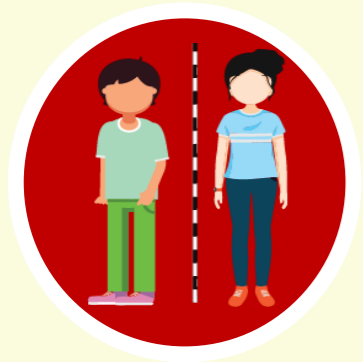
2500
Survey personnel in 30 states

100
Data Quality assurance monitors

200
Lab technicians

900
Interviewers

200
Trainers and coordinators

360
Phlebotomists

Justification and

- To assess the prevalence of malnutrition in both children and adolescents with special focus on assessment of micronutrient deficiencies through biochemical measures.

- To identify determinants and associations of various risk factors for anaemia in both children and adolescents.

- To assess biomarkers for hypertension, diabetes, cholesterol and kidney function and their associations with various risk factors for Non-Communicable Diseases (NCDs).

Malnutrition is responsible for 68% of total under five mortality in India*

*Soumya Swaminathan, et al. (2019), The burden of child and maternal malnutrition and trends in its indicators in the states of India: the Global Burden of Disease Study 1990–2017. https://doi.org/10.1016/S2352-4642(19)30273-1

Birth to Adolescence

Survey Design

CNNS is a cross-sectional, household survey using a multi-stage sampling design.

CNNS covered **2035 Primary Sampling Units (PSUs)** from more than **82%** of all districts from the Census 2011 (516 out of 628 districts) across 30 states:
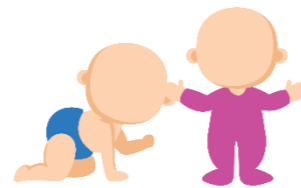
- 160 Districts- one PSU
- 356 Districts- two or more PSUs

District with more than one PSU
District with one PSU

CNNS
Birth to Adolescence
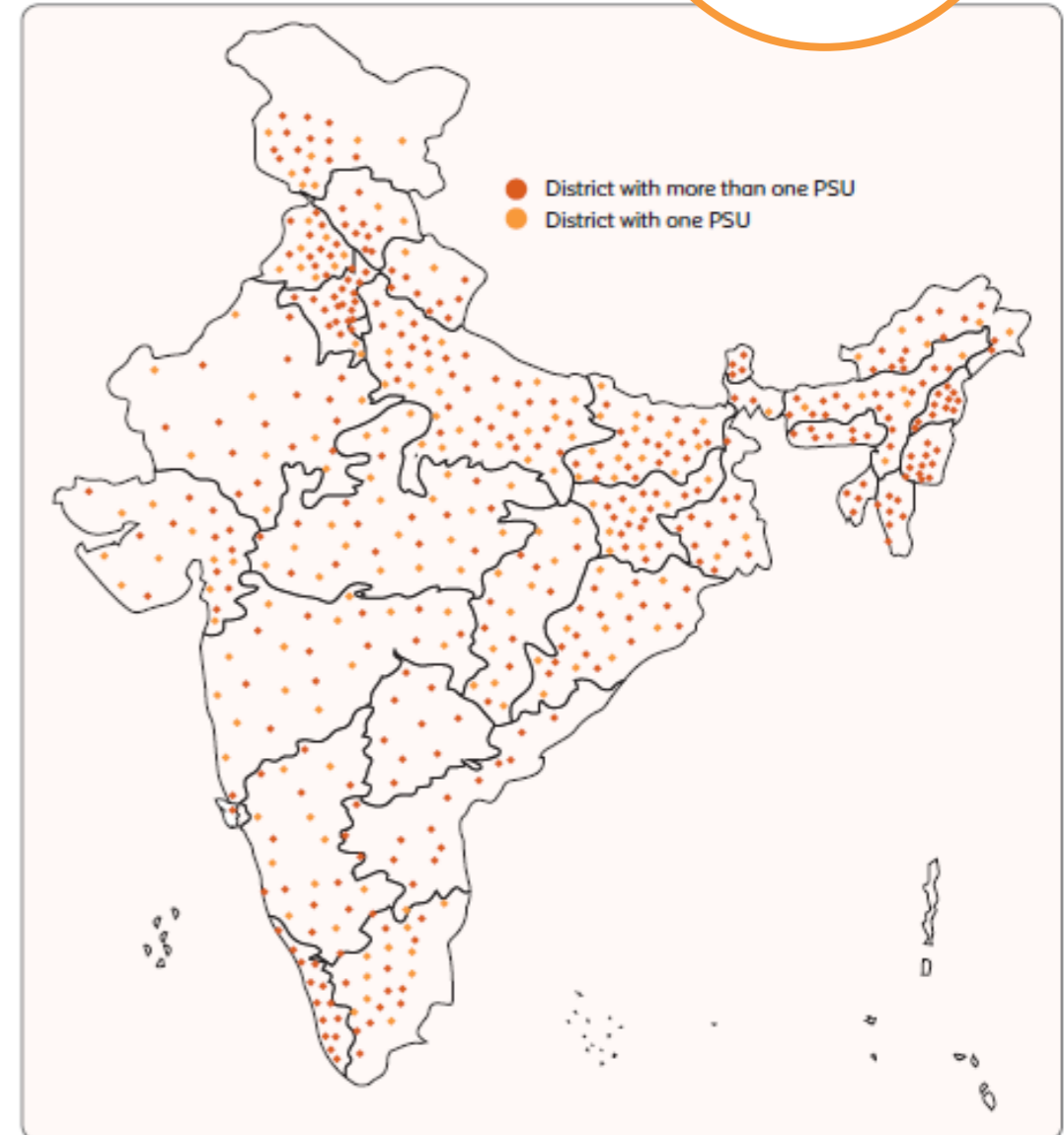
Anthropometry data

	Pre-school children (0-4 years)	School-age children (5-9 years)	Adolescents (10-19 years)
Anthropometric measurements	• Height • Weight • Mid-upper arm circumference (MUAC) • Triceps skinfold • Subscapular skinfold (1-4 years)		
		• Waist circumference	

5

Biochemical indicators - micronutrient deficiencies and NCDs

Indicator Group			
Anaemia and haemoglobinopathies	• Haemoglobin • Variant haemoglobins		
Inflammatory biomarkers	• C-reactive protein		
Protein	• Serum protein and albumin		
Micronutrients	• Iron: Serum ferritin, serum transferrin receptor • Vitamin A: Serum retinol • Zinc: Serum zinc • B-vitamins: Erythrocyte folate, serum B12 • Vitamin D: Serum 25 (OH) D • Urinary Iodine		
Non-communicable diseases		• Blood Pressure • Blood glucose, HbA1c • Lipid profile: Serum cholesterol, LDL, HDL, and triglycerides • Renal function: Serum creatinine, urinary protein creatinine ratio	

Monitoring and Supervision

Three-tiers of Data Quality Assurance

- Field work/protocol/training monitoring: by quality control team
- Biological sample quality control : by AIIMS, NIN and US CDC

- 3-member Data Quality Assurance (DQA) team for re-interviews & observations
- Concurrent monitoring of biological sample collection, storage and transportation by CDSA

- Internal monitoring by the Quality Control Observer
- Daily supervision of the field work by Team Supervisor

Team Composition for data collection

Team Supervisor   **Quality Control Observer**

Four Survey Investigators

Two Anthropometry Investigators   **Two Phlebotomists for biological sample collection**

CNNS
Birth to Adolescence

7
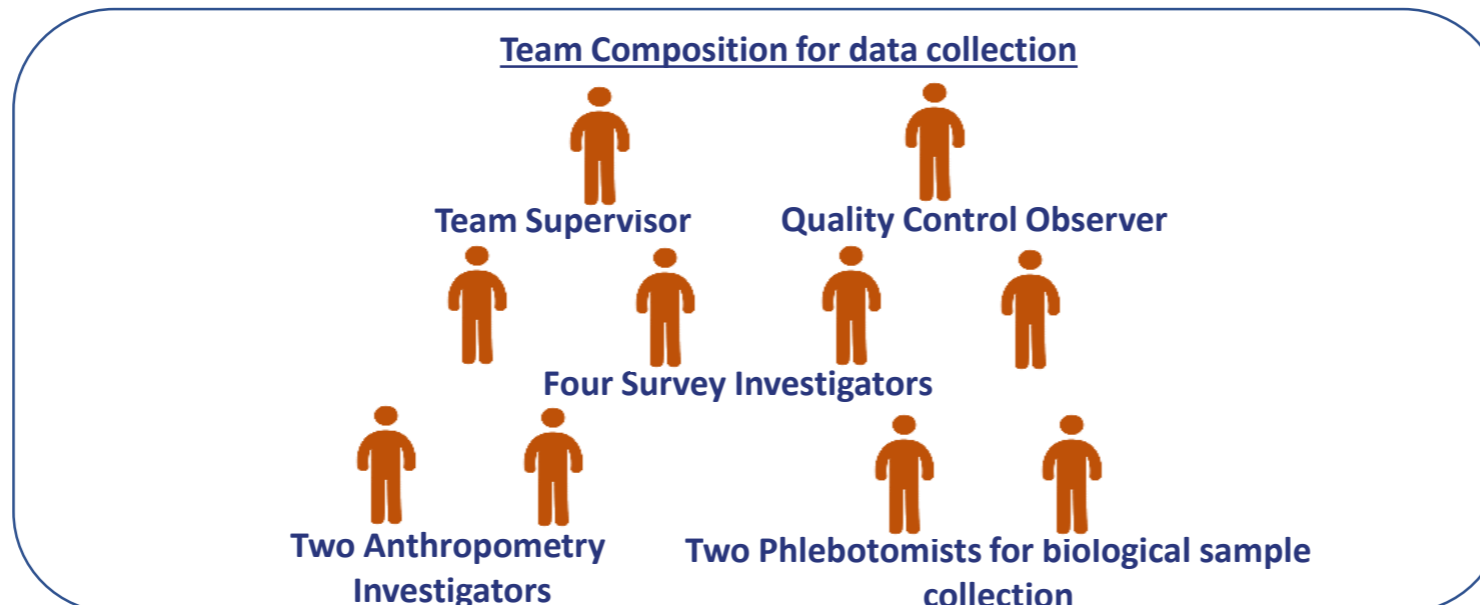
Quality Assurance Measures for Data Quality

Evaluation of Interviewers
prior to employment

Survey team
- Written and oral test
- Mock interview
- Ethics test

Anthropometry team
- Standardisation
- Selection based of demonstrated capacity measured by technical error of measurements (TEM)

Quality Assurance Measures

	DQA team conducted consistency checks, and provided feedback on real time basis
	No more than 4 interviews allowed in a day by an interviewer
	Daily SMS based monitoring/ alerts system for biological sample (from PSUs, collection points and reference labs).
	Sample transportation in thermal insulation bags maintaining temperature at 2-8° Celsius for up to 16 hours
	Time and temperature monitoring of samples by digital data loggers

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Birth to Adolescence

Agencies engaged in the implementation of CNNS

Survey Implementation by MoHFW, Government of India and supported by UNICEF

Technical support:
US Centre for Disease Control and UNICEF

Regular review and technical guidance: Technical advisory group constituted by MoHFW

Quality assurance and external monitoring: AIIMS, PGIMER, NIN, KSCH and CDSA

Overall field coordination, training, quality monitoring, data management and analysis: Population Council

Biological sample collection, transportation & analysis: SRL Limited

Survey and anthropometric data collection: IIHMR, Kantar Public, Gfk Mode and Sigma Consulting

Sample size in Maharashtra

CNNS covered 100 PSUs for data collection in Maharashtra

Achieved following sample size by age groups:

	0-4 years	5-9 years	10-19 years	Total
Household and anthropometry data	1,921	1,957	1,910	**5,788**
Biological sample	873	959	895	**2,727**

Birth to Adolescence

Period of data collection in Maharashtra

CNNS data collection period: November 14, 2016 to May 17, 2017

- CNNS collected data during the winter season of 2016 through summer season of 2017

- NFHS collected data during the summer season and monsoon season of 2015

Survey	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CNNS 2016-17	May, 2017										November, 2016 to	
NFHS 4 2015				April to September, 2015								

Birth to Adolescence

Maharashtra key findings: Anthropometry (1/2)

No significant reduction in stunting and underweight but some decline in wasting in children under 5 years

Legend: ■ NFHS ■ CNNS

Category	NFHS	CNNS
Stunting (Low height for age)	34.4%	34.1%
Wasting (Low weight for height)	25.6%	16.9%
Underweight (Low weight for age)	36.0%	30.9%

CNNS
Birth to Adolescence

1/4 adolescents aged 10-19 years was thin for their age (BMI-Age <-2SD)

1/4 children aged 5-9 years was stunted. The school age period does not provide an opportunity for catch up growth in height.

7% of adolescents aged 10-19 years were overweight.

6.9%

Overweight (high BMI for age)

Birth to Adolescence

NORMAL

OVERWEIGHT/
OBESITY
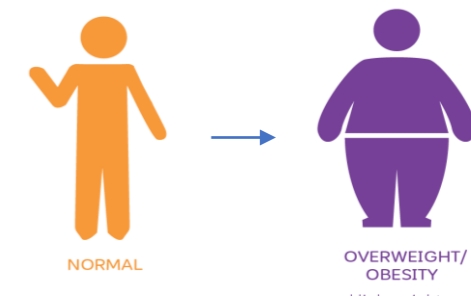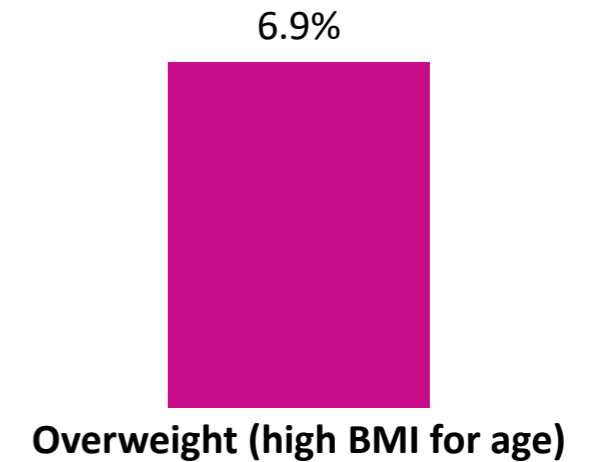
Stunting unchanged among children under five

Prevalence of stunting in Maharashtra was unchanged between CNNS and NFHS-4 – **34%**

Prevalence of stunting remained unchanged in all western states

Legend: NFHS-4, CNNS

	India	Goa	Gujarat	Maharashtra
NFHS-4	38.4	20.1	38.5	34.4
CNNS	34.7	19.6	39.1	34.1

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CNNS
Birth to Adolescence
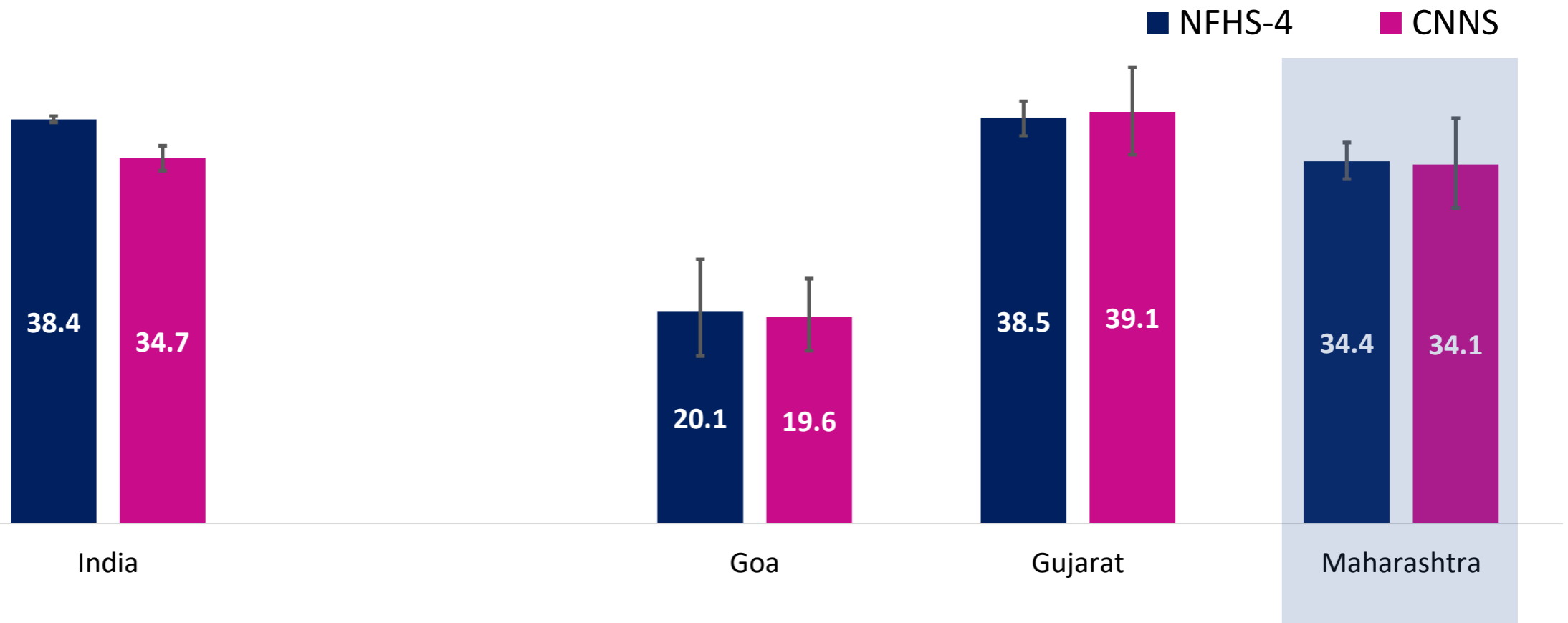
Wasting among children under five declined

Prevalence of wasting significantly declined in Maharashtra between NFHS-4 and CNNS – **26%** vs **17%**

In western region, prevalence of wasting significantly declined in Gujarat and Maharashtra

Legend: ■ NFHS-4 ■ CNNS

India: NFHS-4 21.0, CNNS 17.3
Goa: NFHS-4 21.9, CNNS 15.8
Gujarat: NFHS-4 26.4, CNNS 17
Maharashtra: NFHS-4 25.6, CNNS 16.9

CNNS
Birth to Adolescence
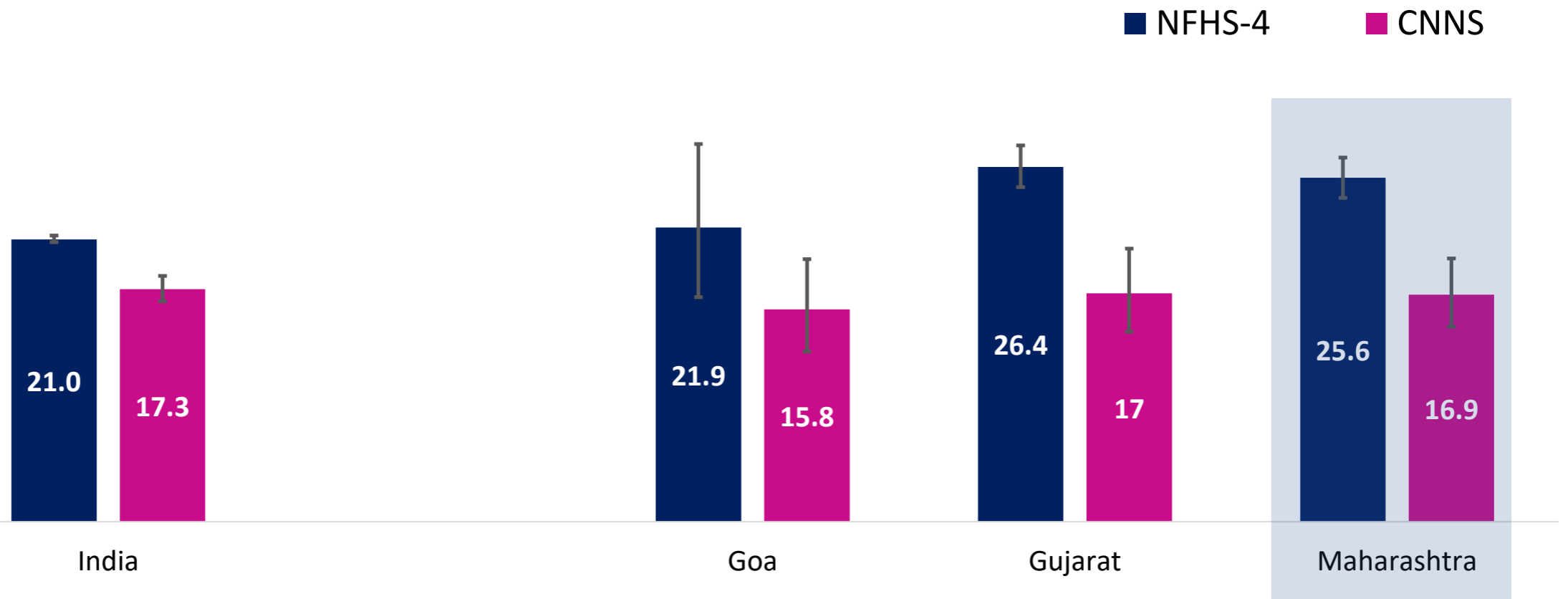
Prevalence of underweight among children under five unchanged
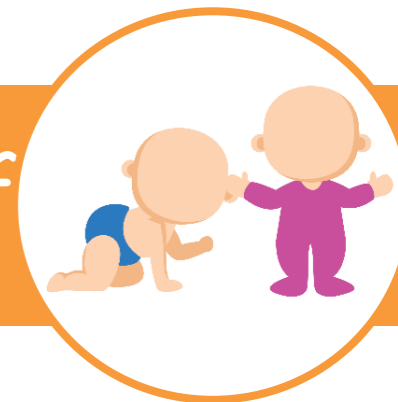
Underweight is a composite measure of chronic and acute malnutrition

The prevalence of underweight did not significantly decline between NFHS-4 and CNNS

Prevalence of underweight unchanged in all western states

■ NFHS-4   ■ CNNS

	India	Goa	Gujarat	Maharashtra
NFHS-4	35.7	23.8	39.3	36.0
CNNS	33.4	20.3	34.2	30.9

16

CNNS
Birth to Adolescence
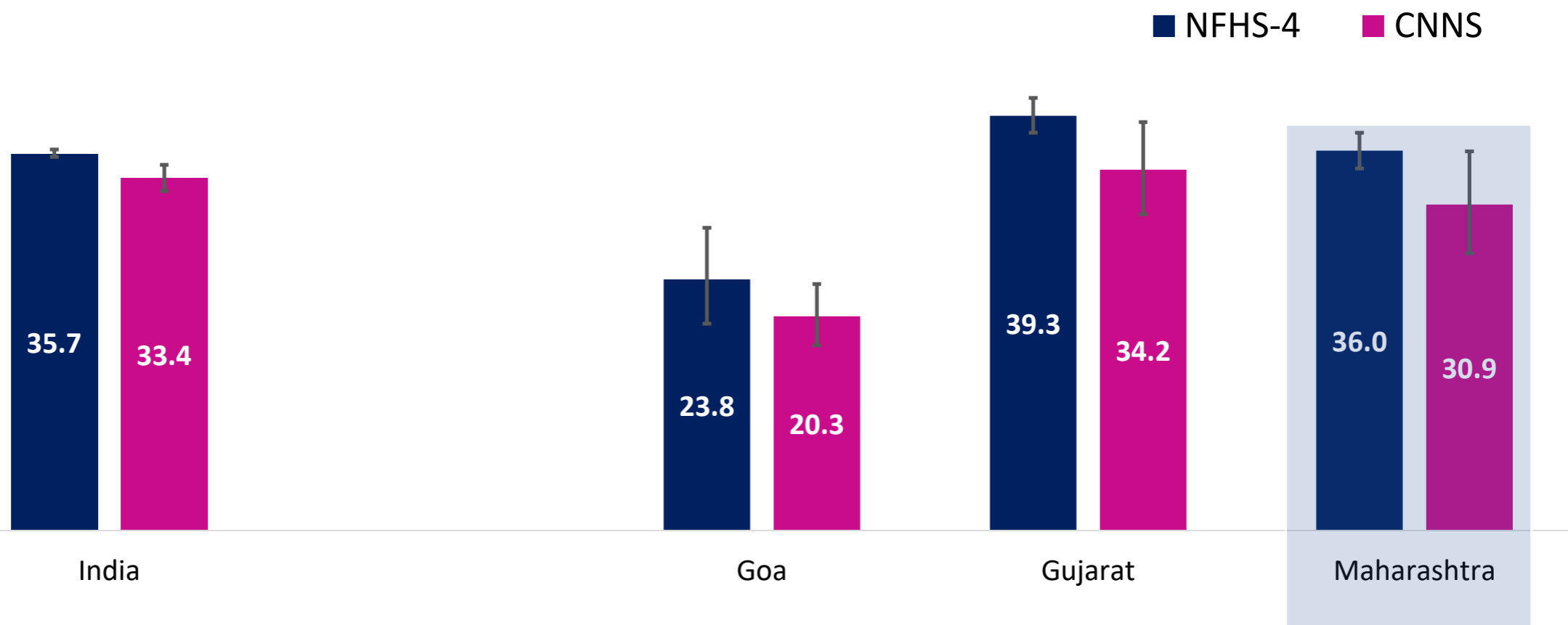
Triceps Skinfold Thickness (TSFT) for children under five

Low fat mass as reported by TSFT in Maharashtra was lower than other western states and half the national average

Legend: TSFT (-3SD to -2SD) ▨   TSFT (< -3SD) ■

State	TSFT (-3SD to -2SD) total	TSFT (< -3SD)
India	9.7	2.4
Goa	4.9	0.7
Gujarat	19.4	9.3
Maharashtra	4.2	1.2

CNNS
Birth to Adolescence
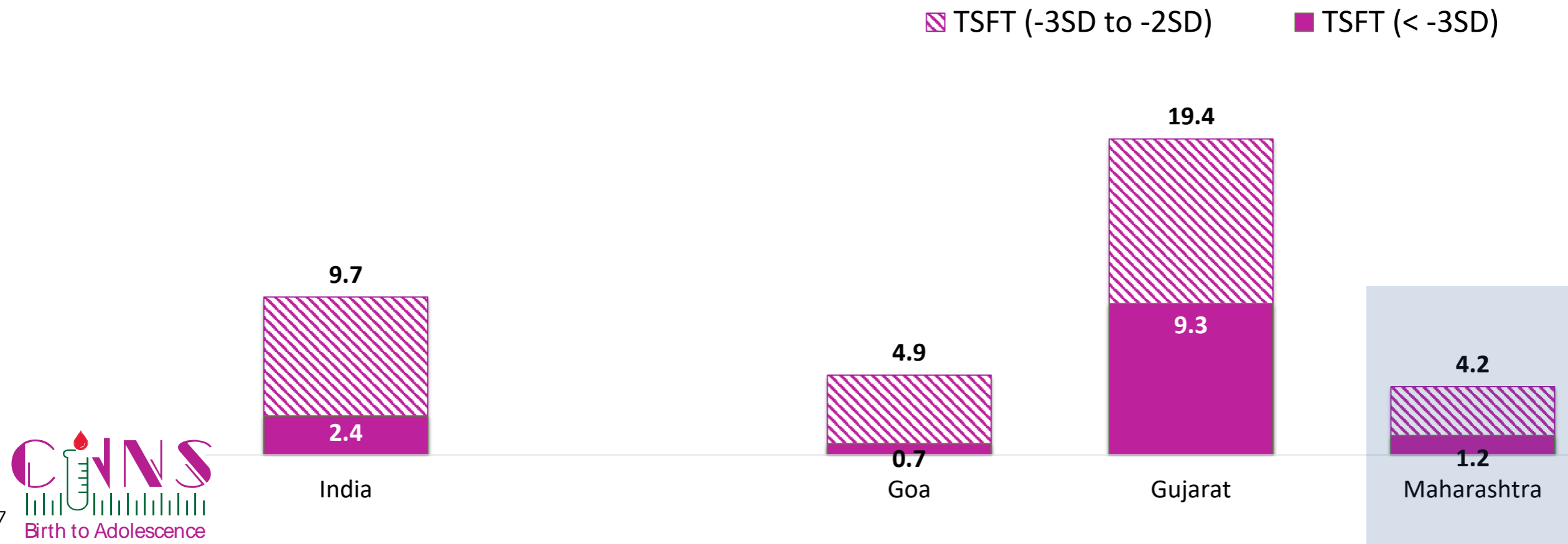
Subscapular Skinfold Thickness (SSFT) for children aged 1-4 years

Thinness as reported by SSFT in Maharashtra was lowest among western states and also half the national average

Legend: SSFT (-3SD to -2SD) ▨   SSFT (< -3SD) ■

State	SSFT (< -3SD)	Total
India	1.6	8.6
Goa	0.7	6.2
Gujarat	1.8	11.5
Maharashtra	0.4	4.0

18
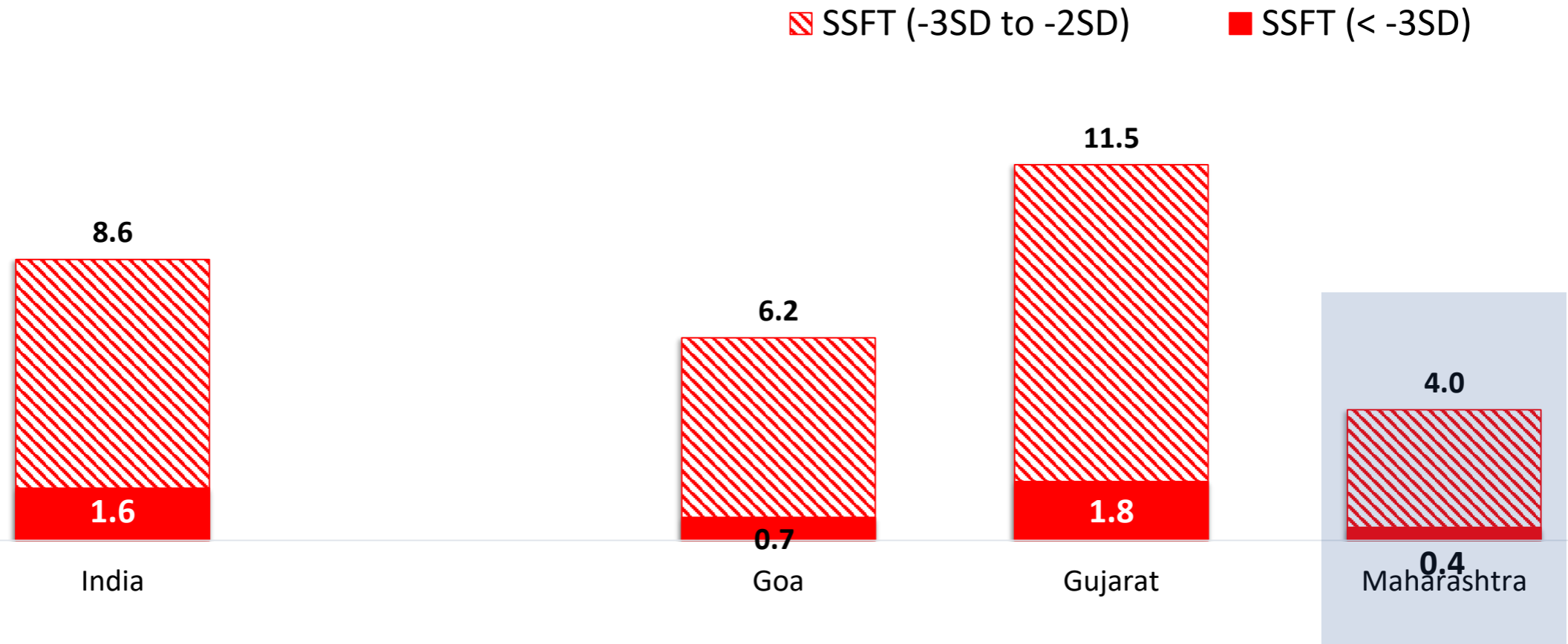
Mid Upper Arm Circumference (MUAC) for children aged 6-59 months

About **3%** children in Maharashtra had low MUAC

Prevalence of low MUAC ranged between **2%** and **5%** across the western states

Legend: ▨ MUAC (>=115mm & <125 mm)   ■ MUAC (<115 mm)

State	MUAC (>=115mm & <125 mm) total	MUAC (<115 mm)
India	4.9	0.9
Goa	2.2	0.3
Gujarat	4.7	0.4
Maharashtra	3.0	0.3

CNNS
Birth to Adolescence
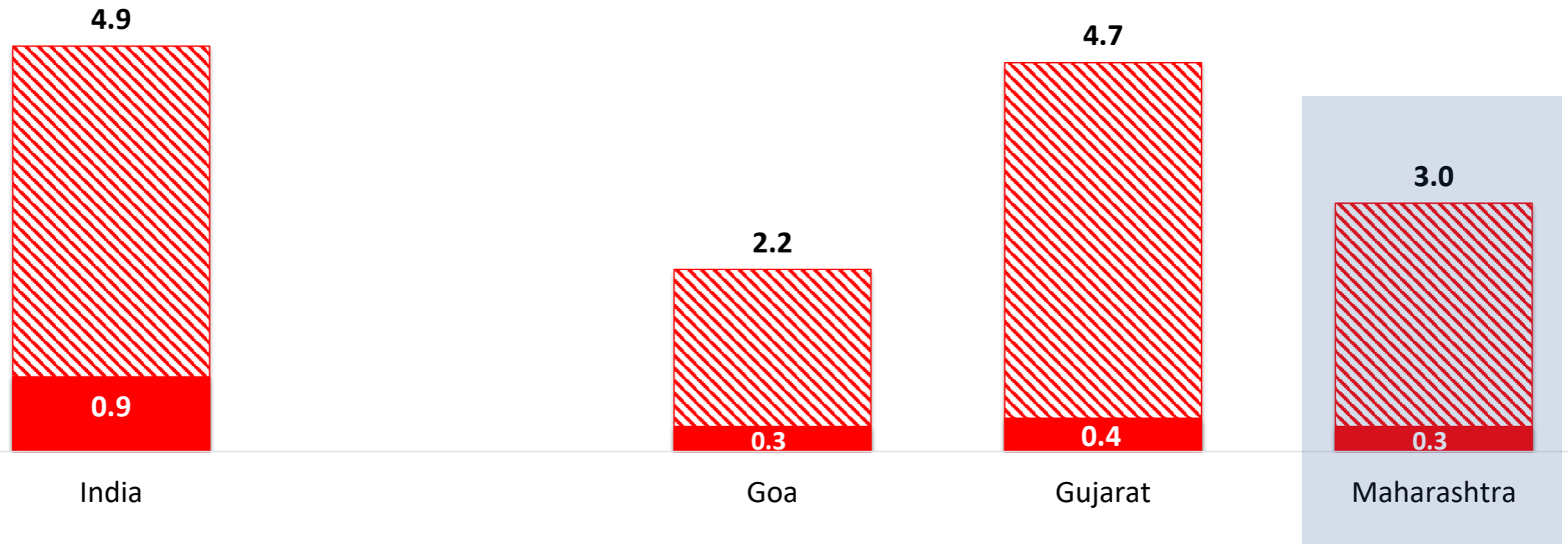
Stunting among school-age children (5-9 years)

1/4 children aged 5-9 years was stunted; significant proportion of children who were stunted in childhood remained stunted into their schooling age reducing their potential capacity for education

In western region Goa had lowest (145) and Gujarat had highest (26%) prevalence of stunting; Maharashtra (25%) was at similar level of Gujarat

Legend: ▨ Moderately stunted (-3SD to -2SD)   ■ Severely stunted (< -3SD)

	India	Goa	Gujarat	Maharashtra
Moderately stunted	21.9	14.2	26.4	24.7
Severely stunted	5.5	3.8	5.1	4.6

Birth to Adolescence
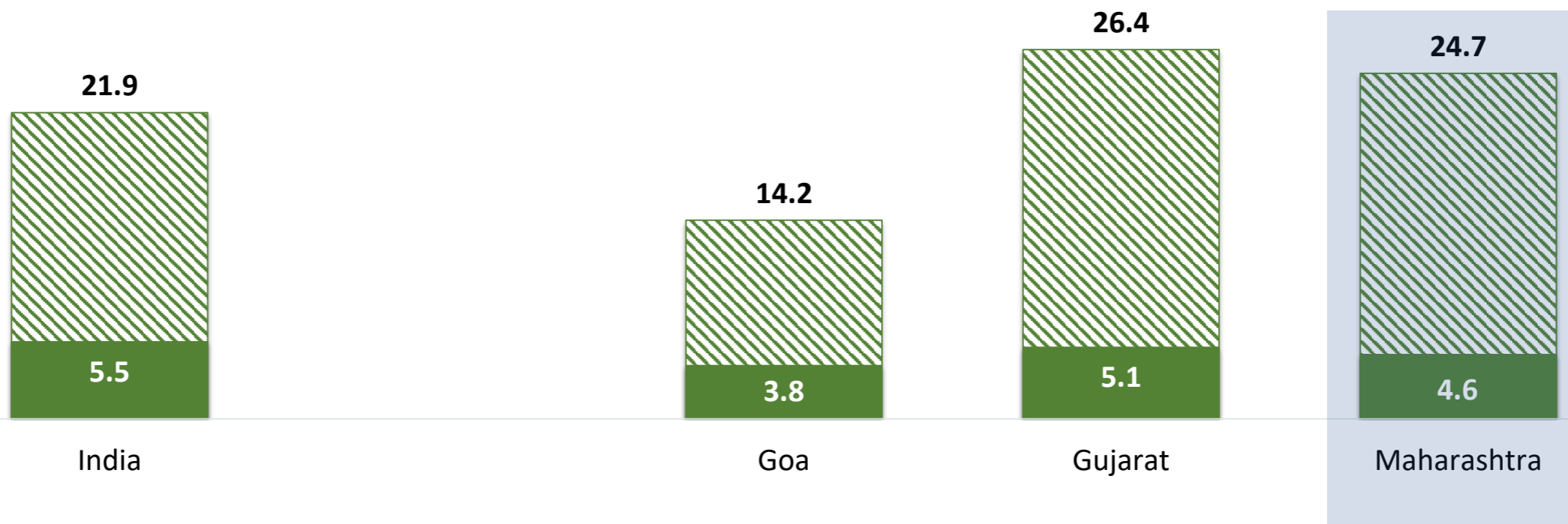
Thinness among school-age children (5-9 years)

1/4 children aged 5-9 years was thin in Maharashtra

Prevalence of thinness in western states ranged from 21% to 23%, close to national average

☒ Moderate thinness (-3SD to -2SD) ■ Severe thinness (< -3SD)

	India	Goa	Gujarat	Maharashtra
Total	23.0	21.1	21.2	23.4
Severe	4.9	5.4	3.3	5.0

CNNS
Birth to Adolescence
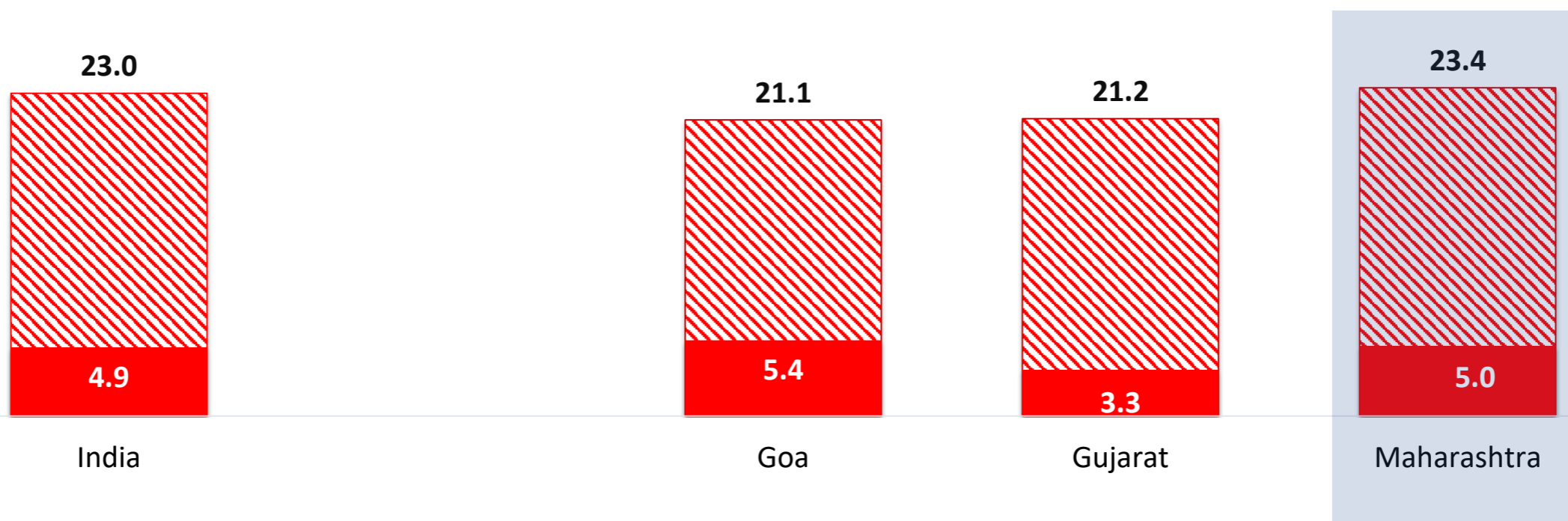
Overweight and obesity among school-age children (5-9 years) increasing

Overweight and obesity are on rise even among children aged 5-9 years

Prevalence of overweight in Maharashtra (7%) was nearly double the national average (4%)

Among western states, Goa was one with high prevalence of overweight in this age group

🔲 Overweight (BMI +1SD to +2SD)   ◼ Obese (BMI > +2SD)

	India	Goa	Gujarat	Maharashtra
Total	3.7	14.5	5.5	6.8
Obese	1.3	5.5	1.6	2.2
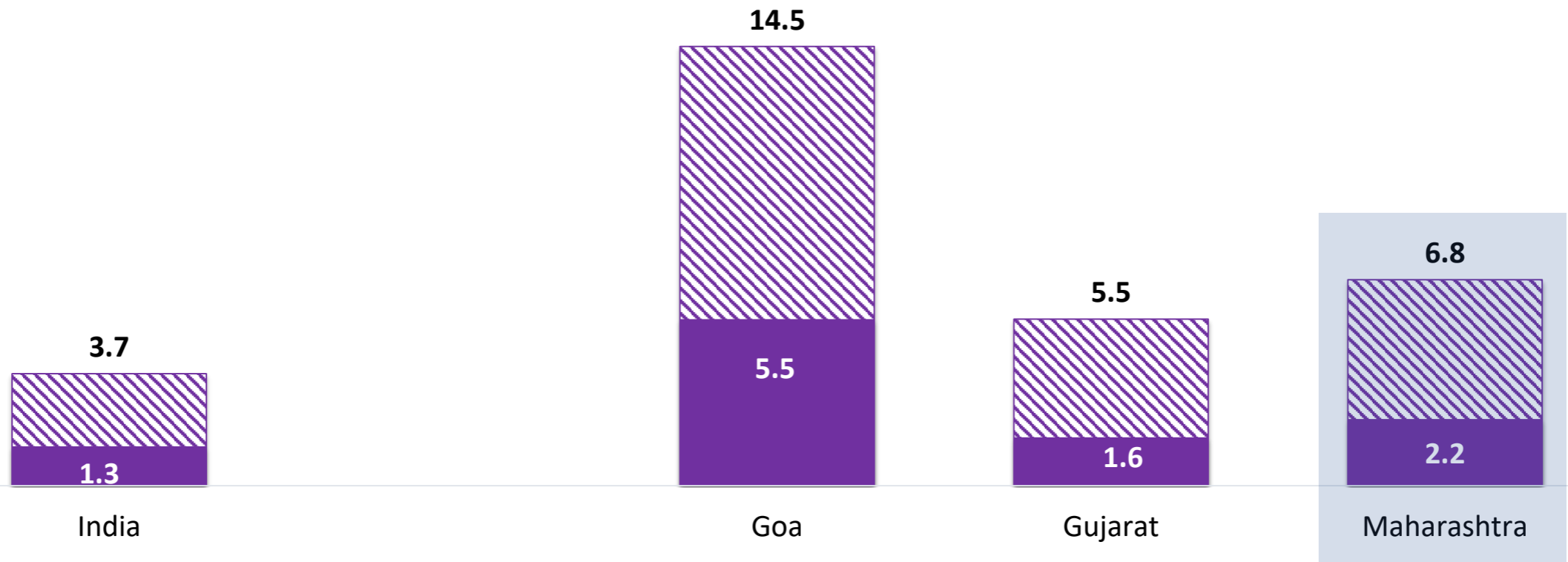
Thinness among adolescents aged 10-19 years substantially high

1/4 adolescents aged 10-19 years was thin in Maharashtra (**25%**), close to national average (**24%**)

Among the western states, Gujarat (**30%**) and Maharashtra (**25%**) had high prevalence of thinness

Moderate thinness (-3SD to -2SD) Severe thinness (< -3SD)

	India	Goa	Gujarat	Maharashtra
Total	24.1	21.8	30.2	24.5
Severe thinness	6.5	6.7	10.5	7.6

CNNS
Birth to Adolescence
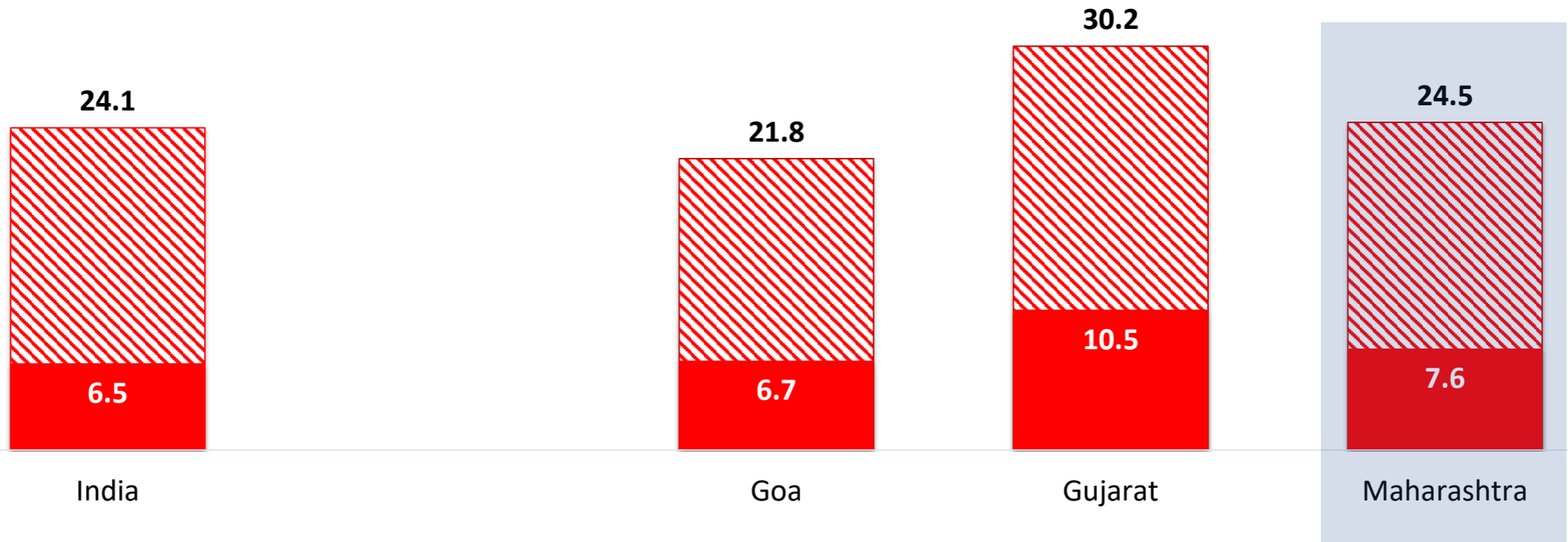
7% of adolescents were overweight in Maharashtra, slightly higher than national average (**5%**)

Among the western states, Goa (**14%**) had highest prevalence, also high in Gujarat (**8%**)

Overweight (BMI +1SD to +2SD) ⬜   Obese (BMI > +2SD) ⬛

	India	Goa	Gujarat	Maharashtra
Total	4.8	14.2	7.9	6.9
Obese	1.1	4.9	1.7	1.8

Birth to Adolescence
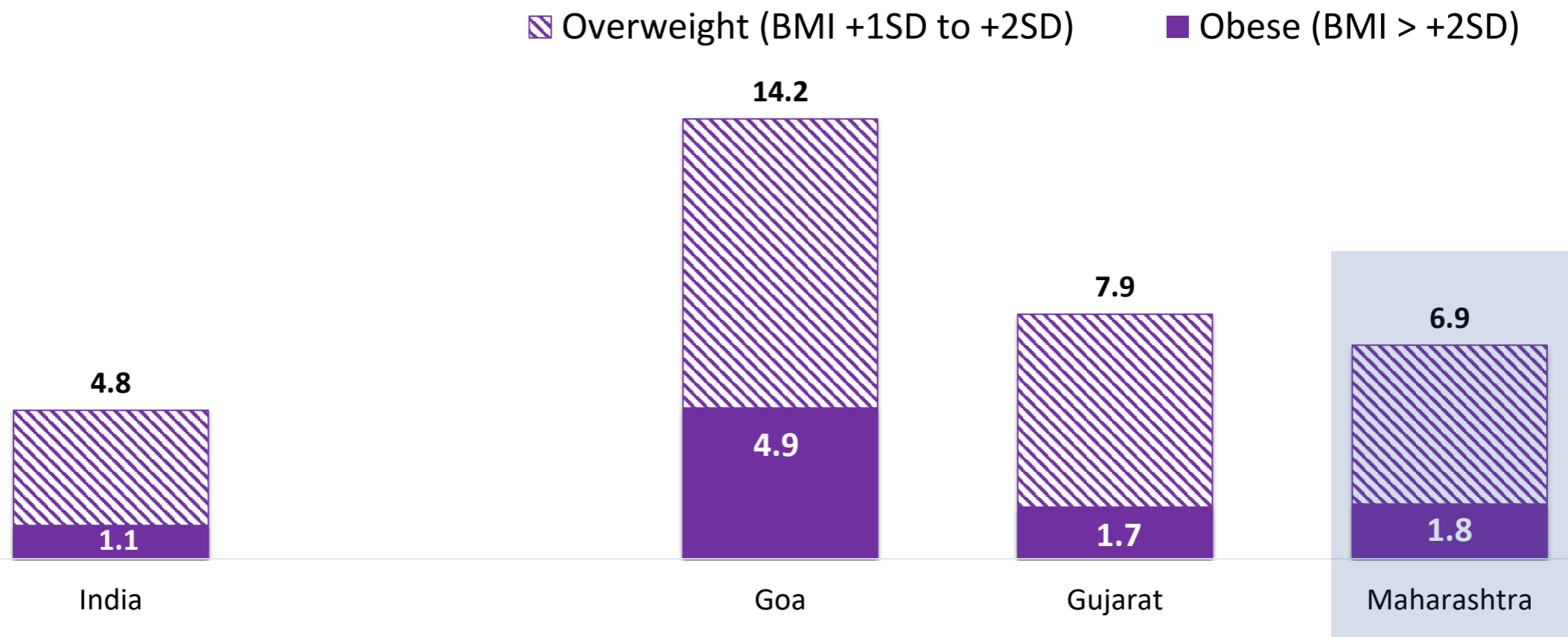
Maharashtra key findings: Anaemia and iron deficiency

Anaemia

Age group	Value
1-4 years	41.6
5-9 years	21.5
10-19 years	28.3
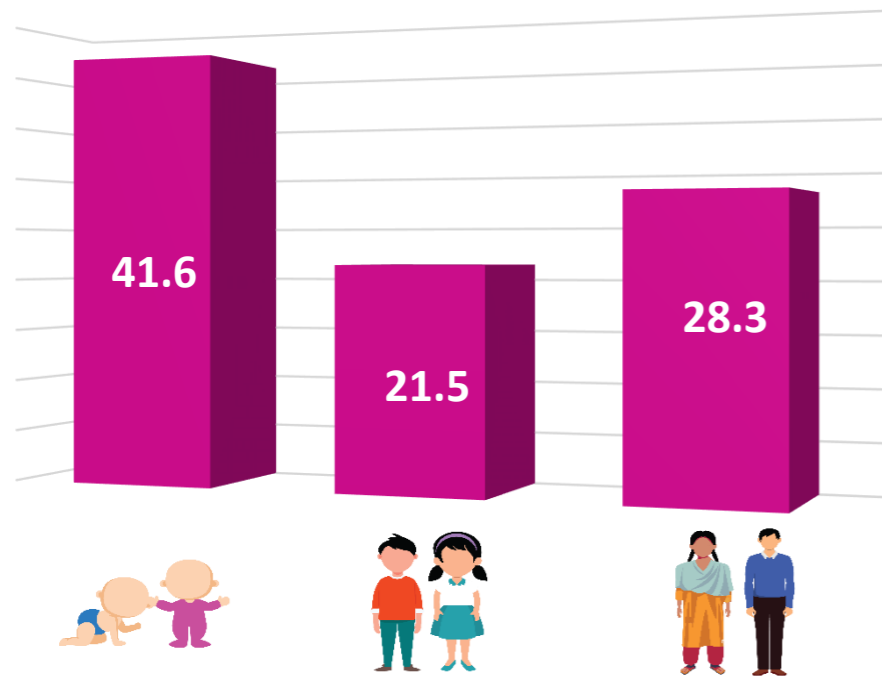
In Maharashtra, like in most states, anaemia was significantly higher among children aged 1-4 years compared to children aged 5-9 years and adolescents aged 10-19 years

Iron deficiency

49%   29%   31%

Findings indicate that children aged 1-4 years had higher iron deficiency (measured by serum ferritin) than other children or adolescents

CiNNS
Birth to Adolescence

Prevalence of Anaemia among children and adolescents

42% of children aged 1-4 years were anaemic in Maharashtra, highest among all western states and at about national average (**41%**)

Prevalence of anaemia was highest among children aged 1-4 years, increased again in adolescence

■ 1-4 Years ■ 5-9 Years ■ 10-19 Years
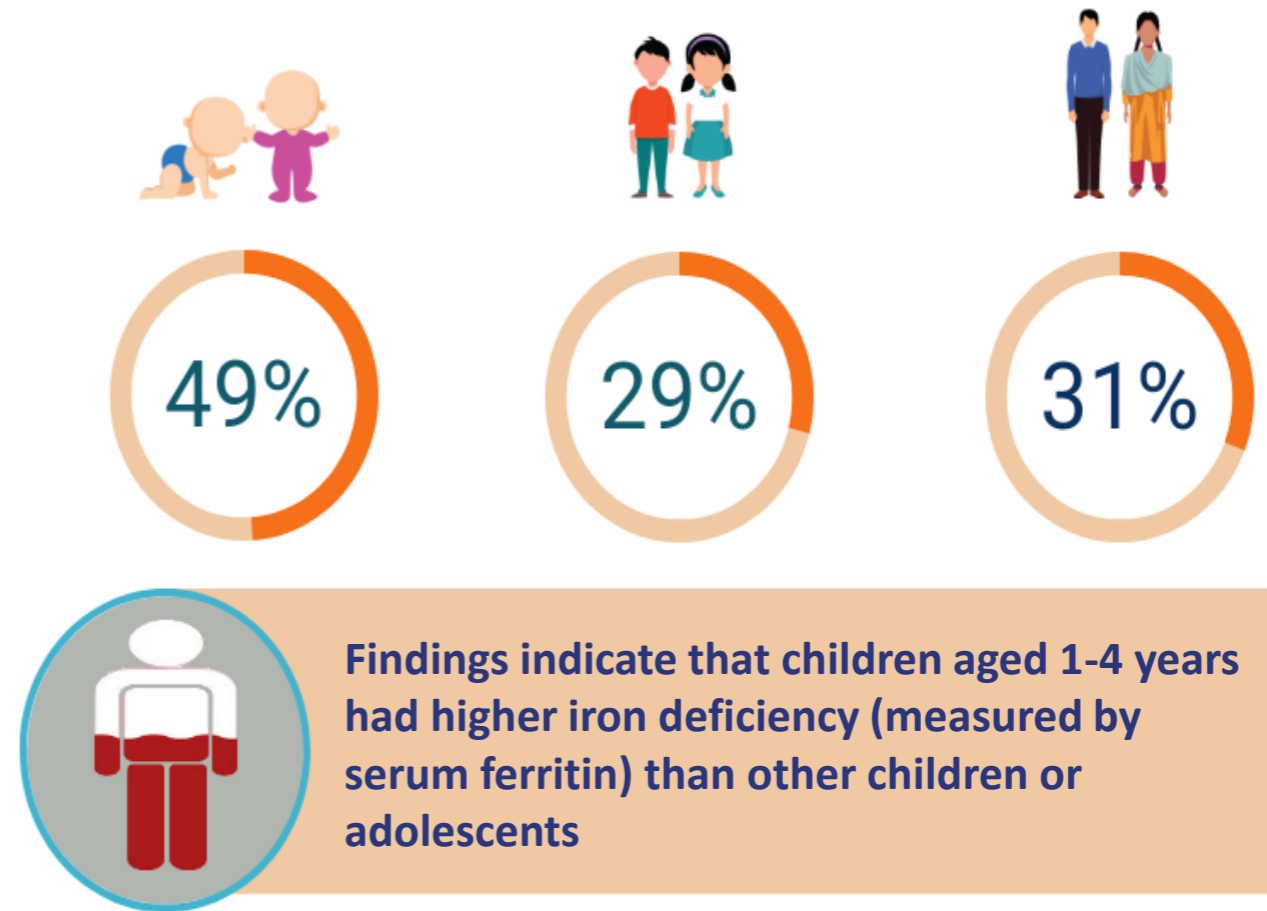
Anaemia Cut Offs (WHO)
1-4 years: Hb<11.0 g/dl
5-11 years: Hb<11.5 g/dl
12-14 years: Hb< 12 g/dl
Girls ≥15years: Hb< 12g/dl
Boys ≥15 years: Hb< 13 g/dl
(Adjusted for altitude)

	India	Goa	Gujarat	Maharashtra
1-4 Years	40.5	22.1	38.2	41.6
5-9 Years	23.5	10.8	28.8	21.5
10-19 Years	28.4	13.6	33.4	28.3

26

Birth to Adolescence
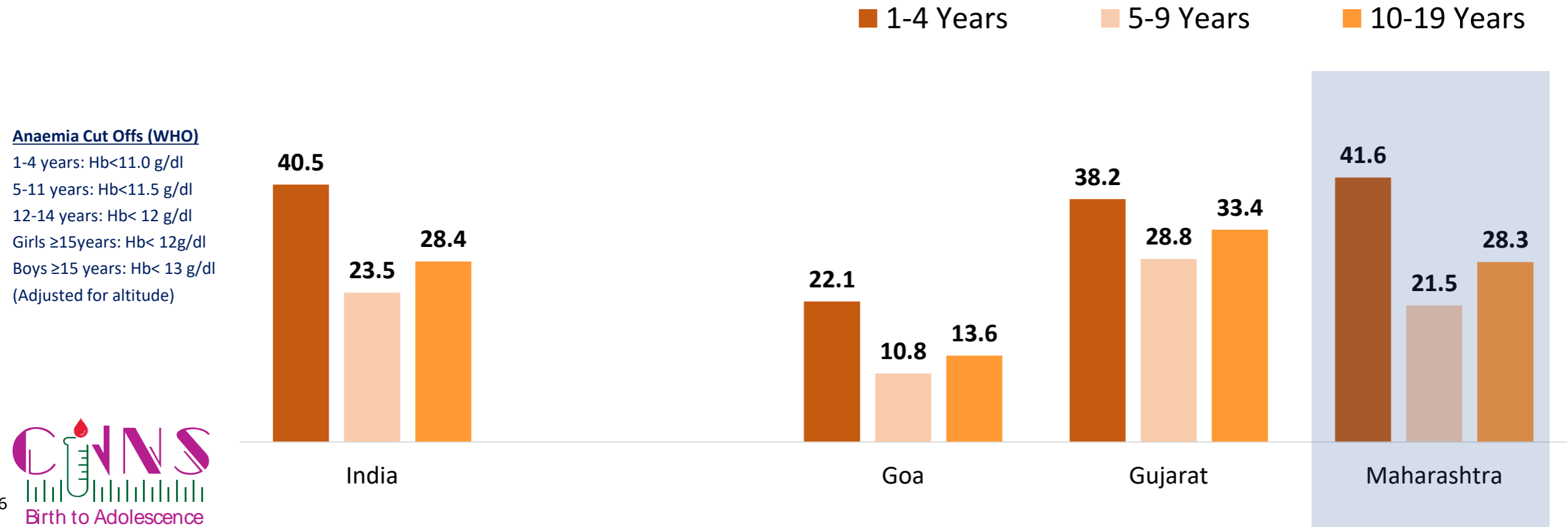
Prevalence of Anaemia among adolescents (10-19 years)

Overall, in the country, anaemia prevalence among adolescent girls (10-19 years) was twice that of adolescent boys

In Maharashtra, as in many other western states, adolescent girls doubly more likely than adolescent boys to be anaemic

■ Male   ■ Female

	India	Goa	Gujarat	Maharashtra
Male	17.5	6.1	21.0	21.0
Female	39.6	22.7	45.8	38.4

CNNS
Birth to Adolescence
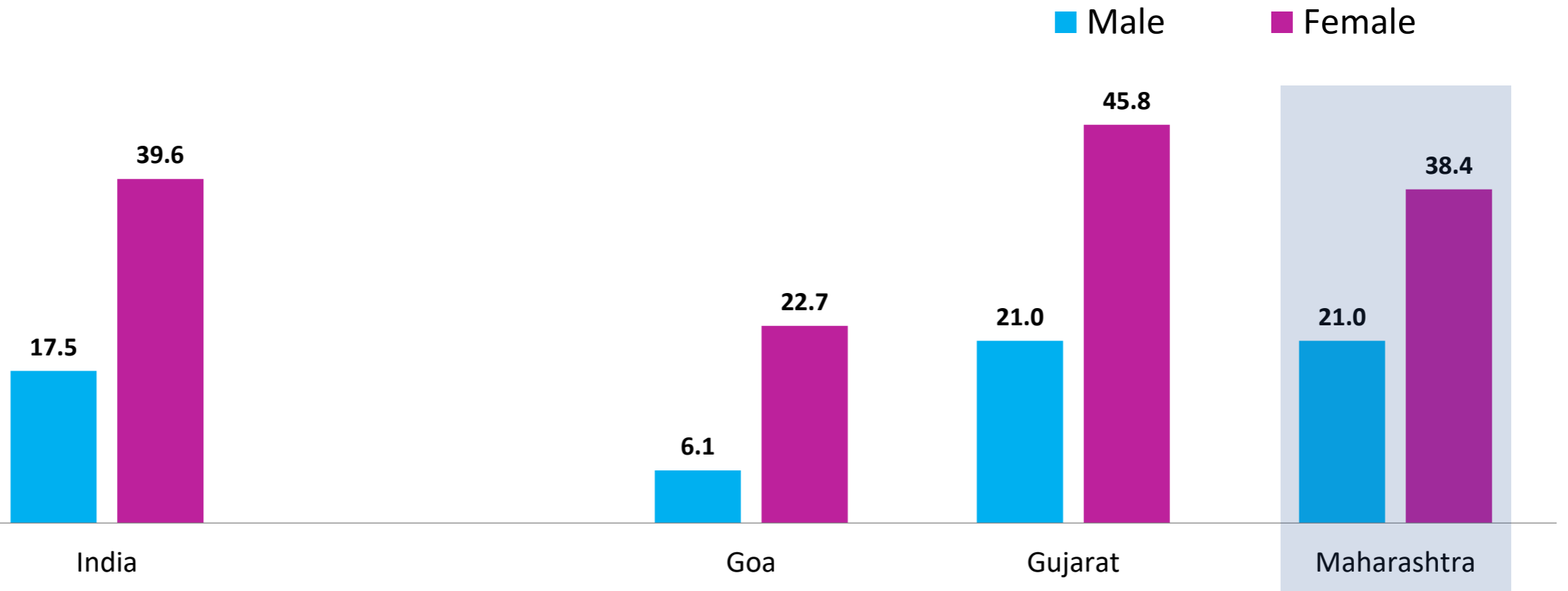
Iron deficiency measured by serum ferritin among children and adolescents

About **1/2** children aged 1-4 years had iron deficiency in Maharashtra (**49%**), higher than the national average (**32%**); prevalence was highest among children aged 1-4 years
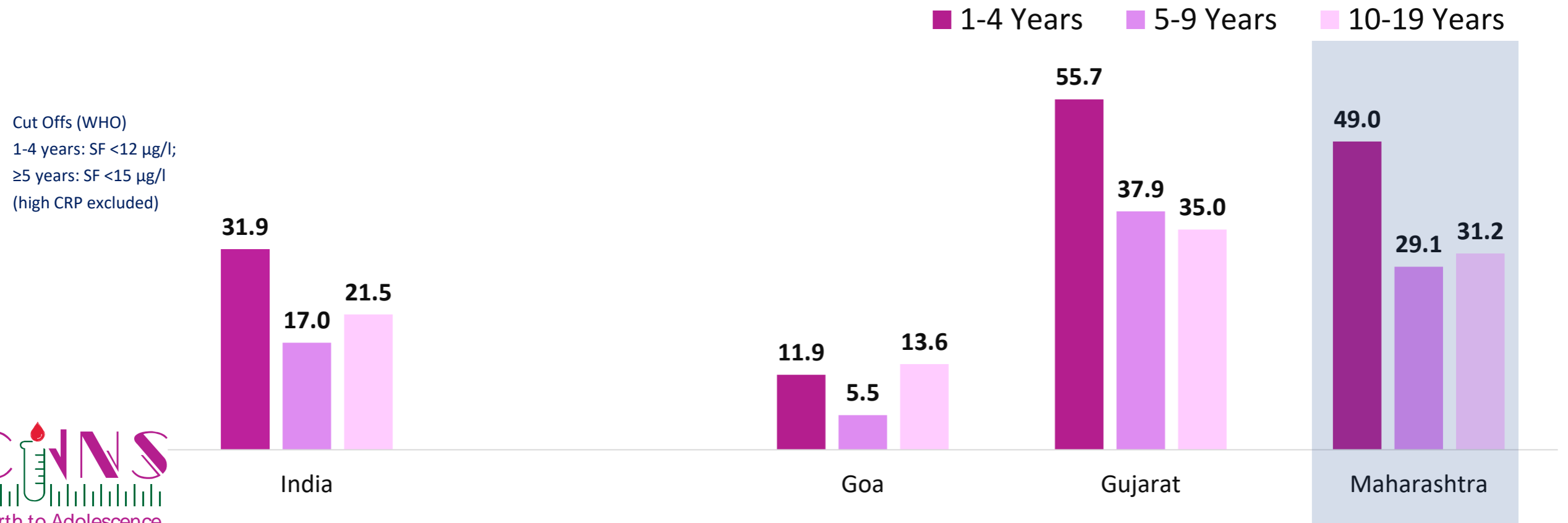
Among western states, children from Gujarat had highest prevalence of iron deficiency

■ 1-4 Years　■ 5-9 Years　■ 10-19 Years

Cut Offs (WHO)
1-4 years: SF <12 μg/l;
≥5 years: SF <15 μg/l
(high CRP excluded)

	India	Goa	Gujarat	Maharashtra
1-4 Years	31.9	11.9	55.7	49.0
5-9 Years	17.0	5.5	37.9	29.1
10-19 Years	21.5	13.6	35.0	31.2

CiNNS
Birth to Adolescence

Maharashtra key findings: Vitamin A and Vitamin D deficiency

A

Children and adolescents were found to have similar levels of Vitamin A deficiency

D

Vitamin D deficiency ranged from 13% to 22% in 1-19 years age group as per cut off by expert panel of IOM.

Adolescents aged 10-19 years were found to have higher level of Vitamin D deficiency than children aged 1-9 years

Birth to Adolescence

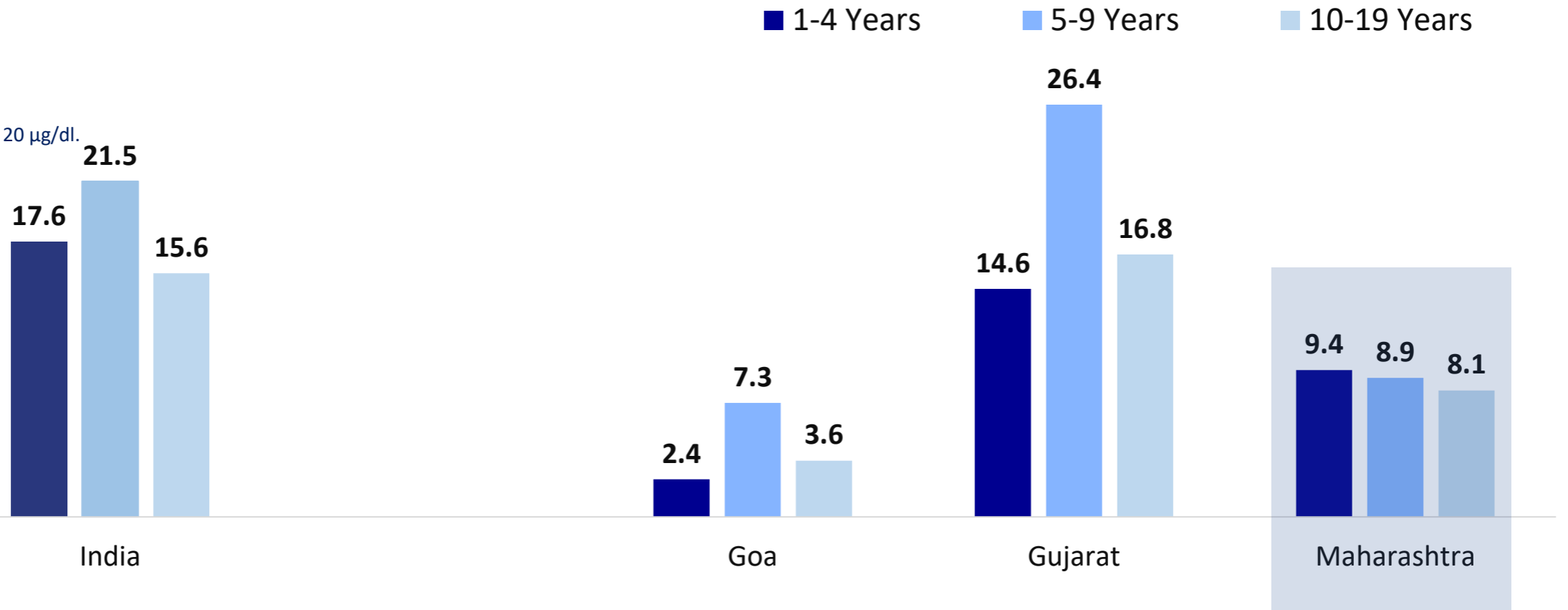# Vitamin A deficiency among children and adolescents

8-9% children and adolescents had Vitamin A deficiency in Maharashtra, significantly lower than national average (**16-22%**)

Among western states, Maharashtra had higher prevalence of Vitamin A deficiency than Goa (2-7%), but lower than Gujarat (15-26%)

■ 1-4 Years   ■ 5-9 Years   ■ 10-19 Years

Cut Offs (WHO)
1-19 Years: Serum retinol < 20 μg/dl.
(High CRP excluded)

	India	Goa	Gujarat	Maharashtra
1-4 Years	17.6	2.4	14.6	9.4
5-9 Years	21.5	7.3	26.4	8.9
10-19 Years	15.6	3.6	16.8	8.1

CiNNS
Birth to Adolescence
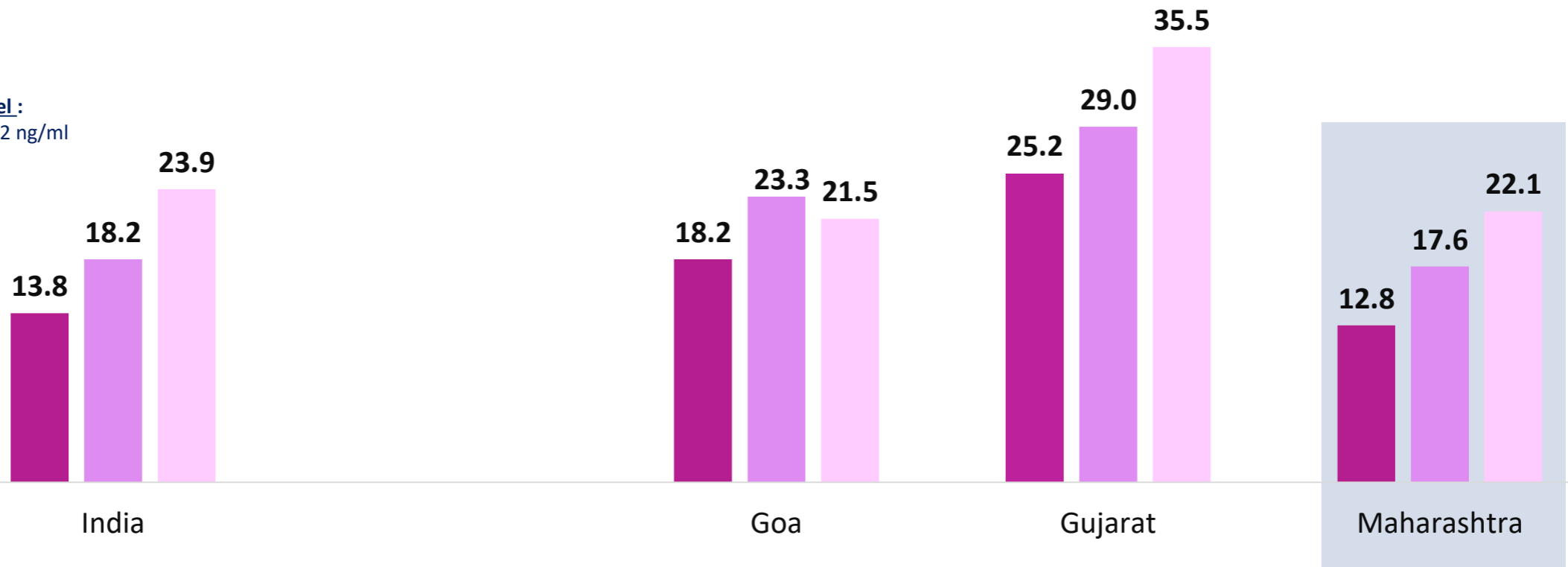
Vitamin D deficiency increases with age

13-22% children and adolescents had Vitamin D deficiency in Maharashtra, close to national average (**14-24%**); Vitamin D deficiency increased sharply with age.

In other western states, except Maharashtra, Vitamin D deficiency among children and adolescents was higher than national average.

Cut Off (IOM) Vit D Expert Panel :
Serum 25-hydroxy vitamin D <12 ng/ml

Legend: ■ 1-4 Years ■ 5-9 Years ☐ 10-19 Years

	India	Goa	Gujarat	Maharashtra
1-4 Years	13.8	18.2	25.2	12.8
5-9 Years	18.2	23.3	29.0	17.6
10-19 Years	23.9	21.5	35.5	22.1

CNNS
Birth to Adolescence

Slightly less than 10% school-age children and adolescents were found with high level of glycosylated haemoglobin (HbA1c).
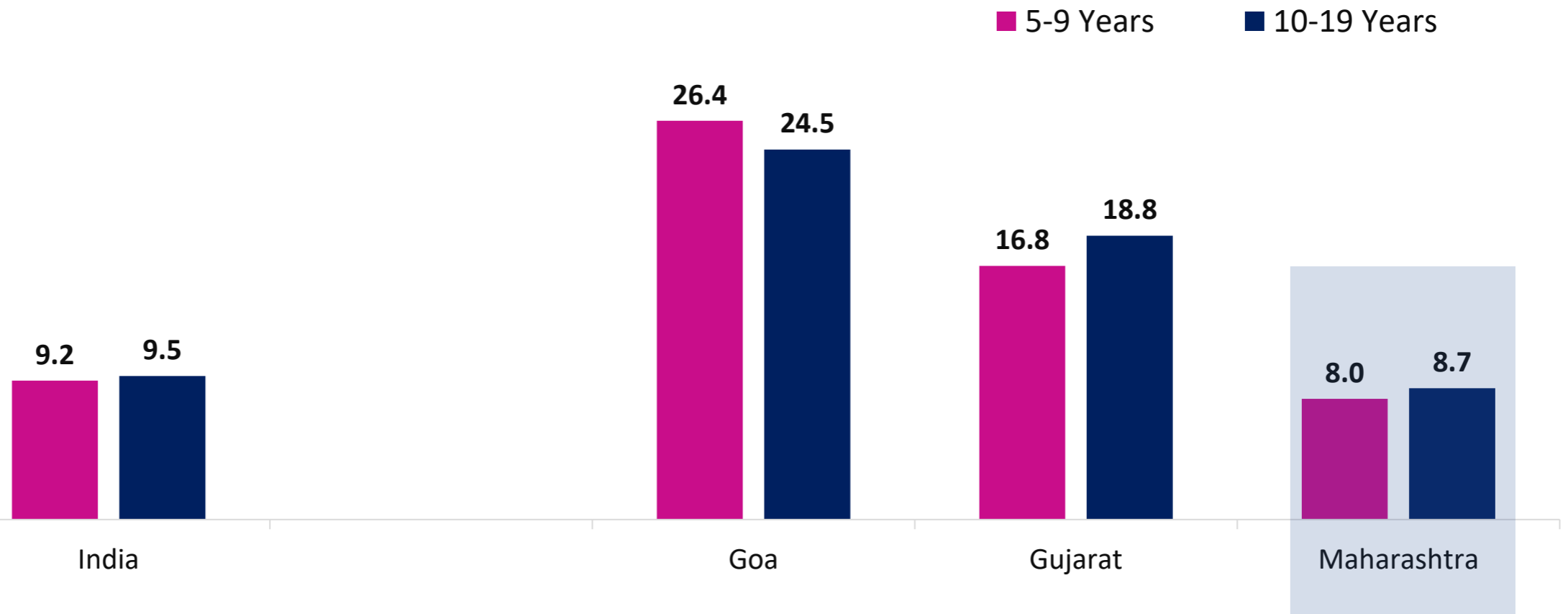
Other indicators of risks of NCDs, such as level of cholesterol, triglycerides, LDL and HDL point to increased risks of NCDs among adolescents.

CiNS
Birth to Adolescence

Risk of diabetes among school-age children and adolescents

Based on Glycosylated hemoglobin (HbA1c), slightly less than **10%** children and adolescents had increased risk of diabetes in Maharashtra, about the same level in the country as a whole (**9-10%**)

Among all western states, risk of diabetes was the lowest in Maharashtra

Legend: ■ 5-9 Years ■ 10-19 Years

India: 9.2, 9.5
Goa: 26.4, 24.5
Gujarat: 16.8, 18.8
Maharashtra: 8.0, 8.7
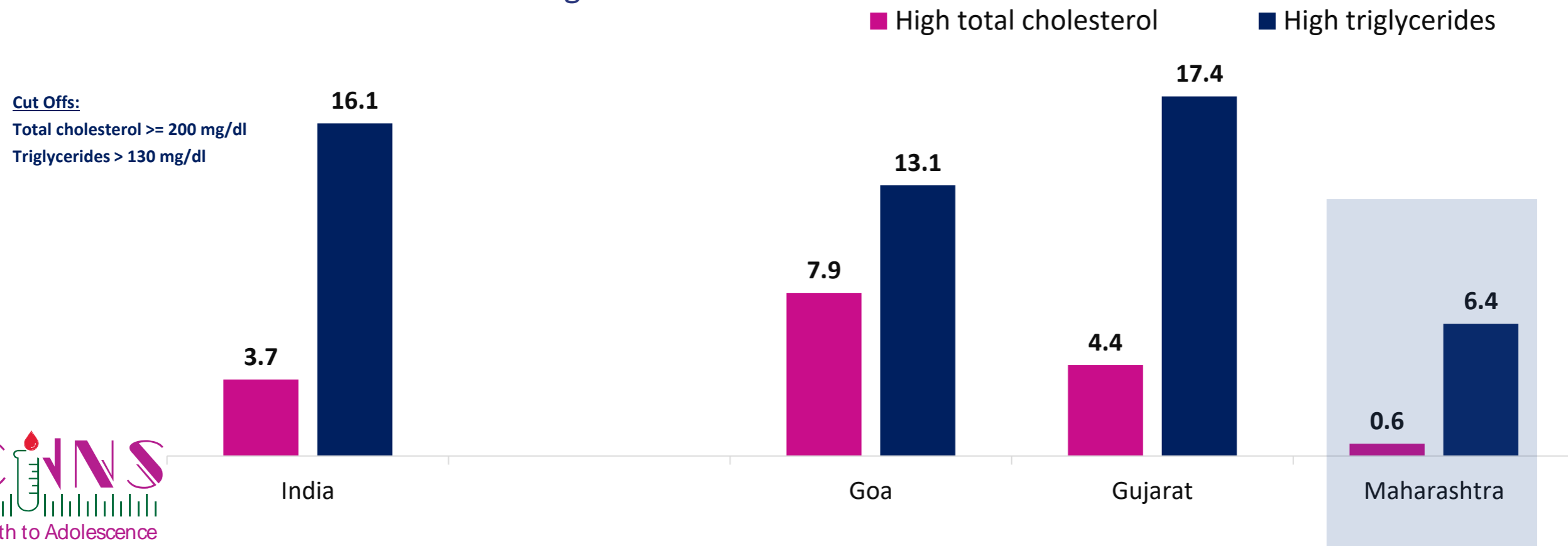
CNNS
Birth to Adolescence

High total cholesterol and high triglycerides among adolescents

Elevated risk of NCDs in Maharashtra among adolescents – **1%** had high level of total cholesterol and **6%** with high level of triglycerides

Prevalence of high total cholesterol and high triglycerides were lowest in Maharashtra among all western states and also lower than national average

■ High total cholesterol   ■ High triglycerides

Cut Offs:
Total cholesterol >= 200 mg/dl
Triglycerides > 130 mg/dl

	India	Goa	Gujarat	Maharashtra
High total cholesterol	3.7	7.9	4.4	0.6
High triglycerides	16.1	13.1	17.4	6.4

CNNS
Birth to Adolescence
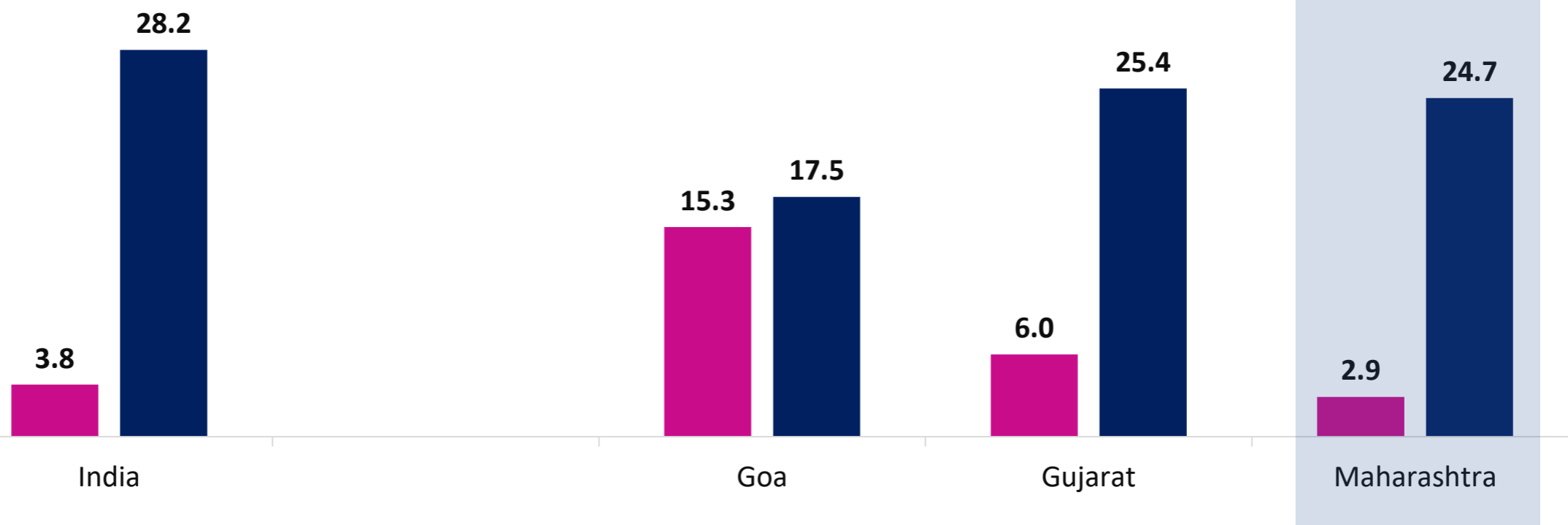
High LDL and low HDL among adolescents

Risk of NCDs among adolescents in Maharashtra – **3%** had high level of LDL and **25%** had low level of HDL

Among the western states, in Goa, prevalence of both high LDL and low HDL was high

Cut Offs:
LDL >= 130 mg/dl
HDL < 40 mg/dl

Legend: ■ High LDL   ■ Low HDL

	High LDL	Low HDL
India	3.8	28.2
Goa	15.3	17.5
Gujarat	6.0	25.4
Maharashtra	2.9	24.7

Birth to Adolescence

Preliminary Policy Discussions from CNNS

- Only about half of anaemia is caused by iron deficiency. Programmes must address all causes of anaemia but continue to address iron deficiency in children under five and adolescent girls (population with largest burden).

- Vitamin A deficiency is less prevalent than expected. Policy review is warranted. Interventions such as dietary diversification and fortification can be taken to scale to address the remaining burden.

- Vitamin D deficiency is an emerging public health issue among urban children and adolescents. Scaling up of fortification efforts can be considered. Further research is required to uncover the effects of pollution and other factors to design better programmes.

- Urinary Iodine data need to be examined in conjunction with salt consumption data for the population and level of iodine in salt at the household level.

- Control of NCDs such as diabetes and cardiovascular disease must start in the early ages to instil lifelong healthy habits as adult diseases start in childhood.

CNNS
Birth to Adolescence

POPULATION COUNCIL
Ideas. Evidence. Impact.

AIIMS New Delhi

CDSA

CDC Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

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INDIAN COUNCIL OF MEDICAL RESEARCH
NATIONAL INSTITUTE OF NUTRITION