Introduction:

WASH: Access to safe drinking water, sanitation, and hygiene is a state subject in India. Despite this, government initiatives like the Swachh Bharat Mission and the Jal Jeevan Mission have significantly improved the WASH infrastructure in India. Access to improved and affordable WASH services is central to achieving Sustainable Development Goal 6, which aims to ensure the availability and sustainable management of water and sanitation for all. Many people die every year from waterborne diseases, primarily stemming from inadequate access to safe drinking water and proper sanitation.

Despite substantial efforts to enhance WASH infrastructure, several Indian states continue to experience a high incidence of waterborne diseases. This persistent challenge prompts a critical evaluation of the effectiveness and reach of WASH interventions in mitigating such waterborne diseases. Focusing on five states that reported high incidences of diarrheal diseases in the **pre-COVID period (2018)** – West Bengal, Sikkim, Meghalaya, Himachal Pradesh, and Jammu & Kashmir – this study aims to see how access to improved water and sanitation services has evolved over time and whether these changes are associated with reduction in disease incidence in the **post-COVID period (2022–2023)**, using data from the 76th (2018) and 79th (2022–2023) rounds of National Sample Survey (NSS).

This analysis uses descriptive statistics, trend comparison, and correlation analysis to identify patterns and associations. By examining temporal and spatial trends in WASH alongside health data, this analysis aims to contribute to targeted and effective WASH interventions in India, especially in regions facing high waterborne disease risks from inadequate water and sanitation access.

Research Question:

Is there a significant association between the improvement in WASH (Water, Sanitation, and Hygiene) services since 2018 and the reduction in the incidence of waterborne diseases, particularly diarrhea, in high-incidence states?

Research objectives:

- To analyze temporal trends in access to improved water and sanitation services in selected high-incidence states since 2018-2023.
- To analyze temporal trends in reported incidence of waterborne diseases, particularly diarrhea in selected high-incidence states since 2018-2023.
- To examine the association between WASH infrastructure improvements and diarrhea incidence over time in the selected states.
- To provide evidence-based insights for more targeted WASH interventions and public health planning in high-risk states.

Database and Methodology:

This study draws on both household-level survey data and national health statistics to examine trends and associations between WASH access and diarrheal disease incidence across five high-burden states: **West Bengal, Sikkim, Meghalaya, Himachal Pradesh, and Jammu & Kashmir**. These states were selected based on their reported high incidence of diarrheal diseases in the **pre-COVID year 2018**, as documented in the **National Health Profile (NHP) 2019**.

Data Sources:

1. **National Sample Survey (NSS)** – *76th Round (2018)* and *79th Round (2022–2023)*:
   These rounds provide household-level data on access to improved sources of drinking water, sanitation facilities, and hygiene practices. The NSS is a nationally representative survey conducted by the Ministry of Statistics and Programme Implementation (MoSPI).

2. **National Health Profile (NHP) – 2019 and 2022 editions:**
   These editions of the NHP, published by the **Central Bureau of Health Intelligence (CBHI)** under the **Ministry of Health and Family Welfare**, were used to extract two key datasets:
   - The **number of reported diarrheal disease cases** by state, and
   - The **projected population figures** for the years 2018 and 2022.
   - These were used to compute **standardized incidence rates** (cases per 1,000 population), enabling meaningful intertemporal and inter-state comparisons.

Exclusion of Union Territories:
Union Territories (UTs) were excluded from the analysis. This decision is methodologically justified because UTs typically have **smaller population sizes**, which can result in **disproportionately high or volatile incidence rates**. Such rates may not reflect consistent patterns over time and could skew broader state-level comparisons.

Methods of Analysis:

- **Descriptive Statistics:**
  Used to summarize changes in household access to improved drinking water and sanitation facilities between 2018 and 2022–2023.
- **Trend Comparison:**
  Temporal trends in WASH service coverage and diarrheal disease incidence were compared across the selected states to observe patterns over pre- and post-COVID periods.
- **Incidence Rate Calculation:**
  Diarrheal disease cases from the NHP were divided by the projected population for the respective years to calculate **incidence rates (cases per 1,000 population)**.
- **Correlation Analysis:**
  Given the small sample size (only five states), conducting formal correlation analysis, such as calculating Pearson correlation coefficients, is not appropriate. Instead, scatter plots with trendlines have been used to visually

explore the association between improvements in WASH services and changes in diarrhoeal disease incidence at the state level over time.

- **Data Notes:**
    - For ease of analysis, the reported cases and projected population of Jammu & Kashmir and Ladakh have been combined.
    - Diarrhoeal case data for West Bengal was not available in the Health Profile 2023 for the year 2022. Therefore, provisional case data from the Health Profile 2022 for the year 2021 has been used instead.
    - For the year 2018, projected population figures and diarrhoeal cases from 2018 have been used.
    - For the year 2022, projected population figures for 2021 and diarrhoeal cases for 2022 have been used.
    - Telangana has been excluded from the calculation of incidence rates due to the unavailability of separate projected population data for 2018.

Analysis and discussion:

Table 1: Percentage of households having sufficient drinking water throughout the year from principal source of drinking water, exclusive access to the principal source of drinking water and facility of drinking water within the household premises as obtained from NSS 79th round and NSS 76th round survey (For selected high incidence states)

Description of items	NSS rounds (year)	Rural	Urban	All
Households having sufficient drinking water throughout the year from principal source of drinking water	79th round (2022-2023)	93.72	98.22	94.95
	76th round (2018)	89.03	92.94	90.25
Households having exclusive access to the principal source of drinking water	79th round (2022-2023)	44.09	48.31	45.24
	76th round (2018)	35.96	39.94	37.2
Households having drinking water facilities within the household premises	79th round (2022-2023)	56.53	71.62	60.63
	76th round (2018)	49.4	57.94	52.06

Sufficient Drinking Water Throughout the Year (from Principal Source):

- There was a notable improvement in year-round water sufficiency, suggesting better water reliability across rural and urban areas, possibly due to targeted interventions in water-stressed regions.

Exclusive Access to Principal Source of Drinking Water:

- A moderate increase was observed, indicating progress in hygiene and reduced contamination risks. However, less than half the households still lack exclusive access.

Drinking Water Facilities Within Household Premises:

- There was a clear rise in access to drinking water within household premises, reflecting improved convenience, reduced burden **(especially for women)**, and potential health benefits.

Table 2: Percentage of households with improved sources of drinking water as obtained from NSS 79th round and NSS 76th round survey (For selected high incidence states)

NSS round	Rural	Urban	All
NSS 79th round (2022-2023)	96.79	99.26	97.5
NSS 76th round (2018)	96.77	99.11	97.5

- **Rural Areas**: Marginal increase from 96.77% (2018) to 96.79% (2022–23).
- **Urban Areas**: Slight rise from 99.11% to 99.26%.
- **Overall (All)**: No significant change; remains stable at 97.5%.

Table 3: Percentage of households with access to toilets, percentage of households used improved toilets and percentage of households with exclusive access to toilets as obtained from NSS 79th and NSS 76th round survey (For selected high incidence states)

Description of items	NSS rounds	Rural	Urban	All
Households having access to toilets	79th round (2022-2023)	95.34	98.56	96.22
	76th round (2018)	85.36	97.01	88.99
Households used improved toilets	79th round (2022-2023)	95.50	99.36	96.58
	76th round (2018)	96.52	98.58	97.22
Households having exclusive access to toilets	79th round (2022-2023)	74.62	75.71	74.92
	76th round (2018)	61.47	65.57	62.75

Households Having Access to Toilets:

- **Rural Areas:** Access rose sharply from 85.36% (2018) to 95.34% (2022–23), driven by initiatives like the Swachh Bharat Mission, better infrastructure, and hygiene awareness.
- **Urban Areas:** Slight increase from 97.01% to 98.56%, as urban areas already had high coverage; reflects continued efforts in underserved pockets.
- **Overall (All Areas):** Improvement from 88.99% to 96.22% highlights strong progress in both rural and urban areas, mainly due to targeted government programs.

Households Using Improved Toilets:

- **Rural Areas:** Small decline from 96.52% to 95.50%, possibly due to behavioural factors maintenance issues or lack of proper waste management systems in rural areas.
- **Urban Areas:** Rise from 98.58% to 99.36%, showing better maintenance and monitoring. This reflects the success of urban sanitation schemes in ensuring access to safe and clean toilets.
- **Overall (All Areas):** Slight drop from 97.22% to 96.58%, suggesting that while access improved, consistent quality and use of improved toilets remain a challenge.

Households with Exclusive Access to Toilets:

- **Rural Areas:** Big jump from 61.47% to 74.62%, reflecting success of schemes like Swachh Bharat Mission promoting individual household toilets and reducing open defecation.
- **Urban Areas:** Increase from 65.57% to 75.71%, indicating better sanitation access, particularly for in Urban areas where communal or shared toilets were previously more common.
- **Overall (All Areas):** Rise from 62.75% to 74.92% shows major progress towards private sanitation, driven by state and national efforts to shift away from shared facilities.

Table 4: Percentage distribution of households of hand washing practice (For selected high incidence states)

Description of items	NSS rounds	Rural	Urban	All
Wash hands with water and soap/detergent	79th round (2022-2023)	93.18	98.12	94.53
	76th round (2018)	72.17	93.03	78.68
Wash hands with water and ash/mud/sand etc.	79th round (2022-2023)	2.95	0.47	2.27
	76th round (2018)	20.10	2.97	14.76
Wash hands with water only	79th round (2022-2023)	2.96	1.32	2.51
	76th round (2018)	7.54	3.99	6.44
Do not wash hands	79th round (2022-2023)	0.91	0.09	0.69
	76th round (2018)	0.18	0.01	0.13

Wash hands with water and soap/detergent:

- **Rural Areas**: Big rise from 72.17% (2018) to 93.18% (2022–23), likely due to health campaigns like Swachh Bharat and COVID-19 awareness that promoted hand hygiene.
- **Urban Areas**: Increased from 93.03% to 98.12%; nearly universal now. The rise in urban areas may also reflect greater awareness and infrastructure.
- **Overall (All Areas)**: Improved from 78.68% to 94.53%, reflecting better hygiene awareness and access.

Wash hands with water and ash/mud/sand:

- **Rural Areas**: Sharp drop from 20.10% to 2.95%, showing a shift to more hygienic practices as well as awareness campaigns encouraging proper hygiene.
- **Urban Areas**: Declined from 2.97% to 0.47%, due to better soap access, contributing to the lower reliance on traditional methods.
- **Overall (All Areas)**: Big fall from 14.76% to 2.27% indicating a shift toward more hygienic practices across selected states.

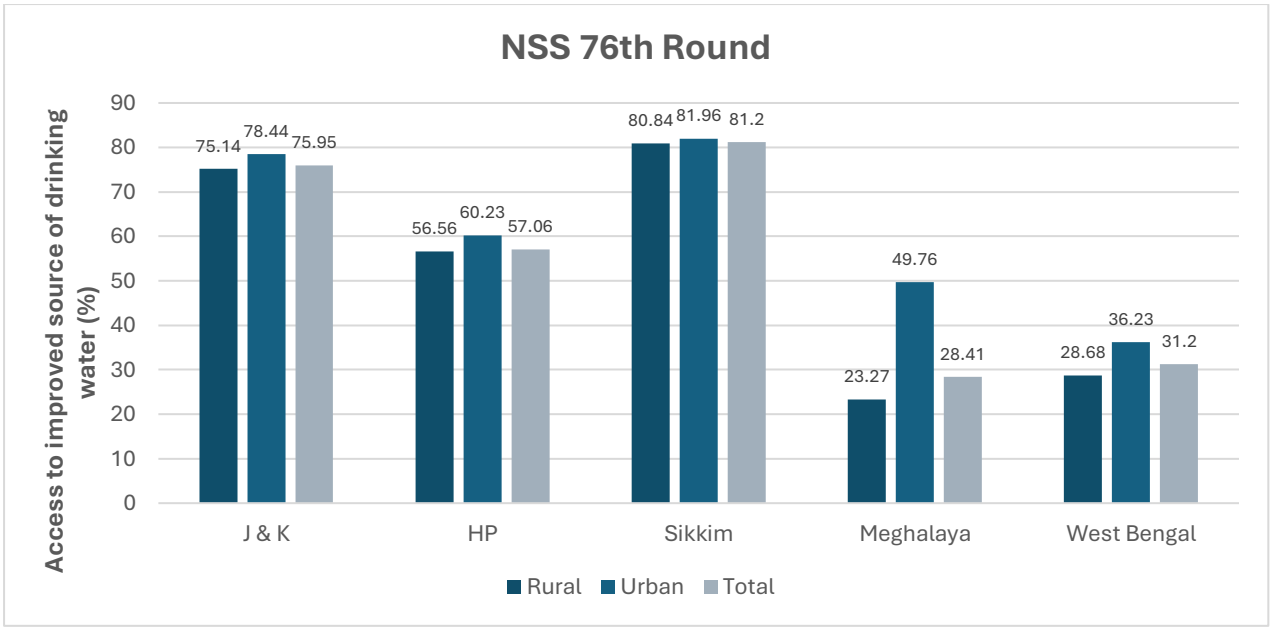
Wash hands with water only:

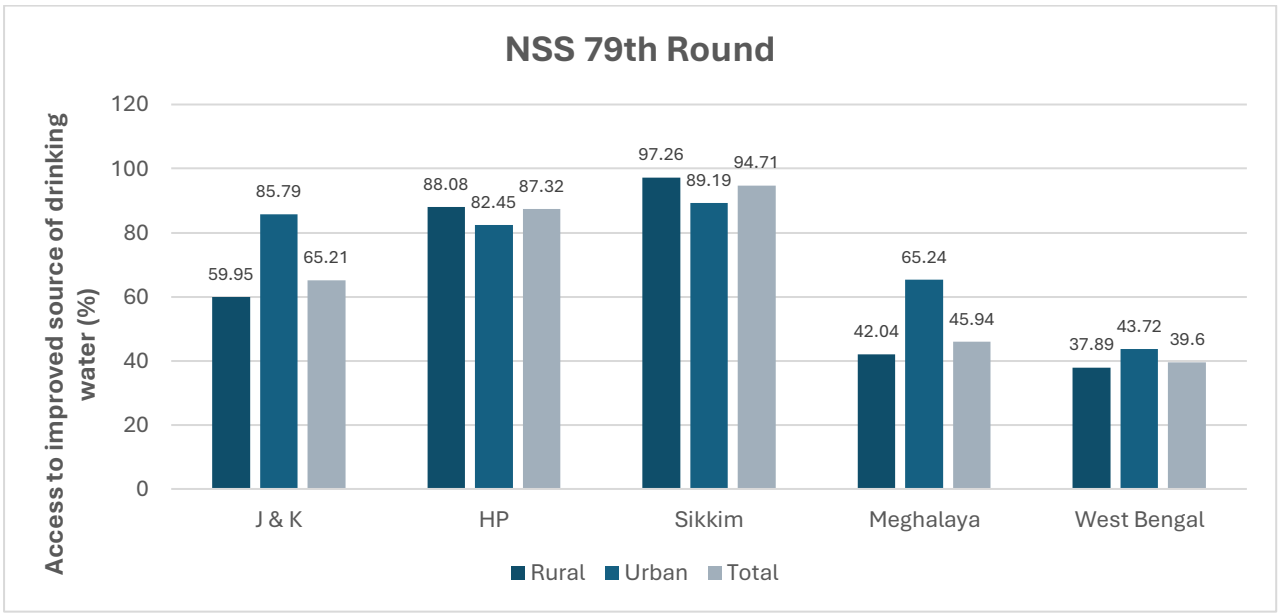
- **Rural Areas**: Decreased from 7.54% to 2.96% , could be attributed to increased access to soap or detergents in rural areas, improving the overall hygiene standard.
- **Urban Areas**: Fell from 3.99% to 1.32%, reflecting the possible availability and usage of soap/detergent, which are more commonly used in urban households.
- **Overall (All Areas)**: Dropped from 6.44% to 2.51%, showing a shift towards using soap or detergent in handwashing instead of just water.

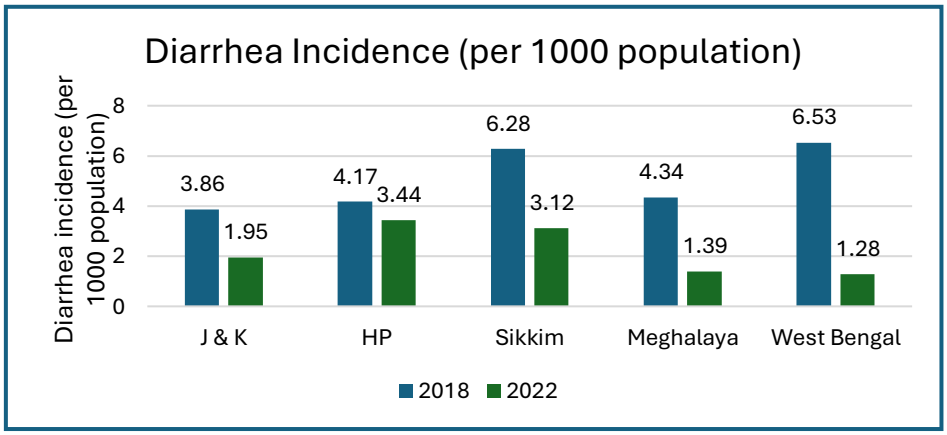
Do not wash hands:

- **Rural Areas**: Increased from 0.18% to 0.91%, though overall very low—may signal regional challenges.
- **Urban Areas**: Slight rise from 0.01% to 0.09%, still almost universal handwashing, might be linked to other factors affecting access to hygiene resources.
- **Overall (All Areas)**: From 0.13% to 0.69%, indicating minor setbacks despite overall improvement.

Table 5: Percentage distribution of households with access to improved source of drinking water in different rounds (For selected high incidence states).


NSS 76th Round
Access to improved source of drinking water (%)
90
80
70
60
50
40
30
20
10
0
75.14
78.44
75.95
56.56
60.23
57.06
80.84
81.96
81.2
23.27
49.76
28.41
28.68
36.23
31.2
J & K
HP
Sikkim
Meghalaya
West Bengal
Rural
Urban
Total


NSS 79th Round
Access to improved source of drinking water (%)
120
100
80
60
40
20
0
59.95
85.79
65.21
88.08
82.45
87.32
97.26
89.19
94.71
42.04
65.24
45.94
37.89
43.72
39.6
J & K
HP
Sikkim
Meghalaya
West Bengal
Rural
Urban
Total


Diarrhea Incidence (per 1000 population)
Diarrhea incidence (per 1000 population)
8
6
4
2
0
3.86
1.95
4.17
3.44
6.28
3.12
4.34
1.39
6.53
1.28
J & K
HP
Sikkim
Meghalaya
West Bengal
2018
2022

Access to Improved Drinking Water (2018 to 2022-23):

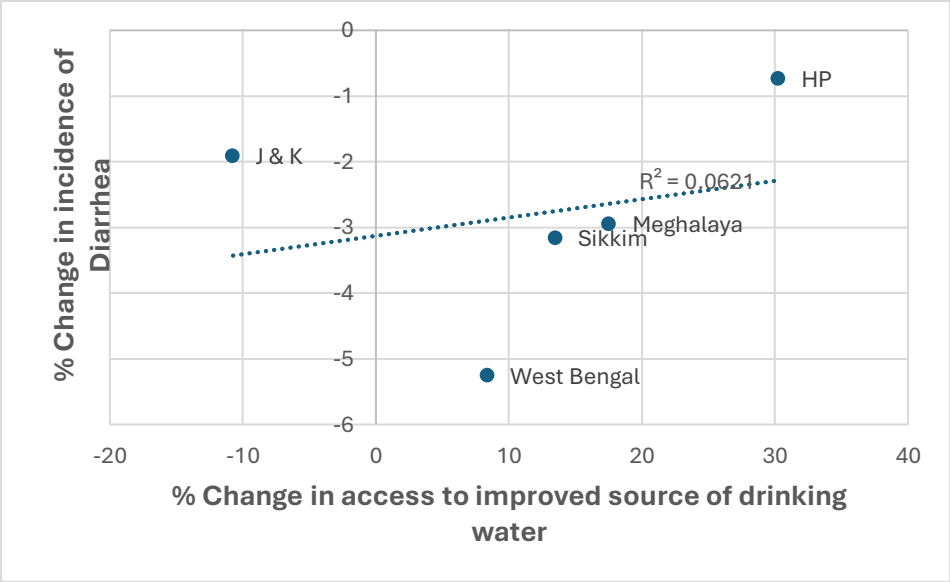
- **Jammu & Kashmir:**
  - Water access decreased **(especially rural).**
  - Diarrheal incidence still fell significantly**.**
  - Possible explanations**:**
    - Other improvements: sanitation, medical services, hygiene behavior, or bottled water use.
    - Existing water supply infrastructure, particularly in rural areas, might have suffered damage due lack of maintenance, or unforeseen events, leading to restricted access for maintenance and repairs but increased awareness of hygiene (e.g., handwashing drives during COVID-19).

- **Himachal Pradesh:**
  - Water access increased substantially **(~30% gain).**
  - Diarrheal incidence decreased **(moderately).**
  - Possible explanations**:**
    - Access expansion worked, but the quality of water supply might still be inconsistent (especially in hilly terrain where piped water faces contamination risks).
    - Behaviour changes (post COVID-19) like better hand hygiene could have contributed.

- **Sikkim:**
  - Water access already high, improved slightly more.
  - Big drop in diarrheal incidence.
  - Possible explanations:
    - Combined effect of better water, strong healthcare access, and high literacy rates supporting hygiene practices.
    - Effective implementation of programs like Jal Jeevan Mission in small states.

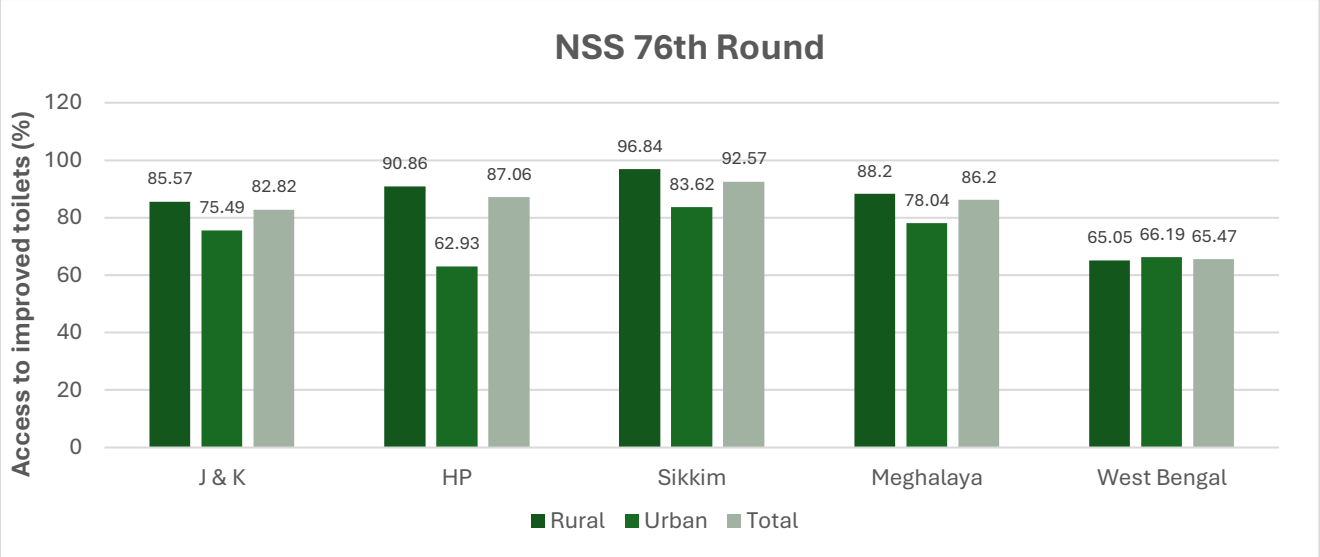
- **Meghalaya:**
  - Moderate improvement in water access, but in rural areas still half of the population struggles access to improved drinking water.
  - Huge decrease in diarrheal cases.
  - Possible explanations**:**
    - Even modest improvements in water access can have **large marginal health effects** in very underserved areas.
    - Water treatment plants or local community practices like boiling practices or chlorination could have amplified impact.

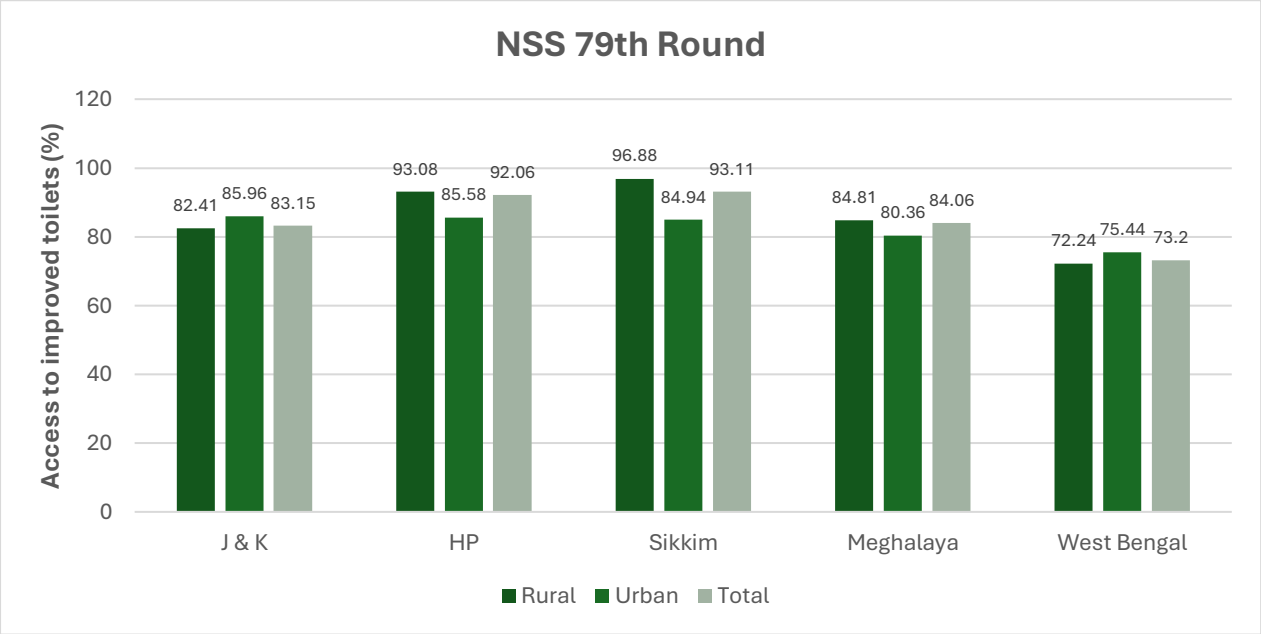
- **West Bengal:**
  - Slight improvement in water access (~9%), though West Bengal is still struggling.
  - Less than half of the population struggles access to improved water.
  - Largest drop in diarrheal cases (~5.2 fewer cases per 1000).
  - Possible explanations:
    - Huge focus on public health campaigns (e.g., Swachh Bharat, water quality monitoring) in recent years.
    - Improvements in urban sanitation or strong healthcare access might be the reason for drastic drop in diarrheal cases.
    - Behavioural changes — boiling water, better child care practices post-pandemic.



- **Weak correlation** between improved access and diarrheal reduction (low R^2 ~0.06).This suggests **access alone isn't enough — water quality, personal hygiene, sanitation practices**, and **healthcare interventions** also play major roles.
- The trendline is nearly flat because variations in diarrheal incidence are larger compared to changes in access. Jammu & Kashmir stands out as an outlier, showing a decline in access but a notable improvement in health, likely due to factors like better hygiene practices and healthcare services.
- States like West Bengal achieved significant health improvements with only modest gains in water access, highlighting the crucial role of water quality, sanitation, hygiene behaviour, and healthcare interventions alongside infrastructure development.

Table 6: Percentage distribution of households with access to improved toilets in different rounds (For selected high incidence states).





Access to Improved Toilets (2018 to 2022-23):

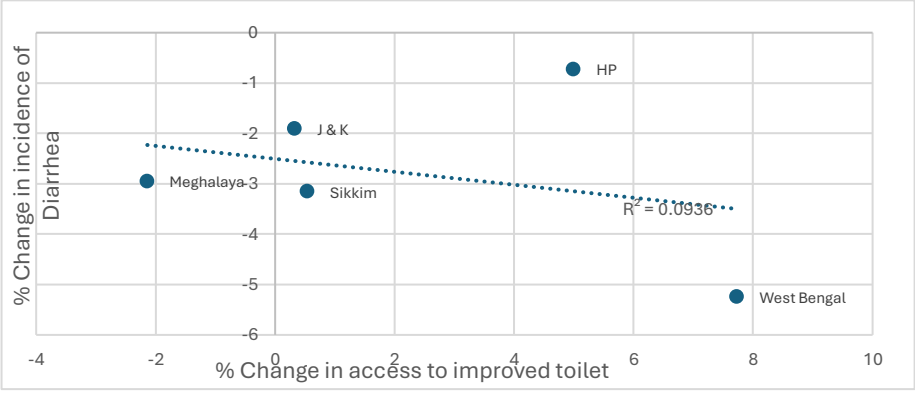
- **Jammu & Kashmir:**
  - **Overall access increased, specifically in urban areas**, but for rural areas it decreased.
  - Diarrheal incidence still fell significantly**.**
  - **Possible explanations:**
    - Infrastructure improvements (new toilet construction) under Swachh Bharat Mission in urban areas.
    - Hygiene behaviour changes post-COVID (even without perfect infrastructure) likely helped health outcomes.
    - However, maintenance issues or unforeseen events, lead to limited rural progress.

- **Himachal Pradesh:**
  - **Access improved modestly** (~5-6% increase).
  - **Possible explanations:**
    - Himachal already had high toilet access; thus, only marginal gains possible.
    - Focus might have shifted toward improving quality (functionality, maintenance) rather than only new construction.
    - Strong awareness campaigns could have ensured continued use of toilets, reducing open defecation.

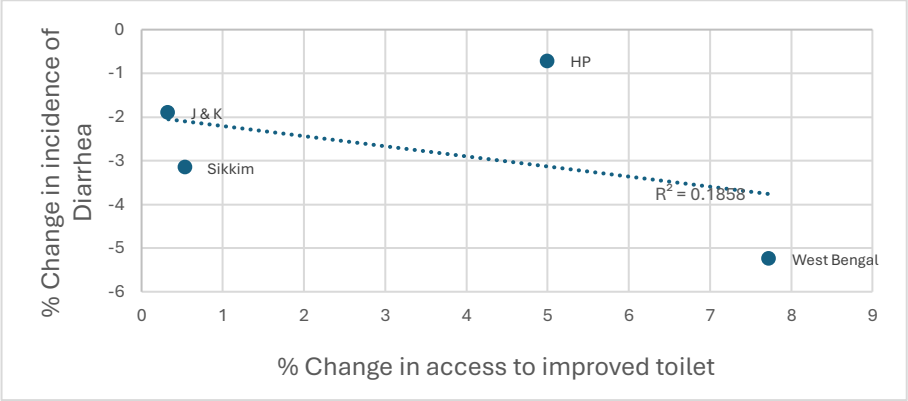
- **Sikkim:**
  - **Access remained very high**, with near-universal coverage.
  - **Possible explanations:**
    - Sikkim too had high toilet access; thus, only marginal gains possible.
    - Government focus shifted to sustaining use, repairing old infrastructure, and ensuring inclusivity.

- **Meghalaya:**
  - **Access to improved toilets decreased slightly** between 2018 and 2022–23, especially in rural areas.
  - **Possible explanations:**
    - Difficult hilly terrain and dispersed rural settlements make building and maintaining sanitation infrastructure challenging.
    - Despite government efforts, behaviour change around consistent toilet usage may have lagged behind infrastructure provision.
    - COVID-19 might have shifted public investment priorities temporarily toward emergency healthcare over sanitation infrastructure upkeep.

- **West Bengal:**
  - **Marginal improvement** (~1–2%), but still **poor access** (only ~65%).
  - **Possible explanations:**
    - Urban slums and peri-urban areas with high population density pose challenges.
    - Despite infrastructure deficits, behaviour change campaigns post-COVID likely had some health benefits.

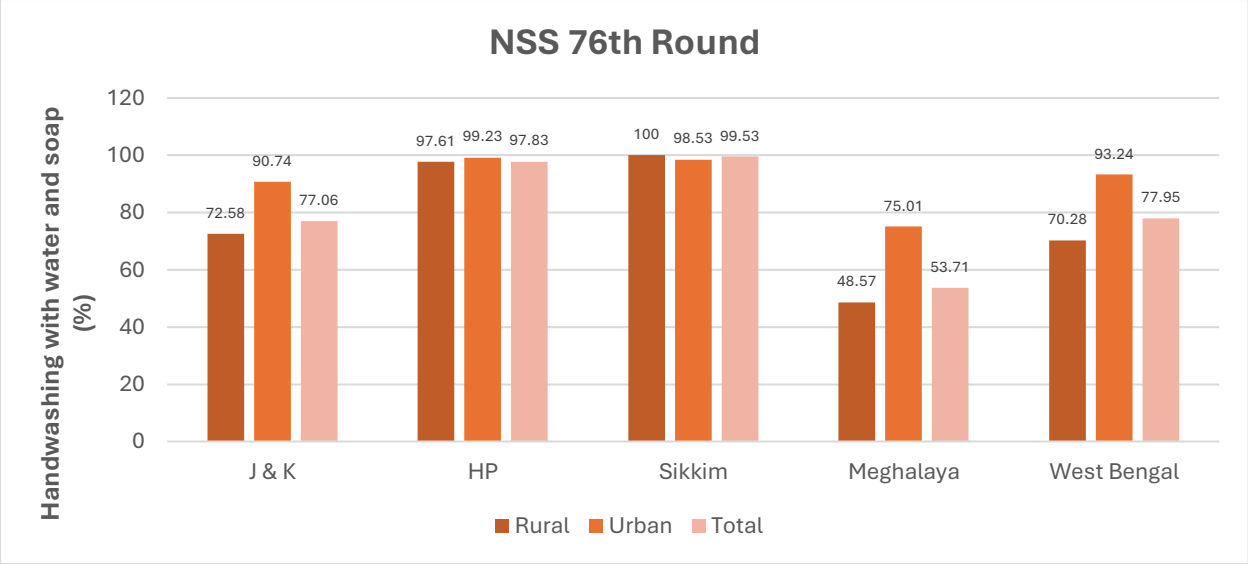


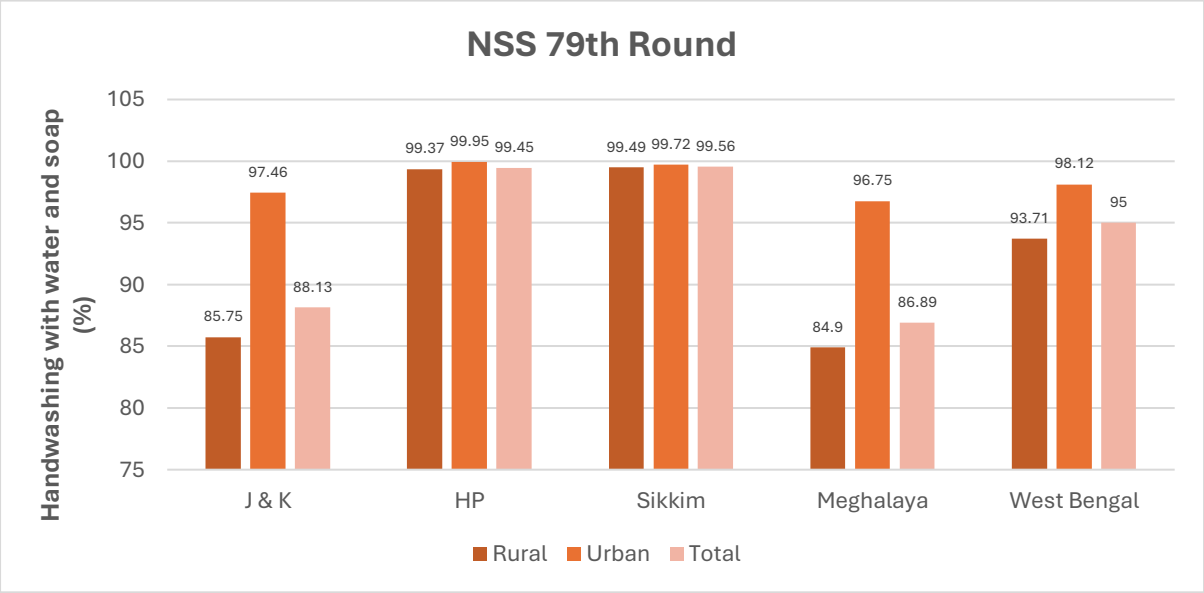
- There is a **negative relationship** between the change in access to improved toilets and the change in diarrheal incidence — **higher improvements in toilet access are loosely associated with greater reductions in diarrheal cases**. However, the relationship is **very weak** (R^2 = 0.03), indicating that **other factors beyond toilet access alone are likely influencing diarrheal trends**.
- Meghalaya saw a **decline in access to improved toilets (~-2%)**, yet experienced a significant reduction in **diarrheal incidence (~-3%).** This outlier behaviour suggests that **hygiene improvements, behaviour change (like better handwashing), or improved healthcare access** might have played a bigger role than toilet infrastructure alone.
- West Bengal achieved a major drop in diarrhea with only modest toilet access improvements, while Himachal Pradesh showed good access gains but limited diarrheal reduction — indicating that **infrastructure alone is not sufficient without behaviour change and complementary interventions**.



- Without Meghalaya, the relationship between improved toilet access and diarrheal reduction becomes slightly stronger (R^2 = 0.18). Overall, higher gains in toilet access are associated with greater drops in diarrheal incidence, but variation across states (e.g., Himachal Pradesh) suggests that toilet access alone is not the only determinant — complementary factors like hygiene practices and healthcare access likely matter too.

Table 7: Percentage distribution of households with handwashing facility with water and soap in different rounds (For selected high incidence states).





Handwashing with water and soap (2018 to 2022-23):

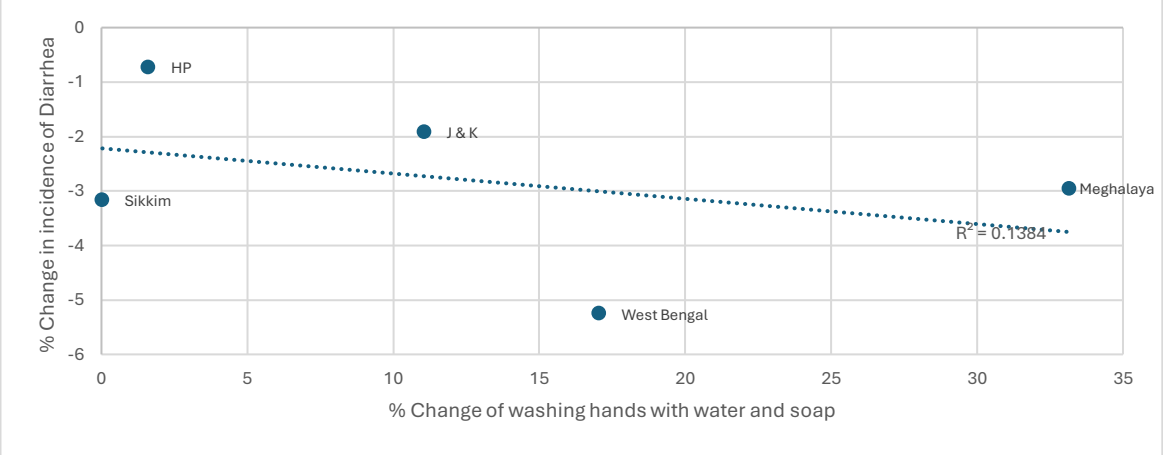
- **Jammu & Kashmir:**
  - **Sharp increase** in rural handwashing practices (from ~73% to ~85%).
  - **Possible explanations:**
    - COVID-19 pandemic dramatically changed hygiene behaviour even without large infrastructure changes.
    - Community-based awareness campaigns and school-level programs probably had significant effects.

- **Himachal Pradesh:**
  - **Very high handwashing levels maintained and slightly improved** (>99% now).
  - **Possible explanations:**
    - Existing culture of hygiene, reinforced by COVID-19 health messaging.
    - High levels of literacy and good health outreach services.

- **Sikkim:**
  - **Near-universal handwashing maintained** (~99% in both rounds).
  - **Possible explanations:**
    - Strong public health systems and small population facilitated targeted hygiene campaigns.
    - Strong social norms around cleanliness and health.

- **Meghalaya:**
  - **Massive improvement in rural handwashing** (~49% to ~85%).
  - **Possible explanations:**
    - Targeted COVID-19 communication campaigns effectively reached rural, underserved communities.
    - Health education and behavioural change interventions were highly successful even without massive infrastructure changes.

- **West Bengal:**
  - **Good improvement** (from ~70% to ~93% rural handwashing rates).
  - **Possible explanations:**
    - Behavioural shifts post-pandemic (boiling water, handwashing with soap, better child care).
    - Stronger focus on WASH behaviour promotion rather than only on infrastructure.
    - Outreach through schools, health centres, and community networks helped normalize good practices.



- The graph shows a negative relationship between the percentage increase in handwashing with water and soap and the percentage reduction in diarrheal incidence — meaning that as handwashing behaviour improves, diarrheal cases tend to decline. However, the strength of this relationship is relatively weak, as indicated by an R^2 value of 0.1384, suggesting that while handwashing improvements help, other factors like water quality, sanitation, and healthcare access also play a major role. Meghalaya saw the largest improvement in handwashing but only a moderate decline in diarrheal cases, while West Bengal achieved a bigger reduction in diarrhea with a comparatively smaller increase in handwashing, indicating varied underlying conditions across states.

Conclusion and policy discussion:

Conclusion:

- **Access to improved water and toilets alone is not sufficient** to ensure major health gains (measured through diarrheal disease reduction).
- **Behavioural changes**, especially **better hygiene practices** like handwashing with soap (accelerated by COVID-19 campaigns), played a **critical role** in improving health outcomes even when infrastructure expansion was limited.
- **Water quality**, **consistent use of sanitation facilities**, and **healthcare accessibility** emerged as equally (or more) important than simple infrastructure presence.
- **Variation across states** (e.g., J&K, Meghalaya, West Bengal) highlights that **local factors** like terrain, settlement patterns, public health efforts, and pre-existing social behaviour significantly shaped outcomes.
- **Statistical relationships** (low R^2 values across water, sanitation, hygiene) show that diarrheal disease reduction is **multi-factorial** — no single intervention (water, sanitation, hygiene) explains the full trend.

Policy discussion:

1. Move Beyond Infrastructure Numbers
   - Focus not just on how many households have toilets or taps, but **whether**:
     - Water is clean or toilets are functional and consistently used or hygiene practices (handwashing, safe water handling) are widespread.

2. Integrate Water Quality Monitoring
   - **Regular testing** and **local water treatment** (like chlorination units, promoting boiling) are needed, especially in hilly or flood-prone areas where contamination is common.

3. Strengthen Behaviour Change Campaigns
   - Continue mass campaigns (like Swachh Bharat, Jal Jeevan Mission) but **shift focus** toward **behavior maintenance**: Handwashing after COVID-19 must remain a habit. Safe child care and food hygiene need promotion. Encourage household-level water purification practices.

4. Prioritize Rural and Hilly Areas
    - Special attention is needed for states like **Meghalaya** and **Jammu & Kashmir**:
        - Difficult terrain means creative, localized solutions (e.g., community water filters, mobile sanitation units).
        - Maintenance and repair systems (for rural water schemes and toilets) should be strengthened.

5. Combine WASH Efforts with Healthcare Access
    - Improving WASH (Water, Sanitation, Hygiene) alone is insufficient without **accessible, affordable healthcare**:
        - Early treatment of diarrheal disease.
        - Public education on when to seek care.
        - Strengthen village-level health workers and clinics.

6. Focus on Data and Impact Evaluation
    - Use household surveys, health records, and water testing reports to **track outcomes** beyond infrastructure targets:
        - Example: Link water access and disease data to see real impacts.
        - **Identify gaps** (e.g., areas with infrastructure but no usage or contaminated water).

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