User Awareness and Behaviors Concerning Encrypted DNS Settings in Web Browsers

Alexandra Nisenoff, **Ranya Sharma**, Nick Feamster

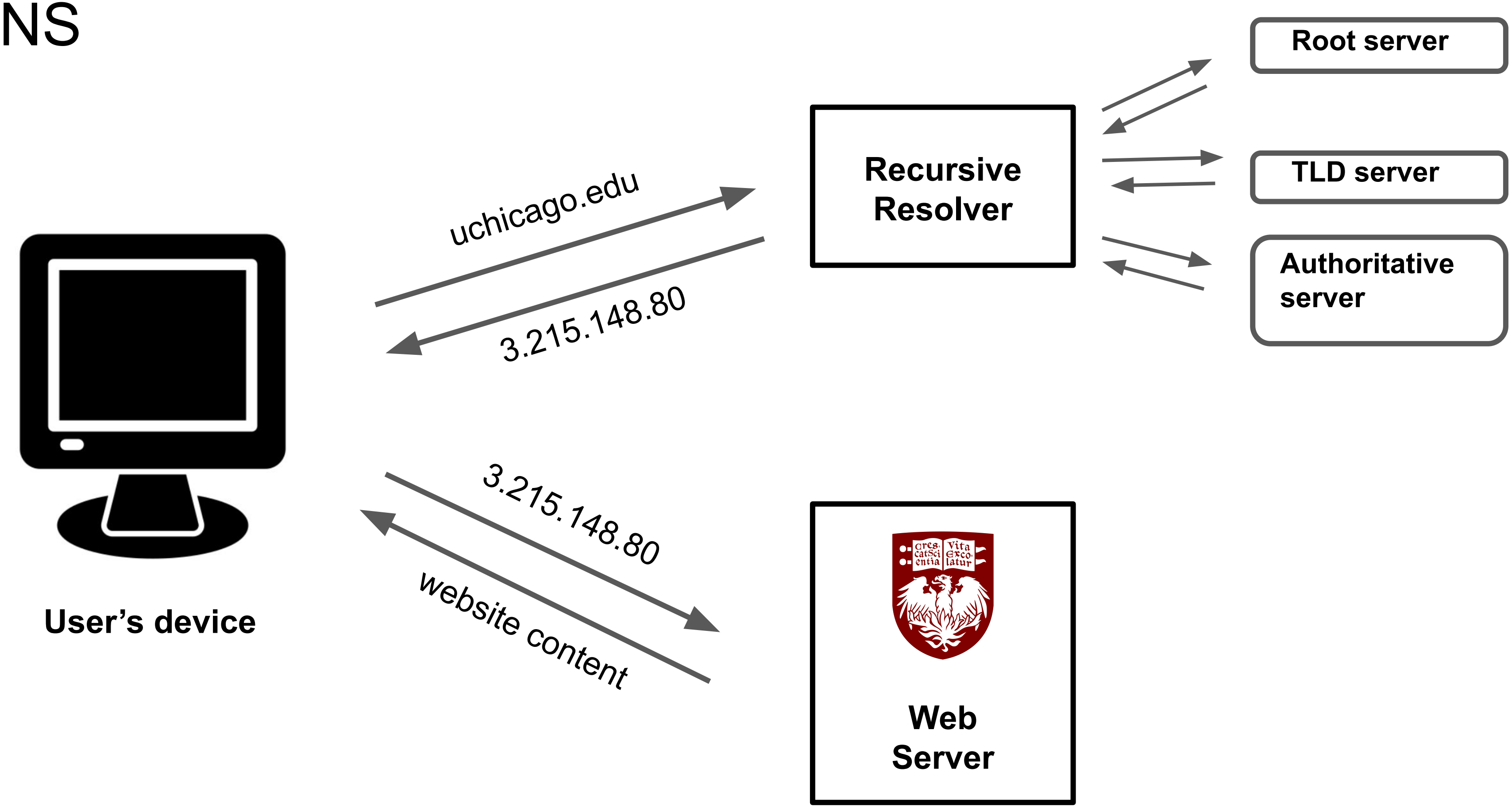
THE UNIVERSITY OF CHICAGO

Carnegie Mellon University

Motivation

- Current encrypted DNS ecosystem has a power imbalance
  - Technical design encourages centralization
- Design choices affect
  - Market consolidation
  - User privacy
  - User experience

DNS



Root server

TLD server

Authoritative server

Recursive Resolver

uchicago.edu

3.215.148.80

User’s device

3.215.148.80

website content

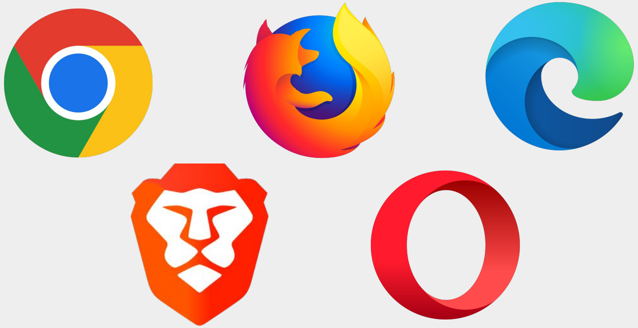
Web Server

Research Questions

1. Are users **aware** of encrypted DNS settings in browsers and devices?
2. What encrypted DNS settings do users have **enabled**?
3. When **shown** encrypted DNS **settings** for different browsers, which settings do users select?
4. When the **technical aspects** of these systems are **explained** to users, how do their choices of settings **change**?

Our Study

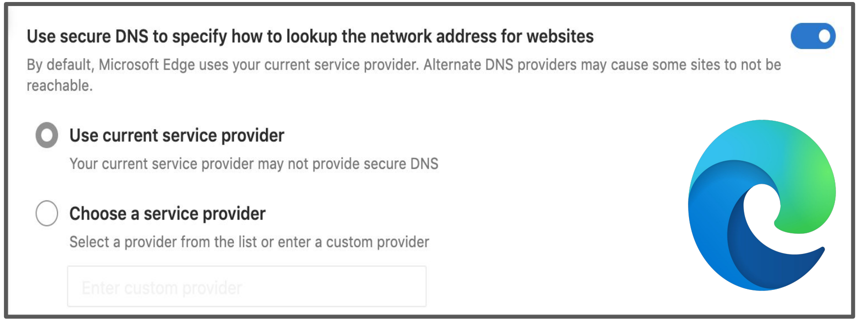
Browsers



Mobile Operating Systems

Encrypted DNS in Chrome

Enabling DNS-over-HTTPS



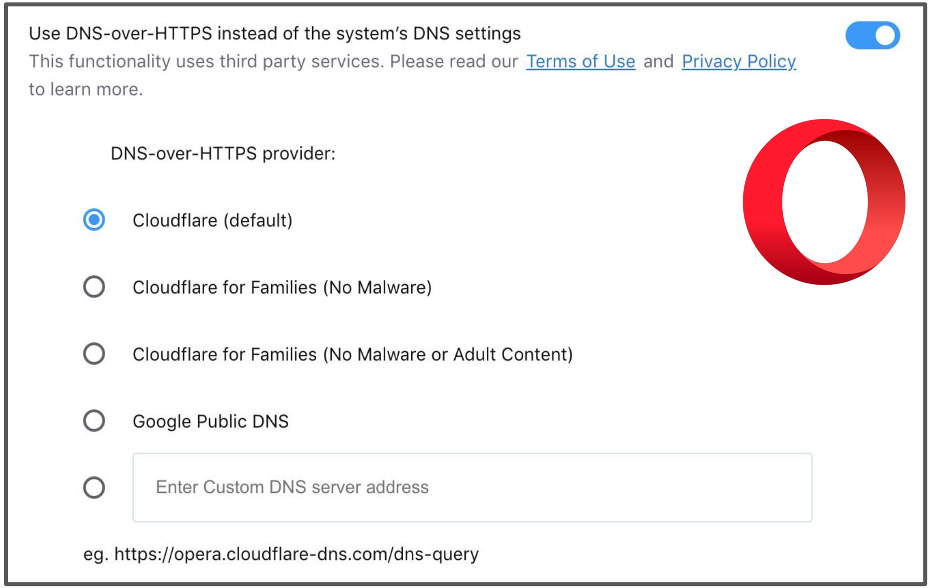
Use secure DNS to specify how to lookup the network address for websites

By default, Microsoft Edge uses your current service provider. Alternate DNS providers may cause some sites to not be reachable.

● **Use current service provider**
Your current service provider may not provide secure DNS

○ **Choose a service provider**
Select a provider from the list or enter a custom provider

Enter custom provider



Use DNS-over-HTTPS instead of the system's DNS settings

This functionality uses third party services. Please read our Terms of Use and Privacy Policy to learn more.

DNS-over-HTTPS provider:

● Cloudflare (default)

○ Cloudflare for Families (No Malware)

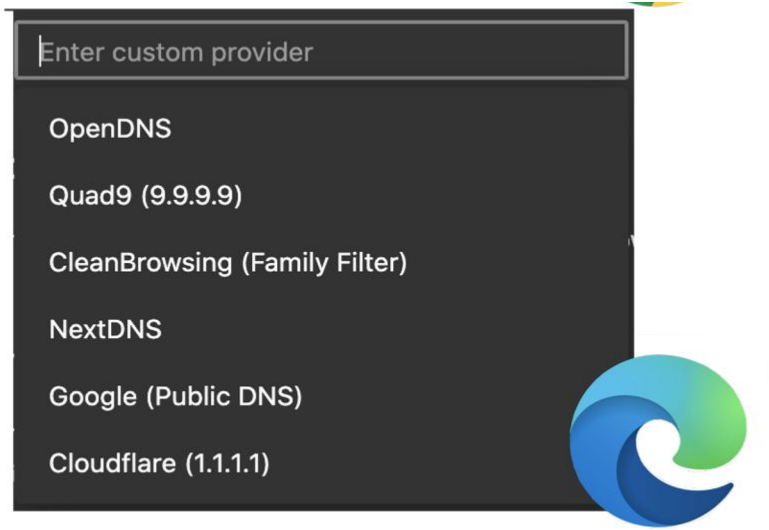
○ Cloudflare for Families (No Malware or Adult Content)

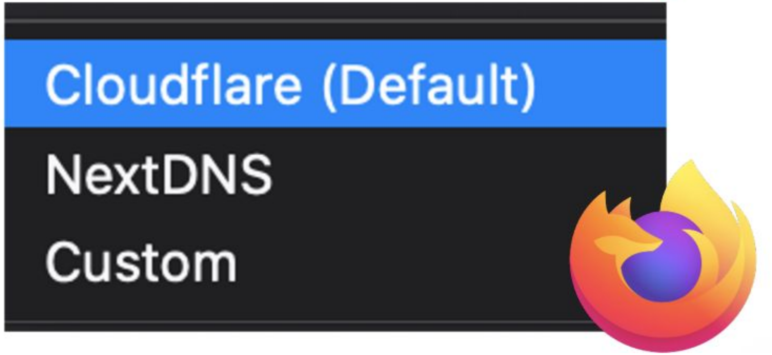
○ Google Public DNS

○ Enter Custom DNS server address

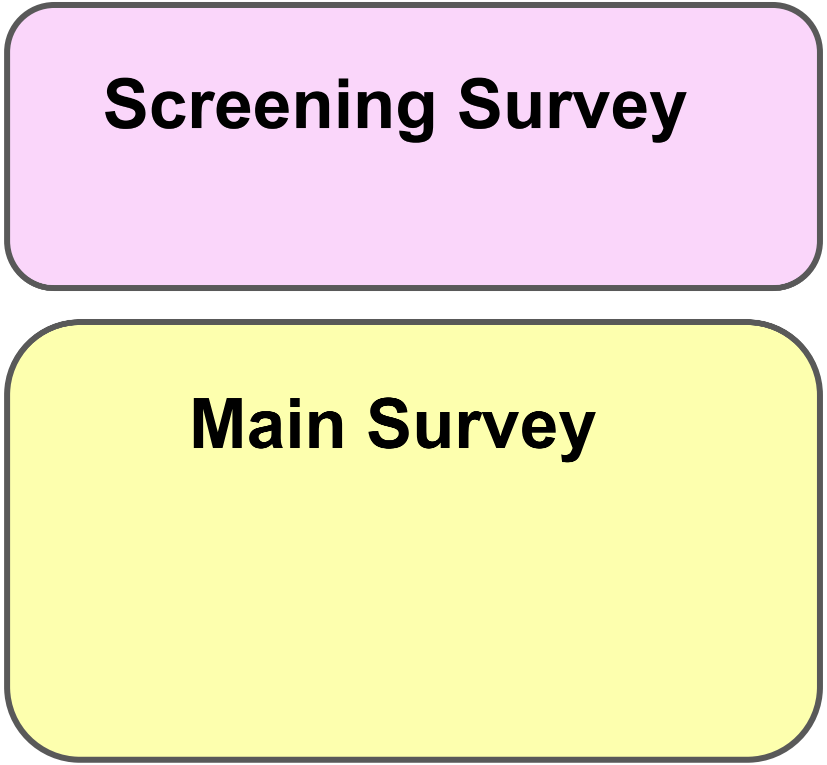
eg. https://opera.cloudflare-dns.com/dns-query

Choosing a Trusted Resolver





Our Study Methods



Screening Survey

Main Survey

Our Study Methods

Screening Survey

Browser usage

800 participants

Main Survey

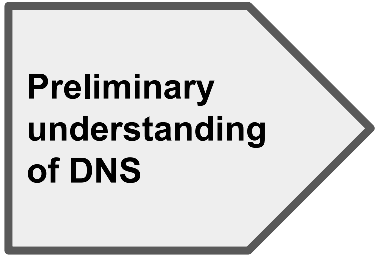
Our Study Methods

Screening Survey

Main Survey

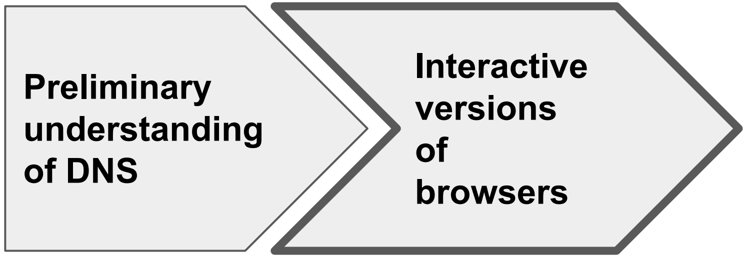
- 184 participants
- Participants assigned to subgroups
- Up to 50 participants from each subgroup participate in main survey

Main Survey



Preliminary understanding of DNS

Main Survey



Preliminary understanding of DNS

Interactive versions of browsers

n = 45

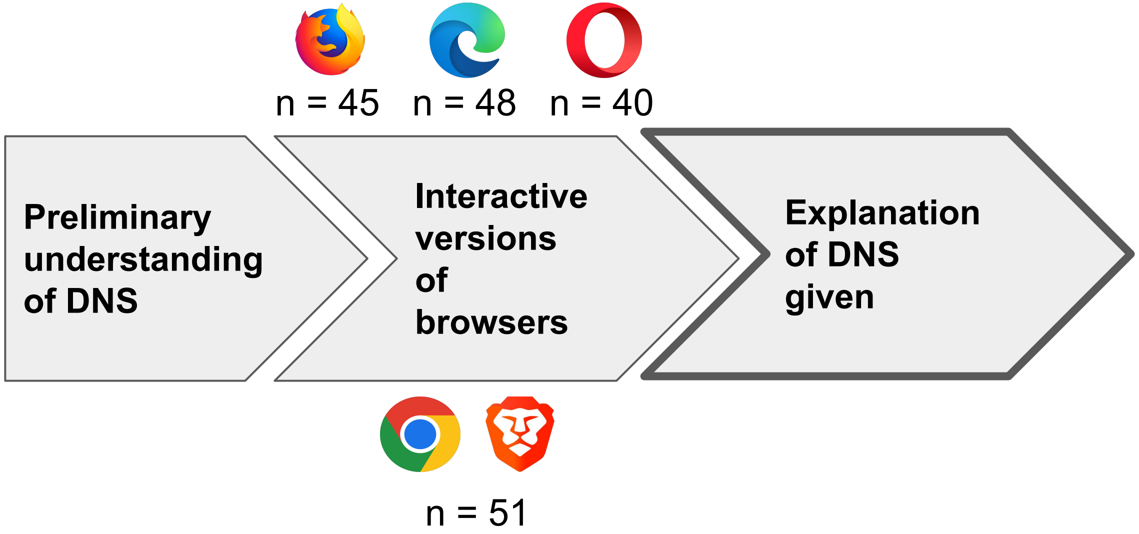
n = 51

$n_{chrome} + n_{brave} = 51$

n = 48

n = 40

Main Survey



n = 45 n = 48 n = 40

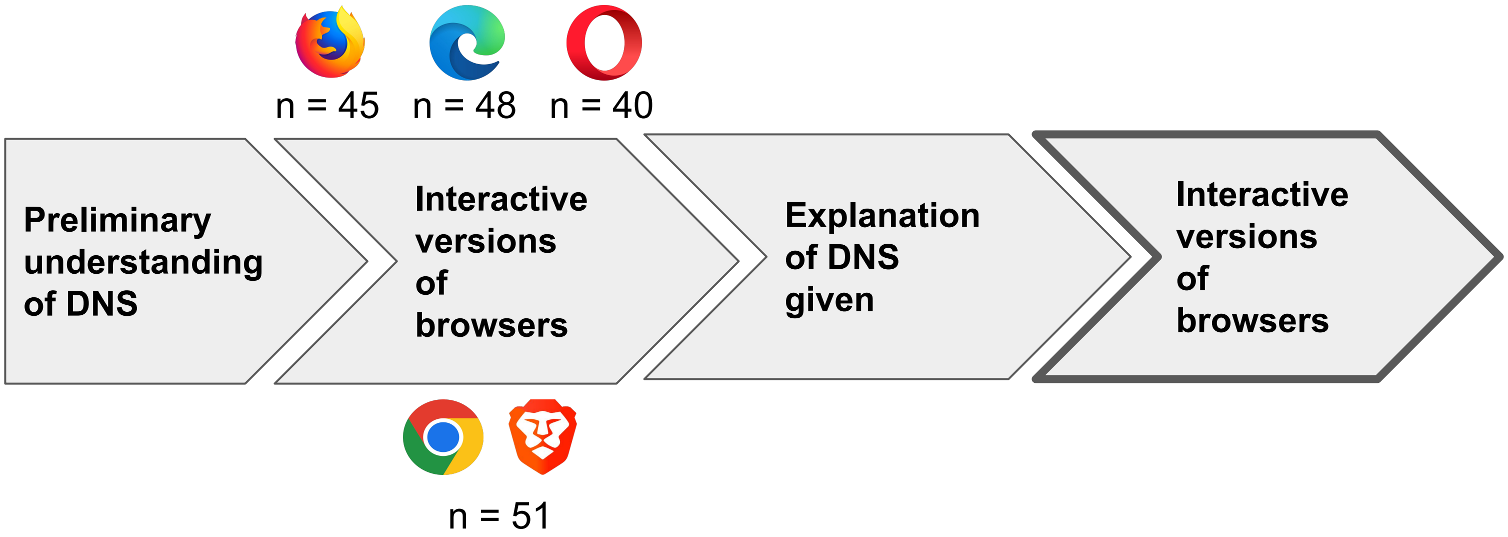
Preliminary understanding of DNS

Interactive versions of browsers

Explanation of DNS given

n = 51

Main Survey



n = 45 n = 48 n = 40

Preliminary understanding of DNS

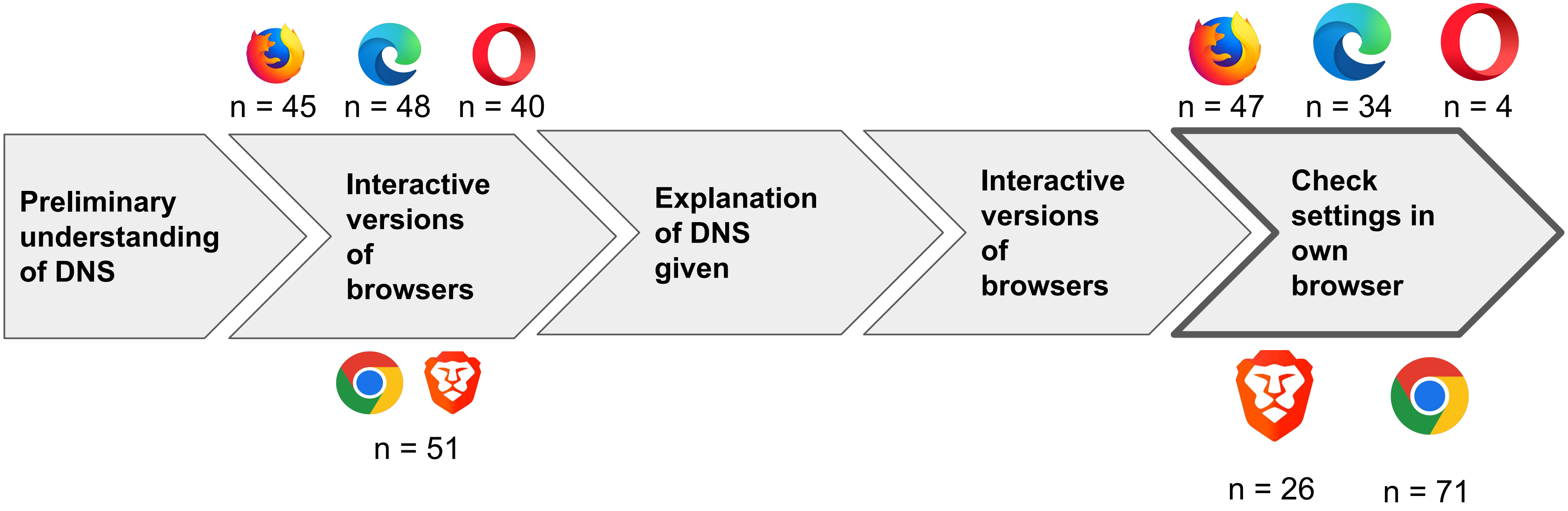
Interactive versions of browsers

Explanation of DNS given

Interactive versions of browsers

n = 51

Main Survey



n = 45 n = 48 n = 40

Preliminary understanding of DNS

Interactive versions of browsers

n = 51

Explanation of DNS given

Interactive versions of browsers

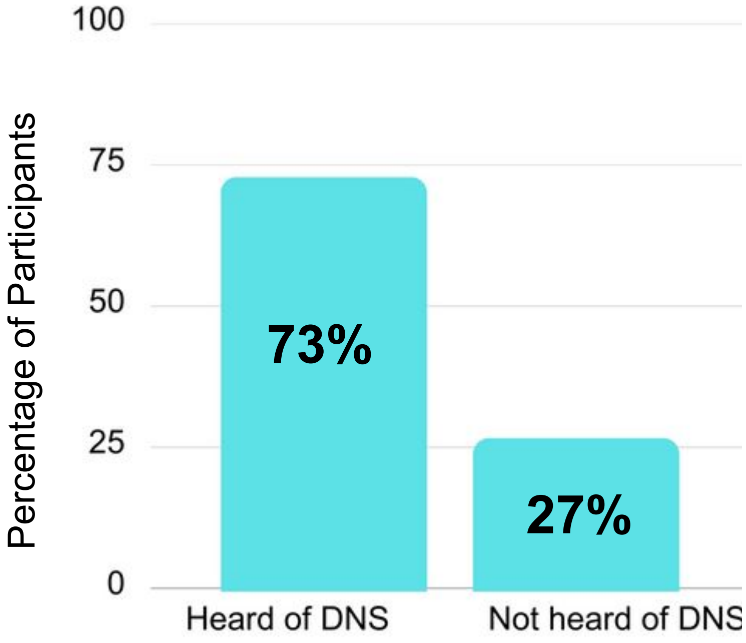
n = 47 n = 34 n = 4

Check settings in own browser

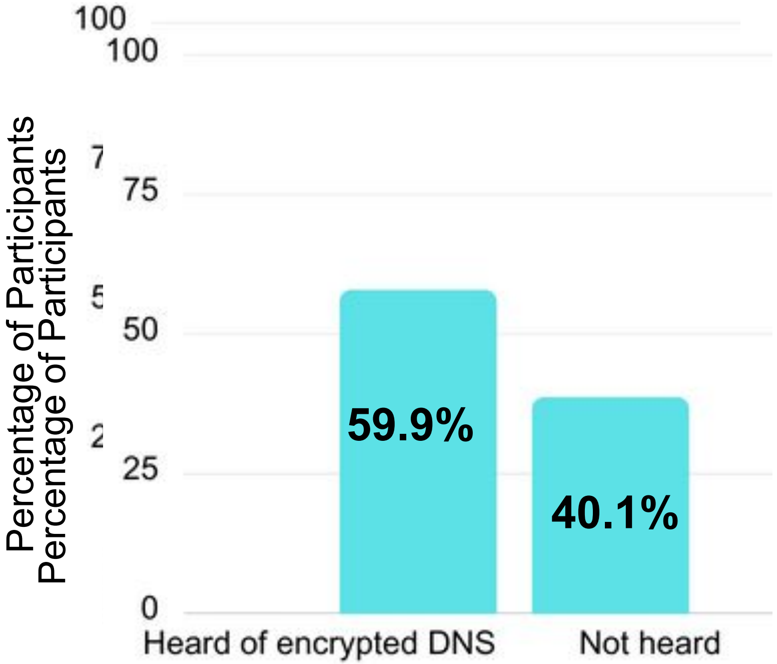
n = 26 n = 71

Are users aware of encrypted DNS settings?

High percentage of participants reported **having heard of DNS** prior to the survey

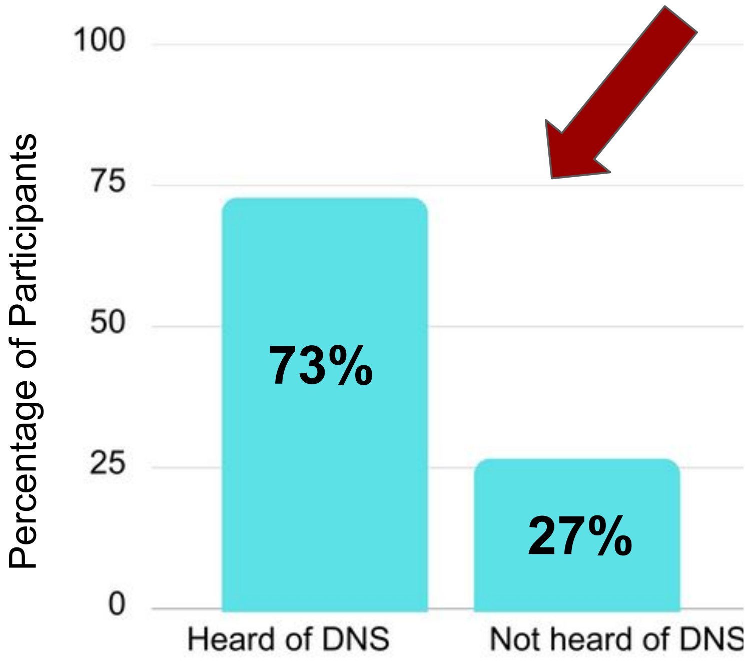


Of the participants who reported **having heard of DNS**, more than half had heard of **encrypted DNS**.

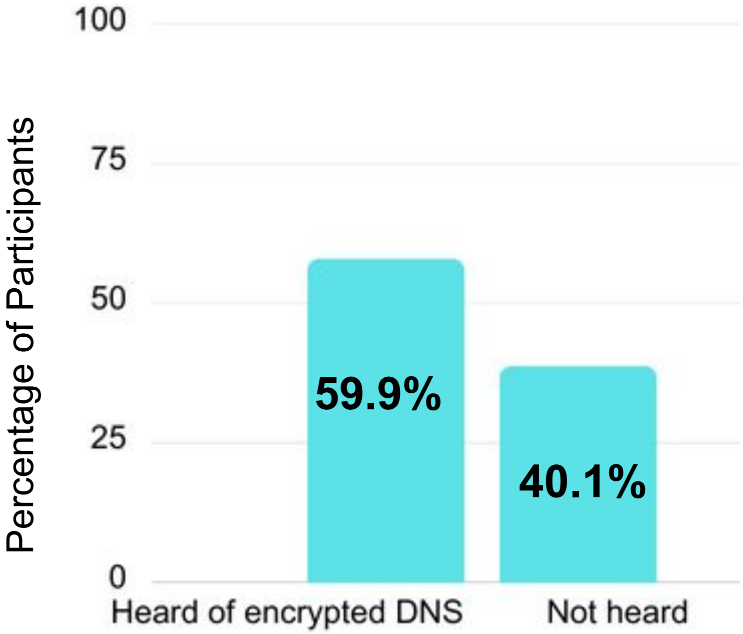


Are users aware of encrypted DNS settings?

High percentage of participants reported **having heard of DNS** prior to the survey

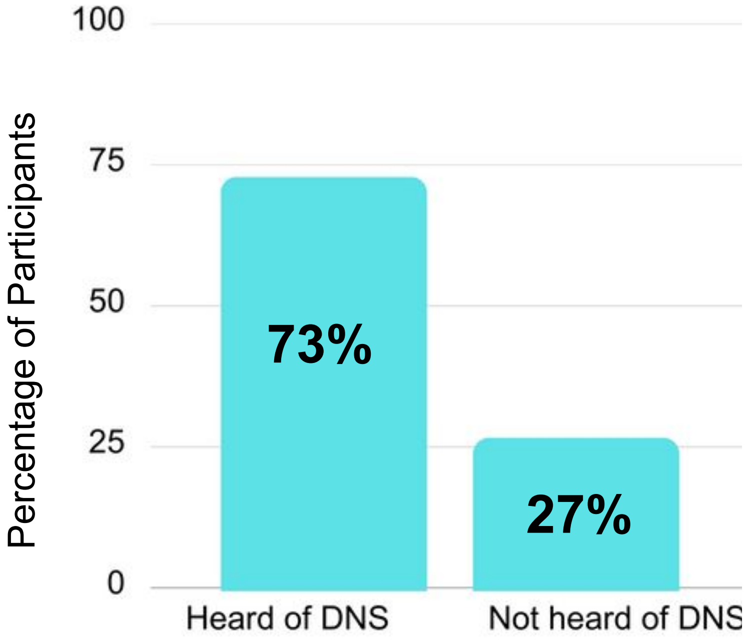


Of the participants who reported **having heard of DNS**, more than half had heard of **encrypted DNS**.

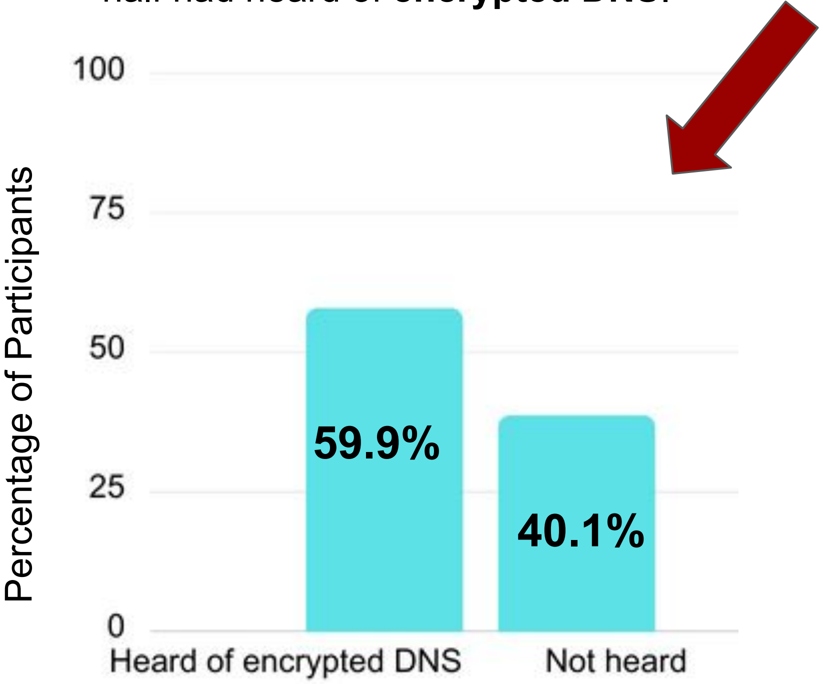


Are users aware of encrypted DNS settings?

High percentage of participants reported **having heard of DNS** prior to the survey

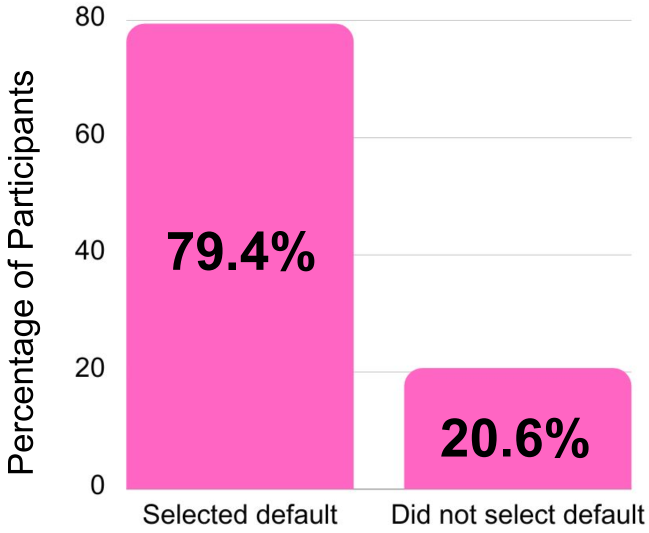


Of the participants who reported **having heard of DNS**, more than half had heard of **encrypted DNS**.



What encrypted DNS settings do users have enabled?

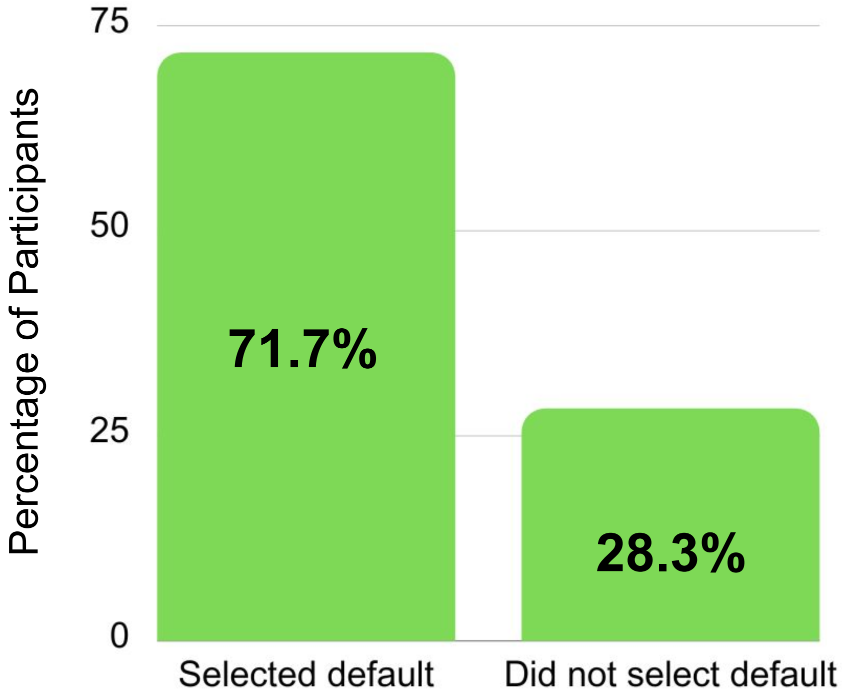
Most participants selected the default settings in their browsers



No participants correctly configured a custom DNS resolver in their browser.

When shown encrypted DNS settings for different browsers, which settings do users select?

Most participants continued to use the default settings shown to them



Custom Resolvers

https://dns.google/dns-query

https://dns.cloudflare.com/dns-query

When shown encrypted DNS settings for different browsers, which settings do users select?

Name of setting and perceived impact

- “Secure DNS”
- “DNS-over-HTTPS”

Participants associated Secure DNS with **safety** and **security**.

“The wording makes it sound like enabling DNS would make my browser more secure,” (P6).

“I don't know a lot about it but it seems like an extra step of protection,” (P50).

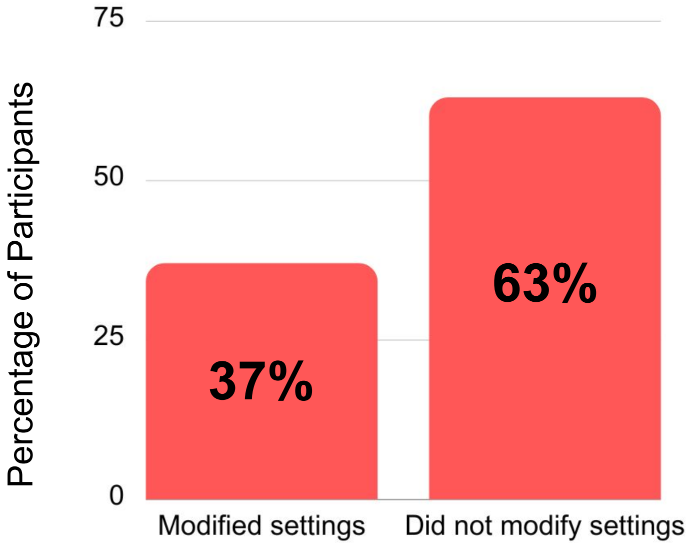
Instead of interpreting DNS-over-HTTPS as meaning **DNS *using* the HTTPS** protocol, they interpreted DoH as meaning use **DNS *instead* of HTTPS**

“I have no earthly idea what DNS is, while I at least have a passing familiarity with HTTPS,” (P3).

“From the little I know I believe that HTTPS is more secure than DNS,” (P30).

When the technical aspects of these systems are explained to users, how do their choices of settings change?

Nearly 40% of participants modified their settings after being shown an explanation of DNS and encrypted DNS



Recommendations

Provide a basic primer on DNS function

- Explain DNS function, privacy risks, tradeoffs associated with each setting

Be thoughtful of the technical protocol terminology

- DNS-over-HTTPS name confusion

Provide users with the necessary format to select a custom resolver

- Add instructions, guidelines, and warnings for more clarity

Recommendations

Provide a basic primer on DNS function

- Explain DNS function, privacy risks, tradeoffs associated with each setting

Be thoughtful of the technical protocol terminology

- DNS-over-HTTPS name confusion

Provide users with the necessary format to select a custom resolver

- Add instructions, guidelines, and warnings for more clarity

Recommendations

Provide a basic primer on DNS function

- Explain DNS function, privacy risks, tradeoffs associated with each setting

Be thoughtful of the technical protocol terminology

- DNS-over-HTTPS name confusion

Provide users with the necessary format to select a custom resolver

- Add instructions, guidelines, and warnings for more clarity

User Awareness and Behaviors Concerning Encrypted DNS Settings in Web Browsers

Alexandra Nisenoff, Ranya Sharma, Nick Feamster

- Work is needed to:
    - Improve user awareness
    - Provide users with more information
    - Design intuitive setting interfaces

Acknowledgements

This work was supported by NSF Award SaTC-2155128, NSF Award TWC-1953513