The move

- Chose between the **27th of September** or the **4th of October** for the move
- Contact Marianne Gallo to share the decision and ask for **access authorization**:
    - Charles and Ghazal in **A-3413**
    - Kaveh, Sadaf and Benoît in **A-3456**
- Take everything you need: **No access to A-3434 for about a month**
- Next Journal Club the 7th of October in A-3413 ?
  https://docs.google.com/document/d/14uolN0ri22cerwco3w87IuS1IIBqN0KtCz-LDJwu8Jw/edit?pli=1
- **Other questions ?**

Hiking

- Schedule: https://www.when2meet.com/?26595864-YpNj7
- Place:
  - Natural reserve Alfred Kelly
  - Mont-Tremblant
  - Mont Orford

Little reminder for Narval

/lustre06/project/6093672/shared_codes/scripts/bashrc/

▼ Name

⬆ ..

⌨ correct_permissions_for_current_user.sh

sbatch /lustre06/project/6093672/shared_codes/scripts/bashrc/correct_permissions_for_current_user.sh

ctb-sbouix

```
[bverre@narval2 6093672]$ ls -la
total 2965
drwxrws---.   13 sbouix    ctb-sbouix    25600 Aug 19 11:15  .
drwxr-xr-x. 9369 root      root        2720768 Sep  9 09:33  ..
drwx--S---.    3 ahmedrek  ctb-sbouix    25600 Sep  8 01:55  ahmedrek
drwxr-s---.    7 sadaf     ctb-sbouix    25600 Aug  9 16:53  'AMP results'
drwxrws---.    2 bverre    ctb-sbouix    25600 Aug 20 13:57  bverre
drwx--S---.    3 cbricout  ctb-sbouix    25600 Aug  1 07:48  cbricout
drwxr-s---.    3 cbricout  ctb-sbouix    25600 Jun 25 15:32  data
drwxrws---.    5 bverre    ctb-sbouix    25600 Jul 26 16:41  datasets
drwxr-s---.    8 ghazal    ctb-sbouix    33792 Aug 19 16:56  ghazal
drwx--S---.    2 kavehets  ctb-sbouix    25600 Jun  5 15:31  kavehets
drwx--S---.    2 sadaf     ctb-sbouix    25600 Jun  5 15:31  sadaf
drwx--S---.    2 sbouix    ctb-sbouix    25600 Jun  5 11:31  sbouix
drwxrws---.    6 bverre    ctb-sbouix    25600 Aug 16 15:55  shared_codes
```

def-sbouix

```
[bverre@narval2 6074560]$ ls -la
total 2957
drwxrws---.   13 sbouix    def-sbouix    25600 Aug 16 15:53 .
drwxr-xr-x. 9369 root      root        2720768 Sep  9 09:33 ..
drwx--S---.   10 ahmedrek  def-sbouix    25600 Aug 31 19:31 ahmedrek
drwxrws---.    5 bverre    def-sbouix    25600 May 27 14:34 bverre
drwx--S---.    4 cbricout  def-sbouix    25600 Jun  5 18:54 cbricout
drwxrws---.   15 sbouix    def-sbouix    25600 Jun  9 09:23 data
drwx--S---.    3 ghazal    def-sbouix    25600 Jun 12 18:24 ghazal
drwx--S---.    2 kavehets  def-sbouix    25600 Sep 14 2023 kavehets
drwxrws---.    6 sadaf     def-sbouix    25600 May  7 11:25 sadaf
drwx--S---.    3 sbouix    def-sbouix    25600 Aug 24 2023 sbouix
drwxrws---.    7 bverre    def-sbouix    25600 May 30 14:24 shared_codes
drwxrws---.   10 bverre    def-sbouix    25600 Jan 18 2024 software
drwxrws---+    4 ghazal    def-sbouix    25600 Aug  1 15:11 Unest-result-segmenta
```

```
[bverre@narval2 6074560]$ diskusage_report
                      Description           Space        # of files
          /home (project bverre)          11G/50G           70k/500k
       /scratch (project bverre)         146k/20T            5/1000k
     /project (project ctb-sbouix)      4360G/185T        1015k/1500k
     /project (project def-sbouix)       3904G/10T          488k/500k
    /nearline (project ctb-sbouix)       196k/1000G            8/5000
    /nearline (project def-sbouix)       196k/1000G            8/5000
```

Automated brain segmentation and volumetry in dementia diagnostics: a narrative review with emphasis on FreeSurfer

Eya Khadhraoui, Thomas Nickl-Jockschat, Hans Henkes, Daniel Behme and Sebastian Johannes Müller
(Clinic for Neuroradiology, University Hospital, Magdeburg, Germany)

Overview

- **Dementia** = syndrome associated with **many** neurodegenerative diseases (Alzheimer, mild cognitive impairment, frontotemporal dementia, Parkinson, Lewy bodies, etc.)
- 7th most common cause of death globally (WHO, 2021) (6 first leading causes of death in 2021?)
- Cause disability and dependency
- **Incidence** expected to increase with population aging
  - 10m new diagnosed patients per year worldwide
  - incidence doubles every 6.3-year increase in age (5% of the population older than 65, and 20–40% of those older than 85)
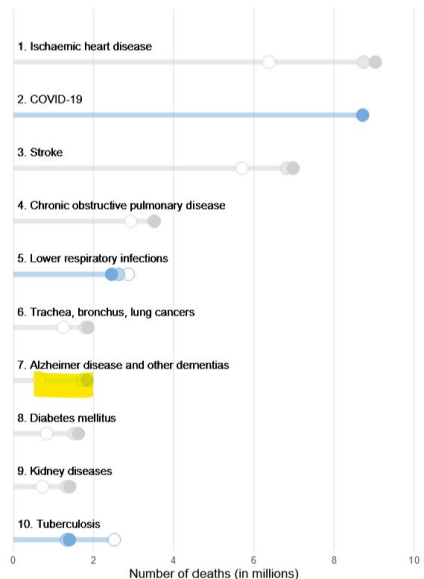
⇒ **early detection** (particularly volumetry from MRI) **and prevention**

- <u>**Goals**</u>:
1) Assess the current use of automated brain segmentation and volumetry in the field of dementia diagnosis (focus on FreeSurfer and Alzheimer's disease)
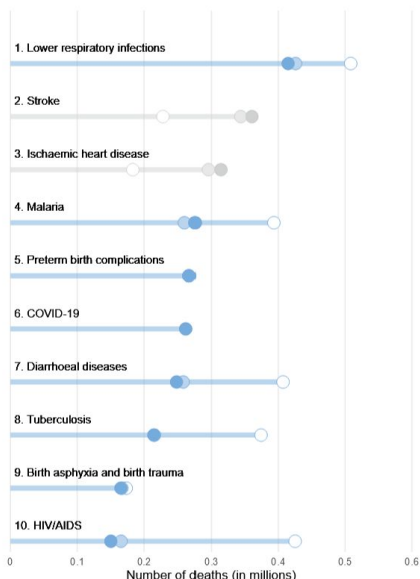2) Identify recommandations, gaps, and opportunities with brain MRI research

Leading causes of death in 2021 ? (WHO)

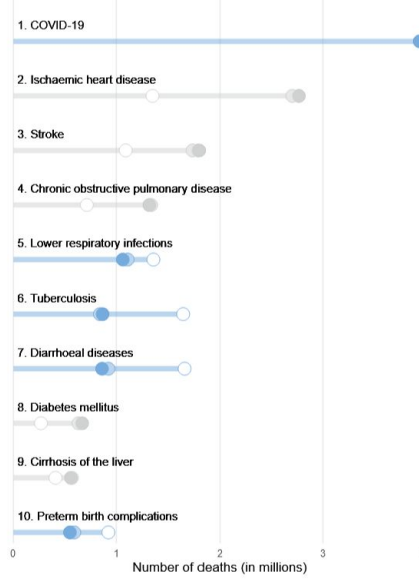Depends on the **country's level of income** !
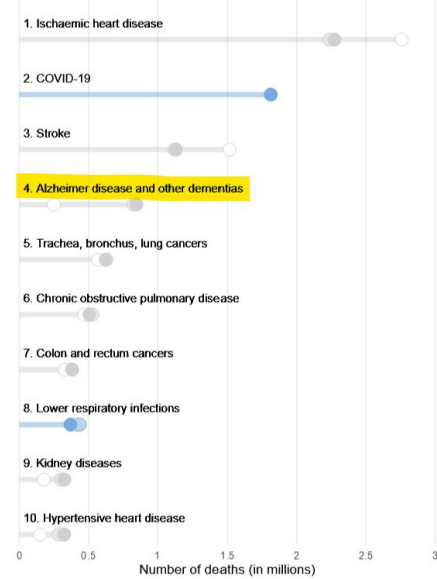

Leading causes of death in 2021 globally

1. Ischaemic heart disease
2. COVID-19
3. Stroke
4. Chronic obstructive pulmonary disease
5. Lower respiratory infections
6. Trachea, bronchus, lung cancers
7. Alzheimer disease and other dementias
8. Diabetes mellitus
9. Kidney diseases
10. Tuberculosis

Number of deaths (in millions)

○ 2000   ● Communicable, maternal, perinatal and nutritional conditions
◑ 2019   ● Injuries
● 2021   ○ Noncommunicable diseases

Leading causes of death in 2021 in low-income countries

1. Lower respiratory infections
2. Stroke
3. Ischaemic heart disease
4. Malaria
5. Preterm birth complications
6. COVID-19
7. Diarrhoeal diseases
8. Tuberculosis
9. Birth asphyxia and birth trauma
10. HIV/AIDS

Number of deaths (in millions)

○ 2000   ● Communicable, maternal, perinatal and nutritional conditions
◑ 2019   ● Injuries
● 2021   ○ Noncommunicable diseases

Leading causes of death in 2021 in lower-middle-income countries

1. COVID-19
2. Ischaemic heart disease
3. Stroke
4. Chronic obstructive pulmonary disease
5. Lower respiratory infections
6. Tuberculosis
7. Diarrhoeal diseases
8. Diabetes mellitus
9. Cirrhosis of the liver
10. Preterm birth complications

Number of deaths (in millions)

○ 2000   ● Communicable, maternal, perinatal and nutritional conditions
◑ 2019   ● Injuries
● 2021   ○ Noncommunicable diseases

Leading causes of death in 2021 in high-income countries

1. Ischaemic heart disease
2. COVID-19
3. Stroke
4. Alzheimer disease and other dementias
5. Trachea, bronchus, lung cancers
6. Chronic obstructive pulmonary disease
7. Colon and rectum cancers
8. Lower respiratory infections
9. Kidney diseases
10. Hypertensive heart disease

Number of deaths (in millions)

○ 2000   ● Communicable, maternal, perinatal and nutritional conditions
◑ 2019   ● Injuries
● 2021   ○ Noncommunicable diseases

Source: https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death

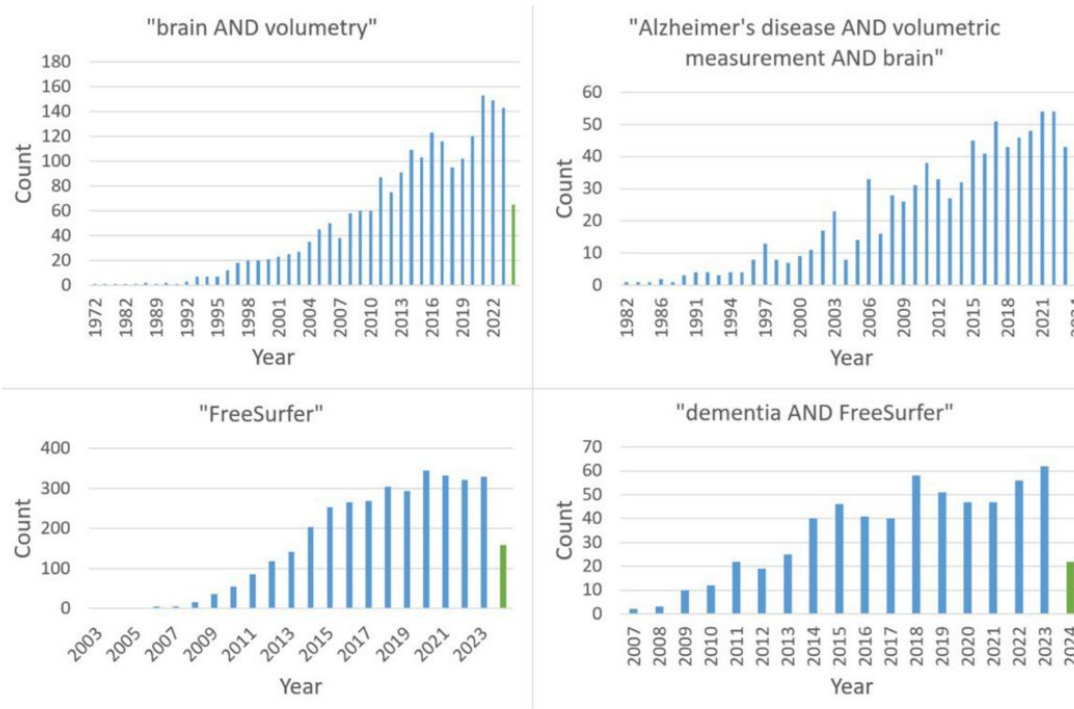# Method of selection of publications

FIGURE 1
The PubMed time line of the four relevant search terms (green: 2024).
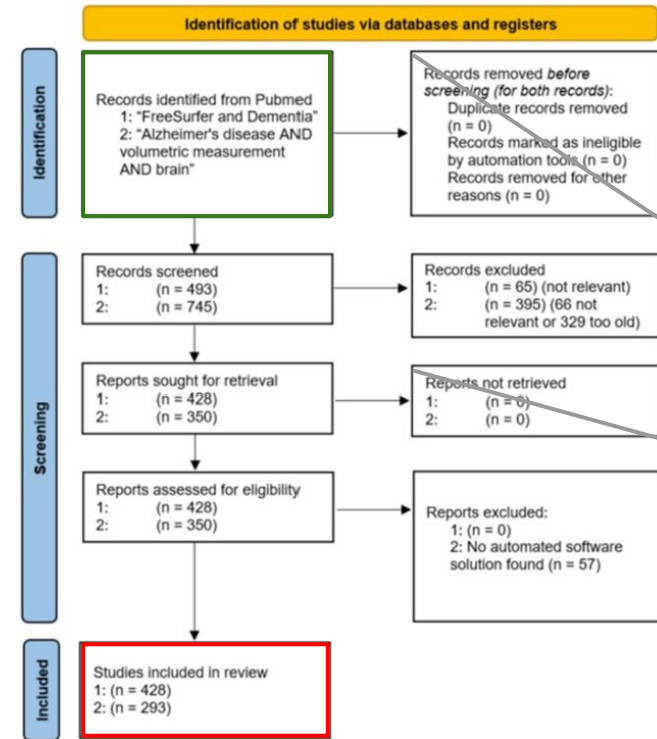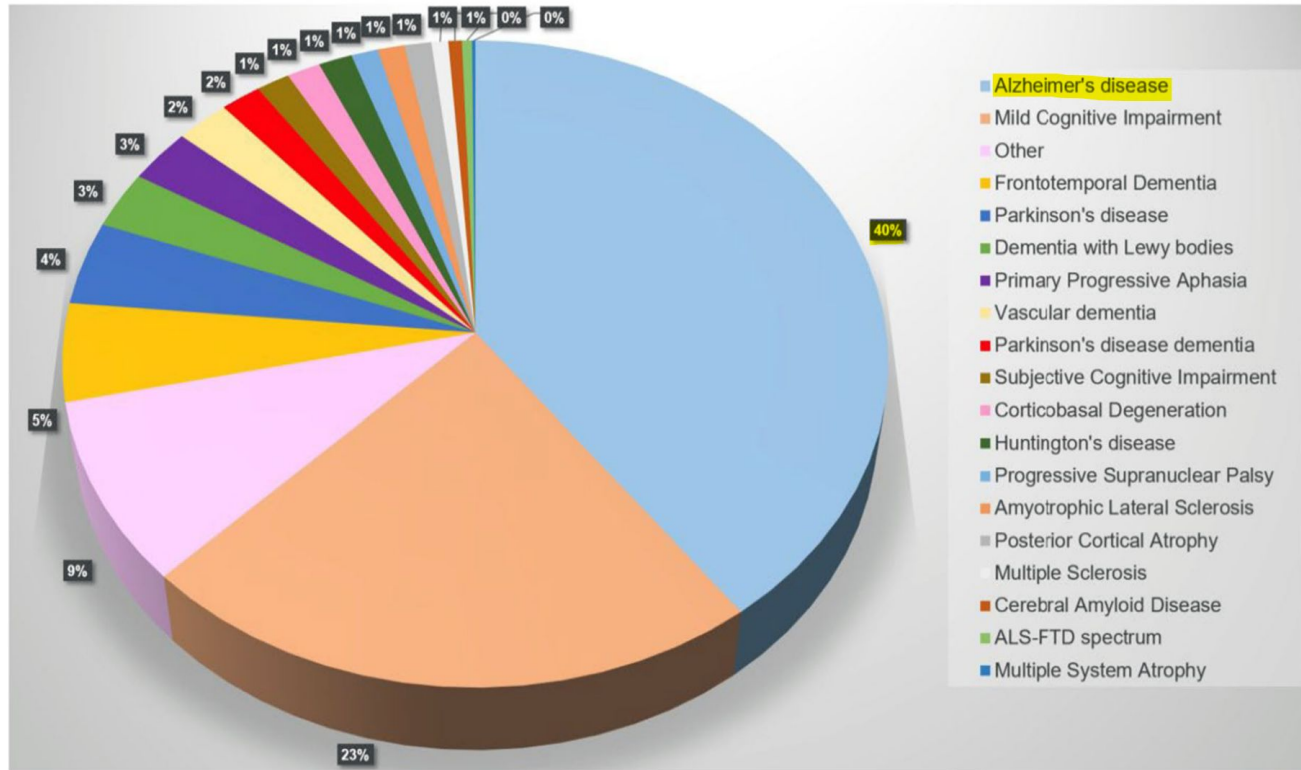
FIGURE 2
PRISMA flow chart of the included PubMed studies for both search terms.

- 16 VS 2925 results on PubMed for 'FastSurfer' (2020) compared to 'FreeSurfer' (2012) (silver standard)

2

Distribution of diseases in PubMed about 'FreeSurfer and Dementia'

Legend:
- Alzheimer's disease
- Mild Cognitive Impairment
- Other
- Frontotemporal Dementia
- Parkinson's disease
- Dementia with Lewy bodies
- Primary Progressive Aphasia
- Vascular dementia
- Parkinson's disease dementia
- Subjective Cognitive Impairment
- Corticobasal Degeneration
- Huntington's disease
- Progressive Supranuclear Palsy
- Amyotrophic Lateral Sclerosis
- Posterior Cortical Atrophy
- Multiple Sclerosis
- Cerebral Amyloid Disease
- ALS-FTD spectrum
- Multiple System Atrophy

Pie chart values: 40%, 23%, 9%, 5%, 4%, 3%, 3%, 2%, 2%, 2%, 1%, 1%, 1%, 1%, 1%, 1%, 1%, 0%, 0%

FIGURE 3
Pie chart showing the distribution of cohorts/diseases returned by the PubMed search "FreeSurfer and Dementia" (n = 428 of 493 studies, 01/01/2024).
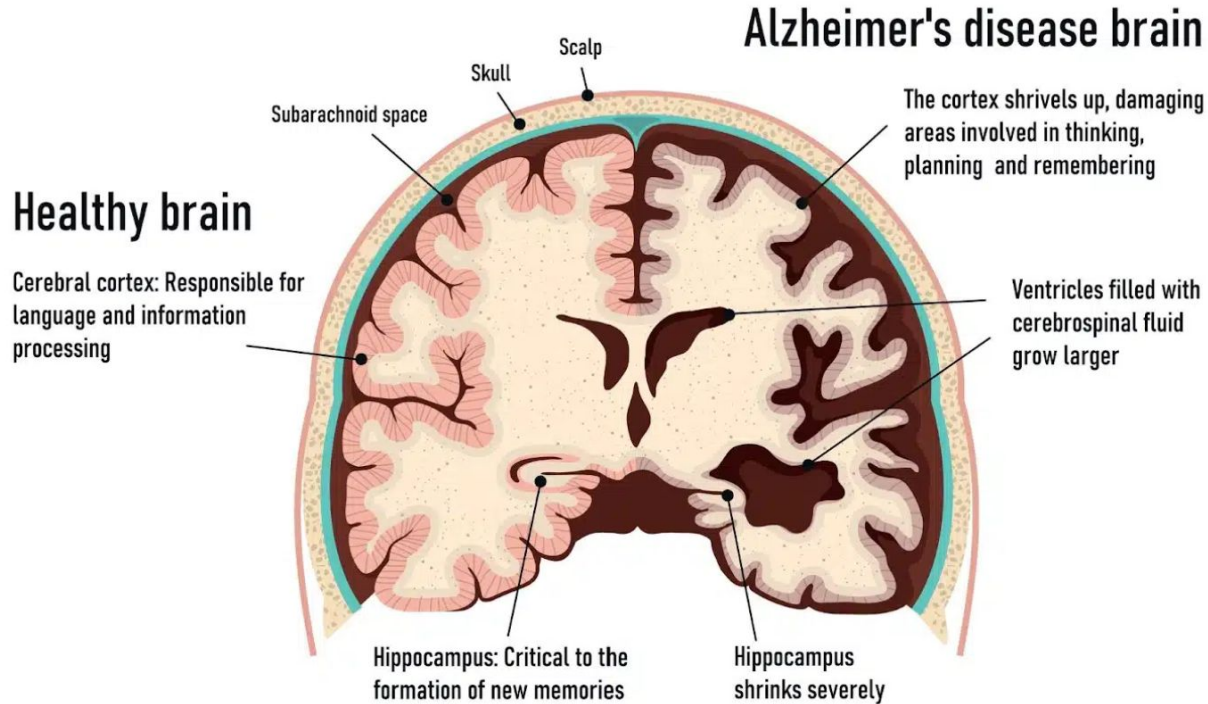
- Mild cognitive impairment: comparison difficult because of different subgroupings between studies

2

Cohorts/diseases distribution in publications

TABLE 1 Evaluated cohorts/diseases returned by the PubMed search "FreeSurfer and Dementia" (n = 428 of 493 studies, 01/01/2024).

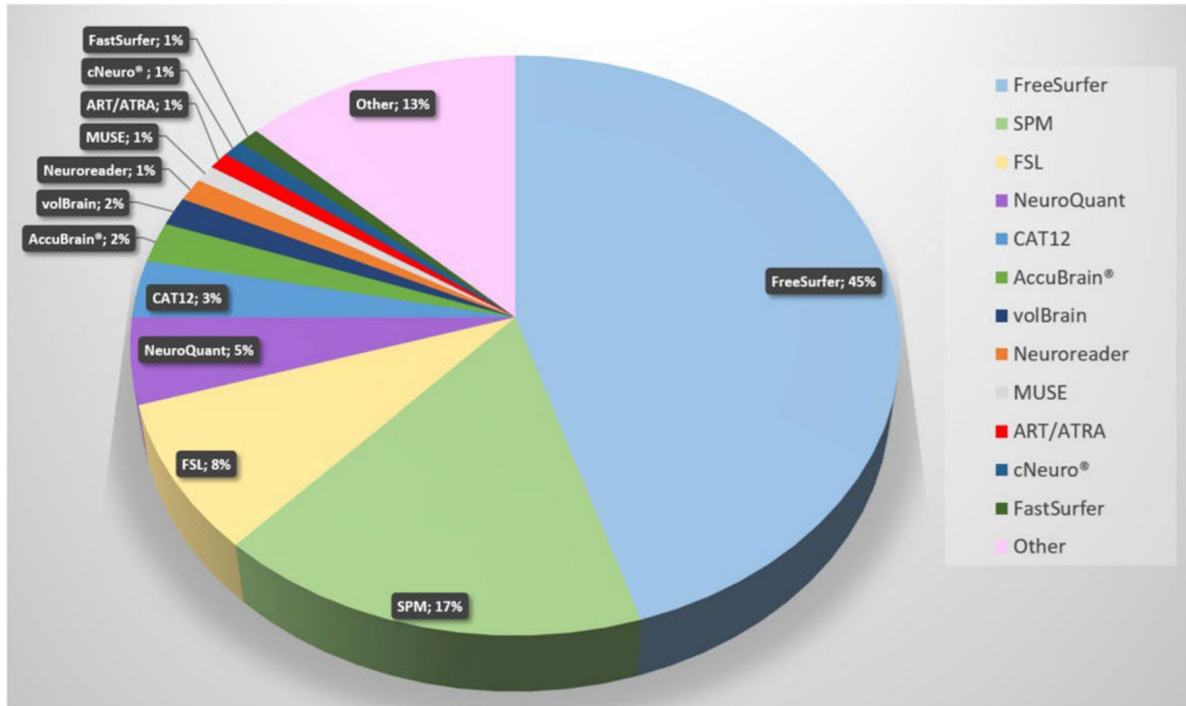| Group	Found cohorts (n)	Found cohorts (%)
Sum	1,049	100.0%
Healthy / control group	356	33.9%
Alzheimer's disease	276	26.3%
Mild cognitive impairment	157	15.0%
Other	63	6.0%
Frontotemporal dementia	34	3.2%
Parkinson's disease	29	2.8%
Dementia with Lewy bodies	20	1.9%
Primary progressive aphasia*	19	1.8%
Vascular dementia	16	1.5%
Parkinson's disease dementia	12	1.1%
Subjective cognitive impairment	10	1.0%
Corticobasal degeneration	10	1.0%
Huntington's disease	10	1.0%
Progressive supranuclear palsy	8	0.8%
Amyotrophic lateral sclerosis	8	0.8%
Posterior cortical atrophy	8	0.8%
Multiple sclerosis	5	0.5%
Cerebral amyloid disease	4	0.4%
ALS-FTD spectrum	3	0.3%
Multiple system atrophy	1	0.1%

- Alzheimer's (AD) cohorts examined dominates (focus here)
- **Underrepresentation of dementias in which no specific atrophy pattern is expected**, such as vascular dementia (VD) or dementia with Lewy bodies (DLB)

Alzheimer's disease brain

early marker of dementia (Gentreau et al., 2023)
But not completely reliable (Ferreira et al., 2017)

Used tools for "Alzheimer's disease volumetric measurement brain"

- **Statistical Parametric Mapping (SPM)**: open source, e.g. fMRI
- **NeuroQuant:** private (CA, US), cloud-based AI software, neurodegenerative diseases
- **Computational Analysis Toolbox (CAT)**: extension of SPM

- Complete list of tools and version used available in Table 2

FIGURE 4
Pie chart of software solutions in reports retrieved from Pubmed with the search term "Alzheimer's disease volumetric measurement brain" (most recent; descending). The newest 350 entries (from 2024 to 2015) were evaluated, 293 were included. All solutions with fewer than three entries are summarized under "Other".

Methods for performance assessment of the segmentation software

- **Dice similarity coefficient** (Dice, 1945; Shamir et al., 2018) (0–1, higher better)
- (Pompeiu-) **Hausdorff distance** (HD) (Birsan and Tiba, 2006) (in mm, lower better)
- **Mean average precision metric** (mAP; 0–1, higher better) (Beitzel et al., 2009)
- **Modified or Robust Hausdorff Distance** (MHD, HD95) (Huttenlocher et al., 1993) (not sensitive to local outliers)

- **FreeSurfer** is used as a Silver Standard most of the time.
- **Asymmetrical approaches needed** because of asymmetric brains (**BRATS challenge** for brain cancer segmentation, hundreds of softwares compared (Kazerooni et al., 2023), e.g. MMGan (Gao et al., 2023), nnUNetFormer (Guo et al., 2023), and multi-scale context UNet-like network (Qian et al., 2024))

Conclusion

- FreeSurfer still used as silver standard:
  - extensive functions for almost all questions and diagnosis, regular updates
  - sufficient accuracy
  - by habit (wide acceptance and validation)
  - large open source community
  - compatible with many other tools (e.g., FastSurfer, CerebNet)
- Numerous gaps in research:
  - Lewy Body Dementia sparsely researched
  - multiple atrophy patterns in Alzheimer's disease not fully understood
  - Misclassification of disease/subgrouping due to absence of biological substrate analysis (e.g. CSF biomarker profile)
  - significant variability in study protocols affects result comparability (accuracy and reliability)
- Promising new techniques:
  - **quantification in MRI using T1-and T2-mappings** (Gräfe et al., 2022; Müller et al., 2022)
  - **quantitative susceptibility mapping** (Li et al., 2024)
  - Improvement from 3 to 7-Tesla scanning (FastSurferVINN)

Thank you for your attention !