

# The pandemic: What have we learned about Infection-Associated Chronic Illnesses (IACIs)?

**David Putrino, PT, PhD**

*Professor, Department of Rehabilitation and Human Performance*

*Nash Family Director, Cohen Center for Recovery from Complex Chronic Illness*



# Mount Sinai



Upper East  
Side, NYC,  
March 2020





March 2020: Mount  
Sinai in crisis

## The unhappy acute COVID choice

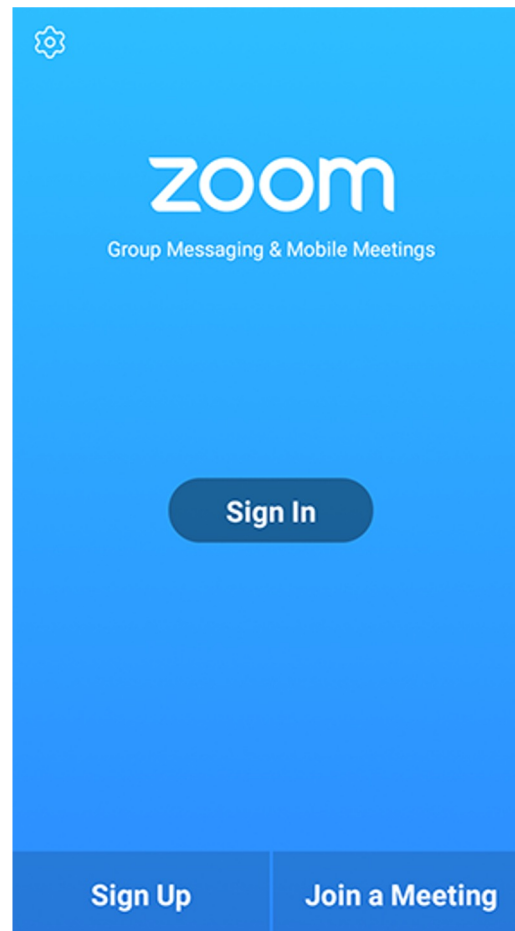


**Too sick for home**

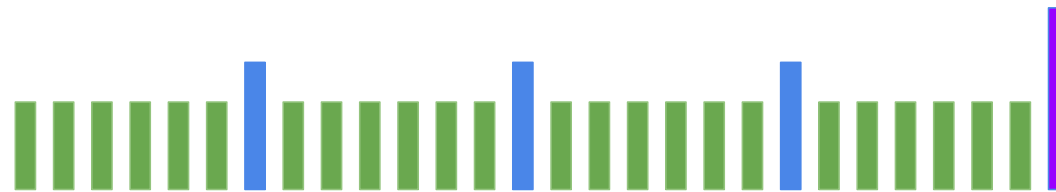
**Not sick enough for  
hospital**



# Remote patient monitoring (RPM): The early rollout technology



# The RPM Protocol



3 minutes



Daily physiologic monitoring and brief survey of symptoms.

10 minutes



Weekly video visit and data review.

30 minutes

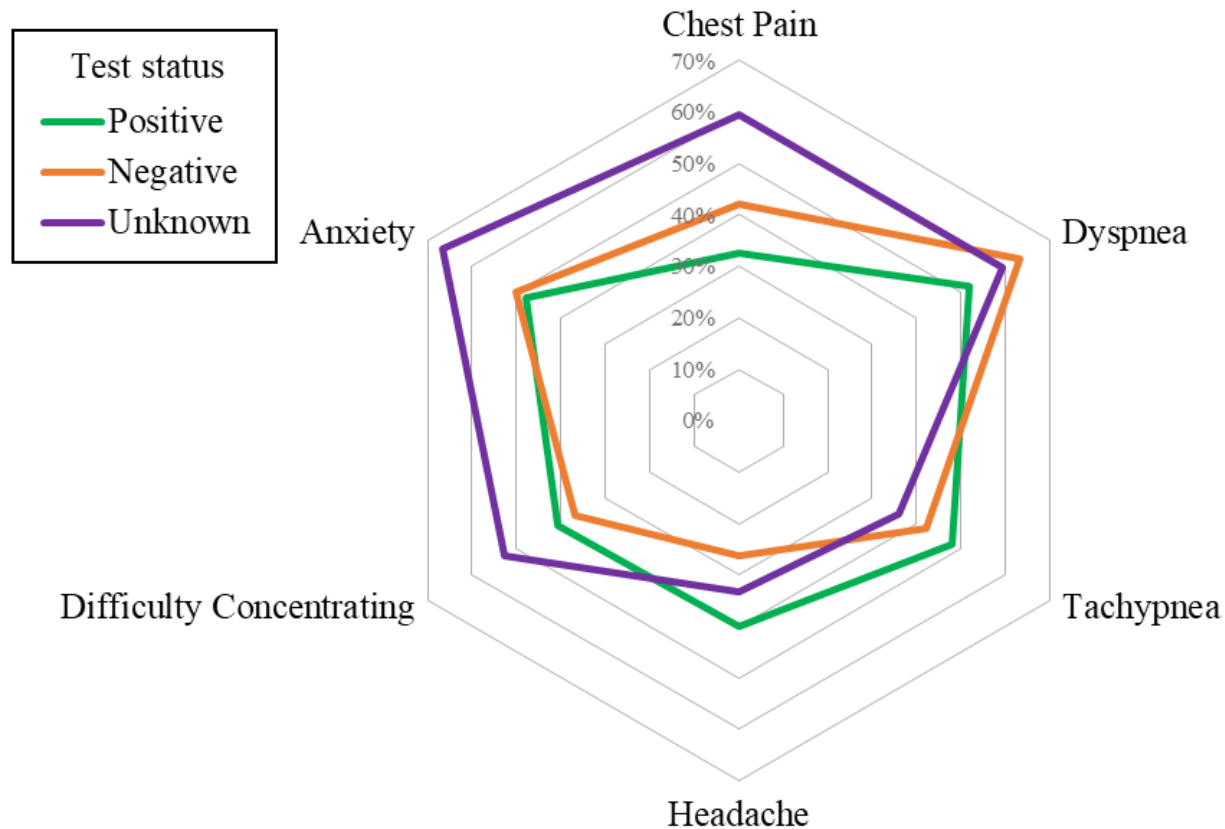


Monthly video visit, data review, curricular self-management education.





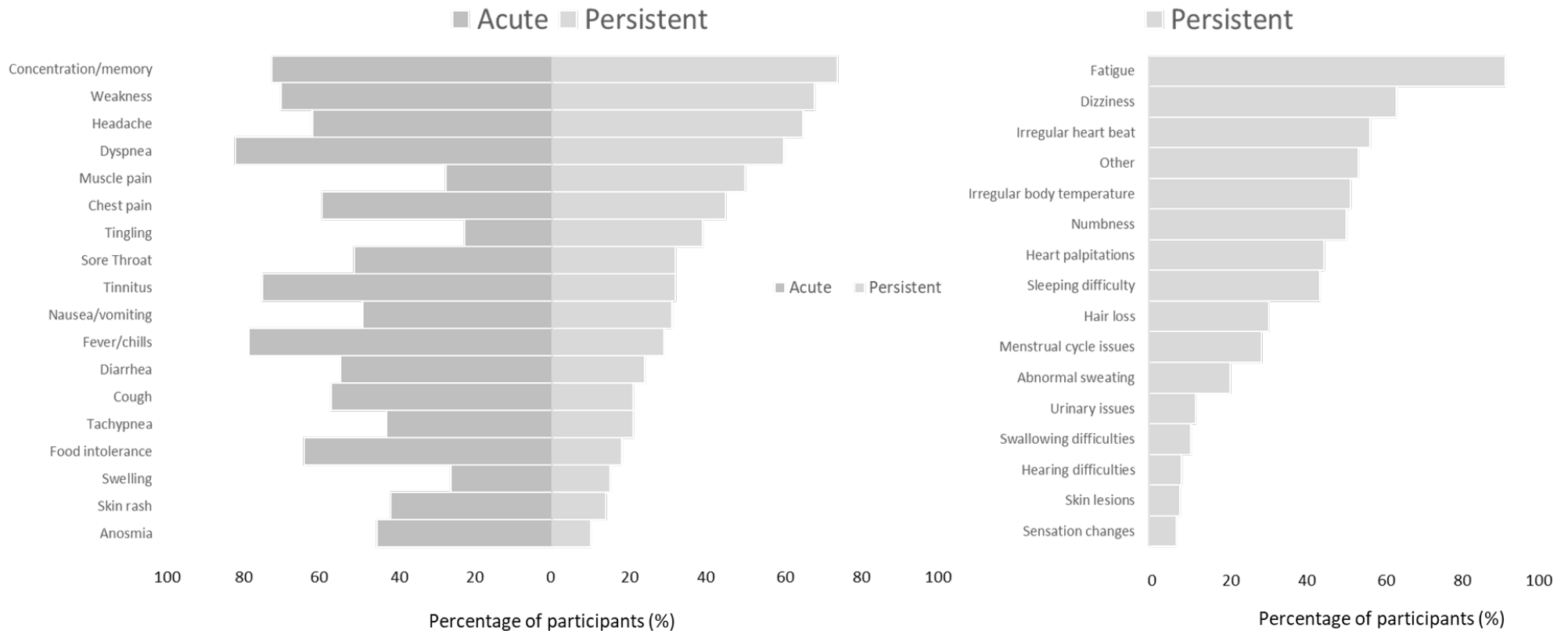
## Acute COVID RPM: Insights from 60,000+ days of monitoring data



Patients that sought out the Precision Recovery program self-reported the same symptomology regardless of PCR-test status.

*Tabacof et al., 2021;  
Telemedicine and eHealth*

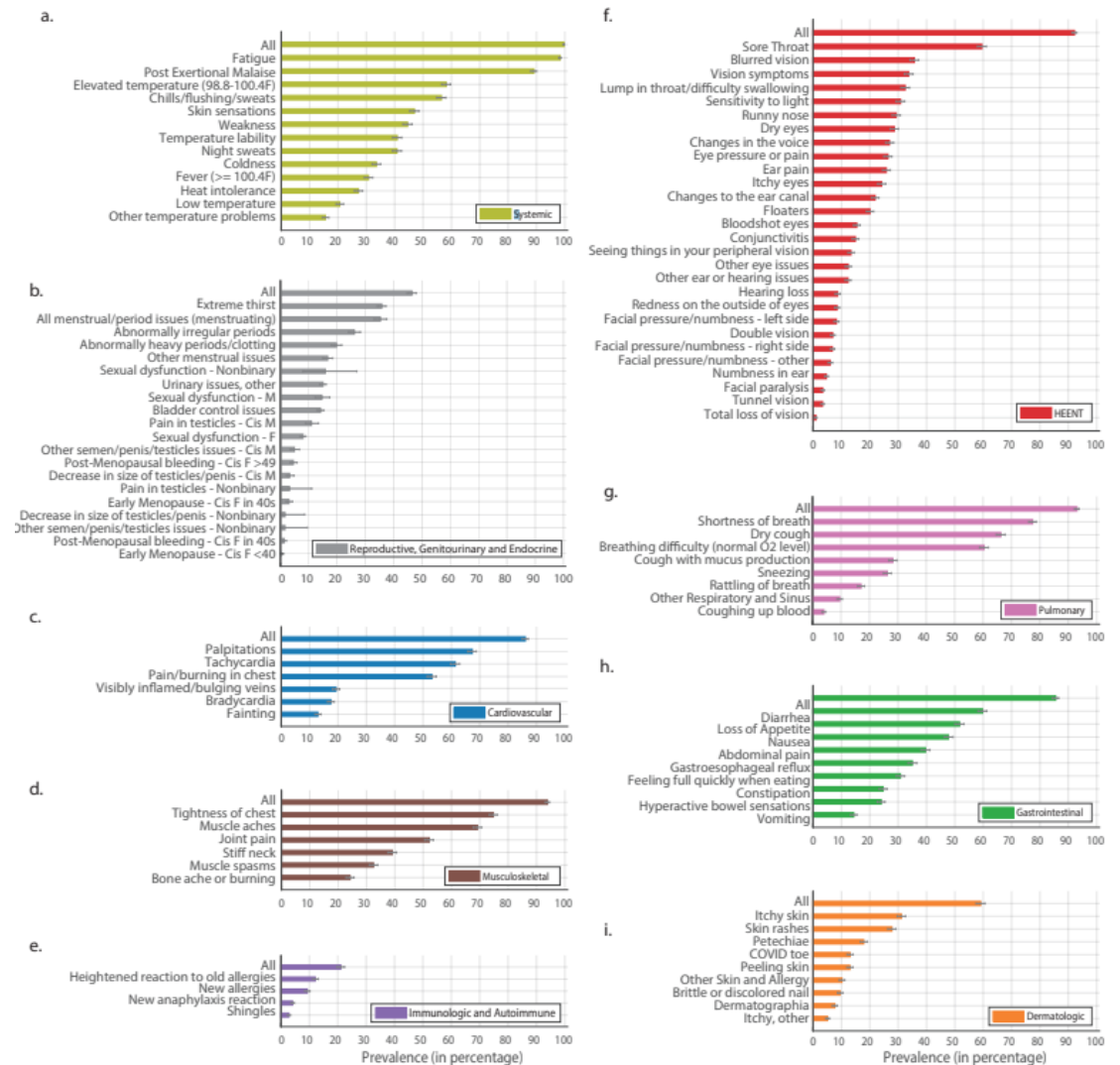
# New, persistent symptoms emerged in ~15% of acute cases





# We've learned a few more symptoms since

- >205 presenting symptoms
- Affecting every organ system

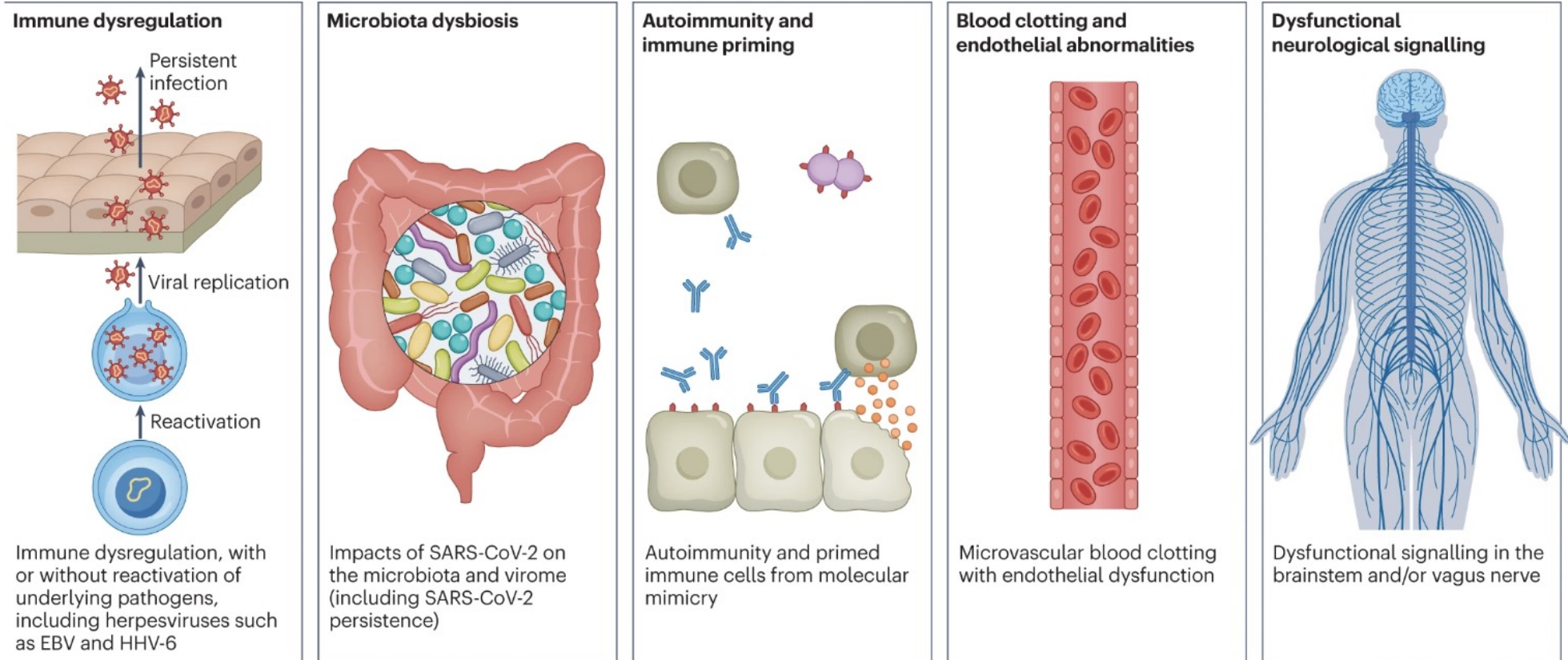


# Digging deeper: the pathobiology of IACIs

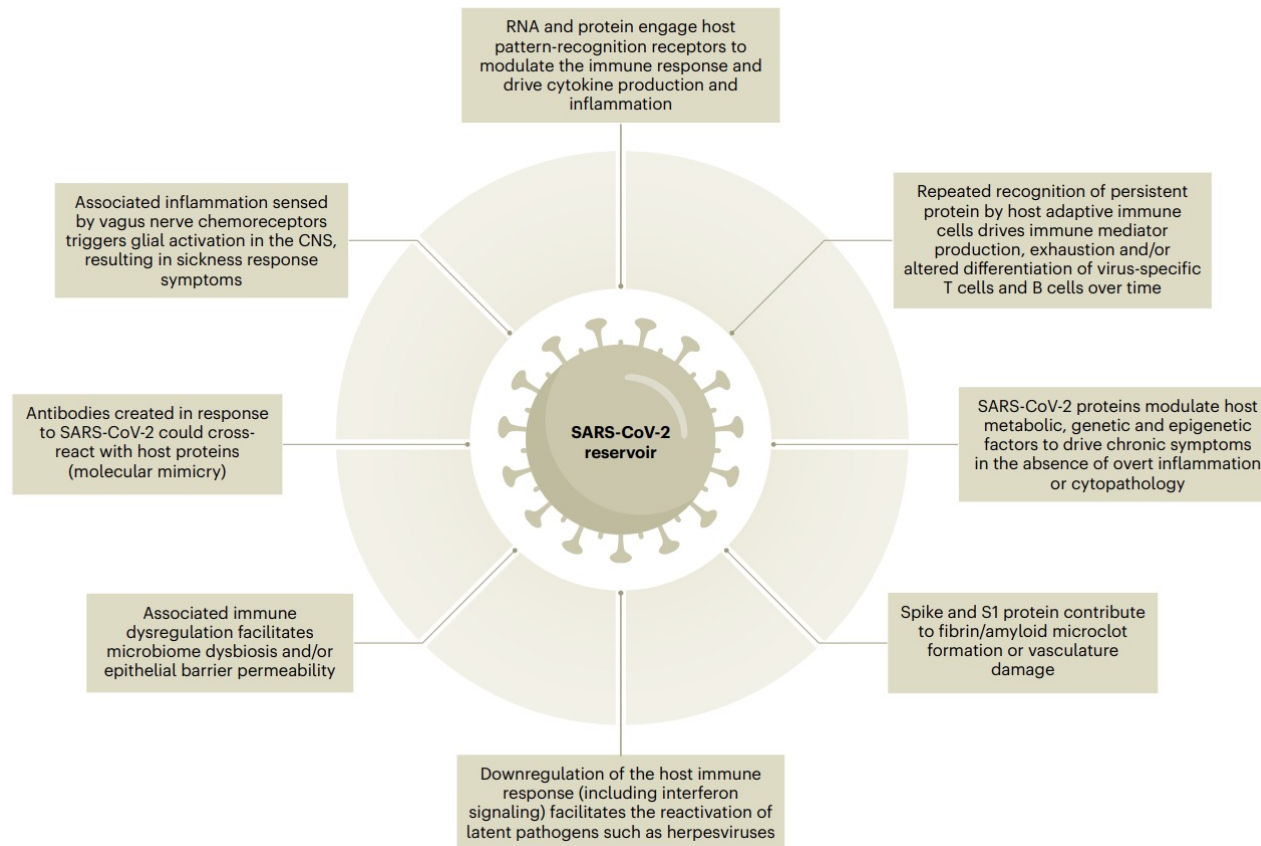




## Zooming in on the most likely underlying causes of Long COVID pathology



# SARS-CoV-2 persistence has a central role in LC pathobiology





SYSTEMATIC REVIEW



## The reactivation of the various types of viruses following COVID-19 infection: a systematic review

Maziar Naderi <sup>a</sup>, Mohieddin Naderi <sup>b</sup>, Mahboob Keramati Jamal <sup>c</sup>, Vida Past <sup>a</sup>, Arezoo Esmaeili <sup>d</sup>, Aynaz Khabazian <sup>e</sup>, Somayeh Hashemi Ali Abadi <sup>f</sup>, Golbarg Saremi <sup>g</sup>, Shima Asghari <sup>h</sup>, Shadi Moghimi <sup>i</sup>, Neda Parnianfard <sup>b</sup> and Mina Parnianfard <sup>j</sup>

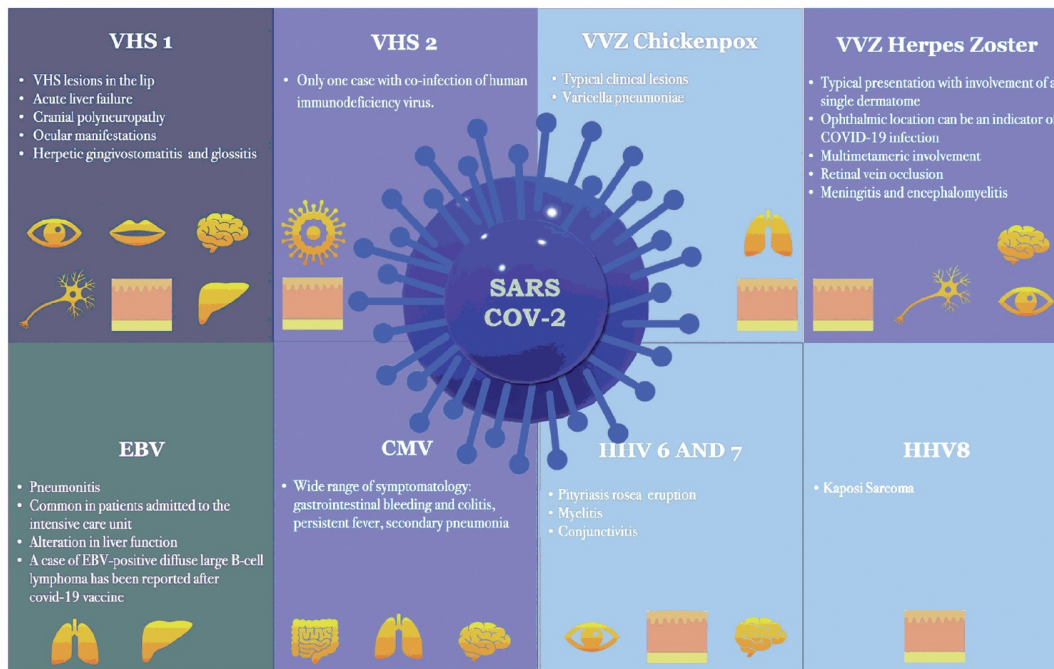
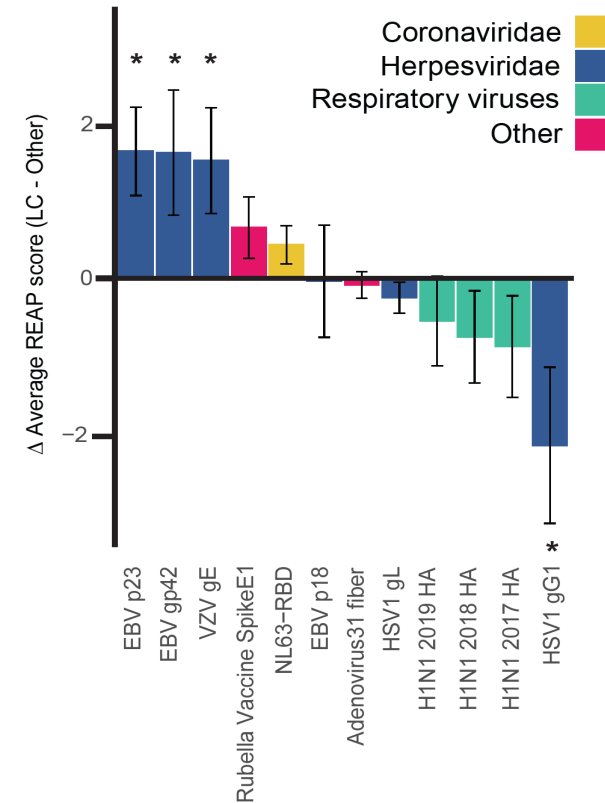


Figure 2. Manifestations of herpesvirus infections associated with COVID-19.

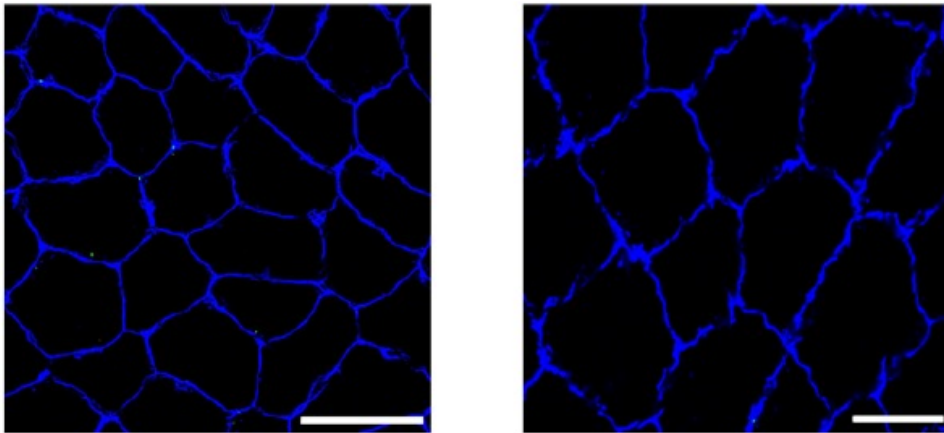
VHS-1, herpes simplex virus type-1; VHS-2, herpes simplex virus type-2; VVZ, varicella-zoster Virus; EBV, Epstein-Barr virus; CMV, cytomegalovirus; HHV-6, herpes virus-6; HHV-7, herpes virus-7; HHV8, herpes virus-8.



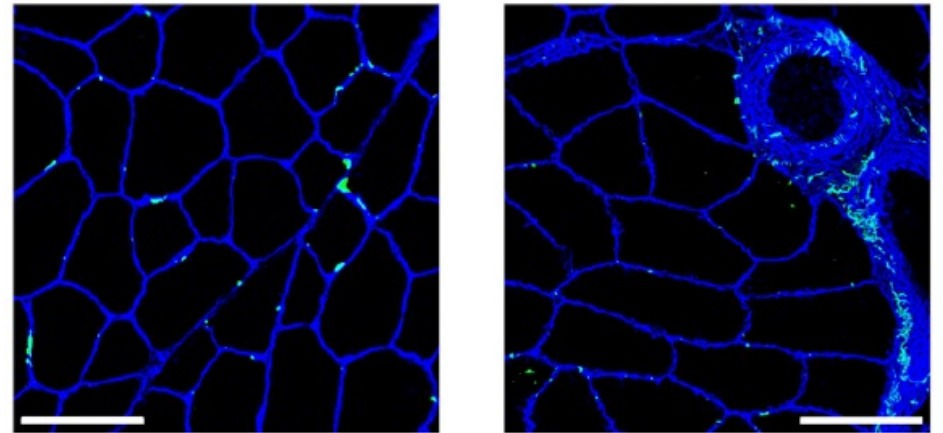
Naderi et al. *Future Virology* (2025); Klein et al. *Nature* (2023)

# Metabolic dysfunction, not deconditioning, drives post-exertional symptoms in IACCs

Healthy Controls



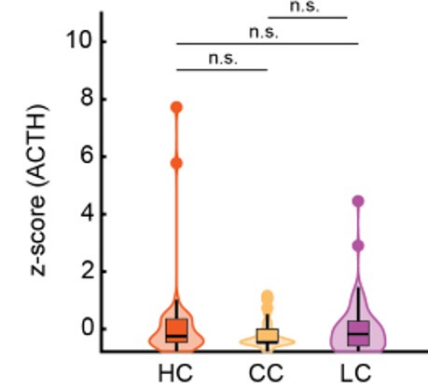
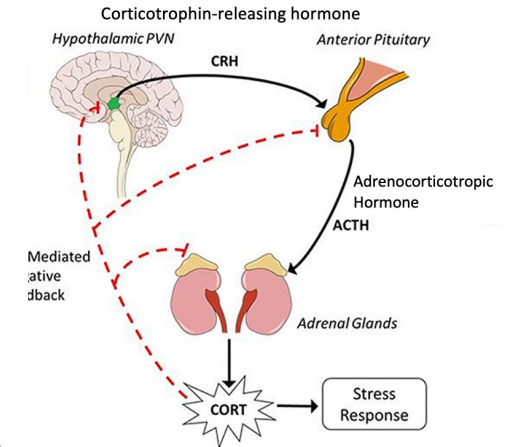
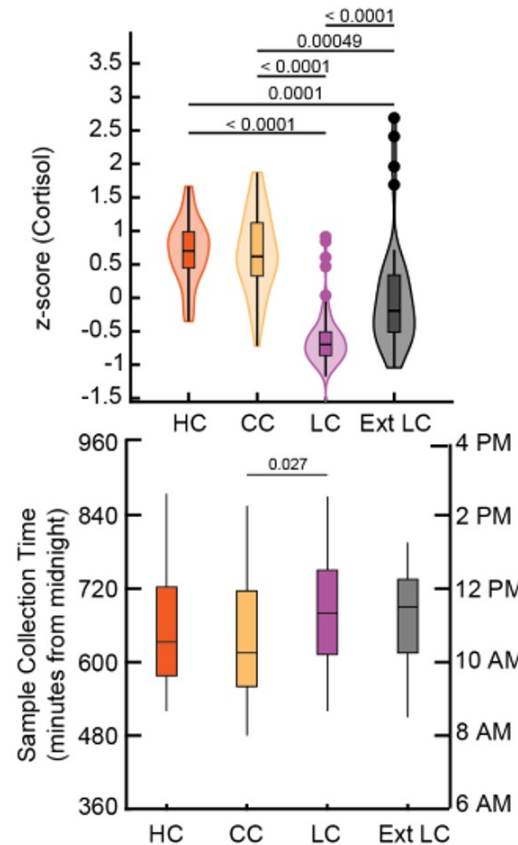
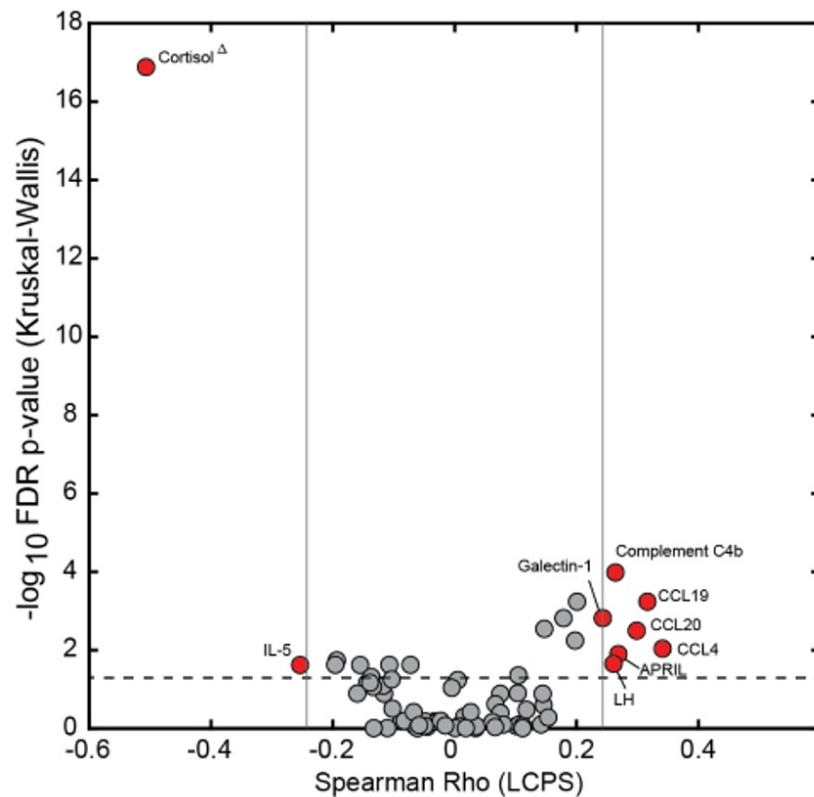
Long COVID



Cell Membrane (WGA) Amyloid deposit (Thioflavin T)

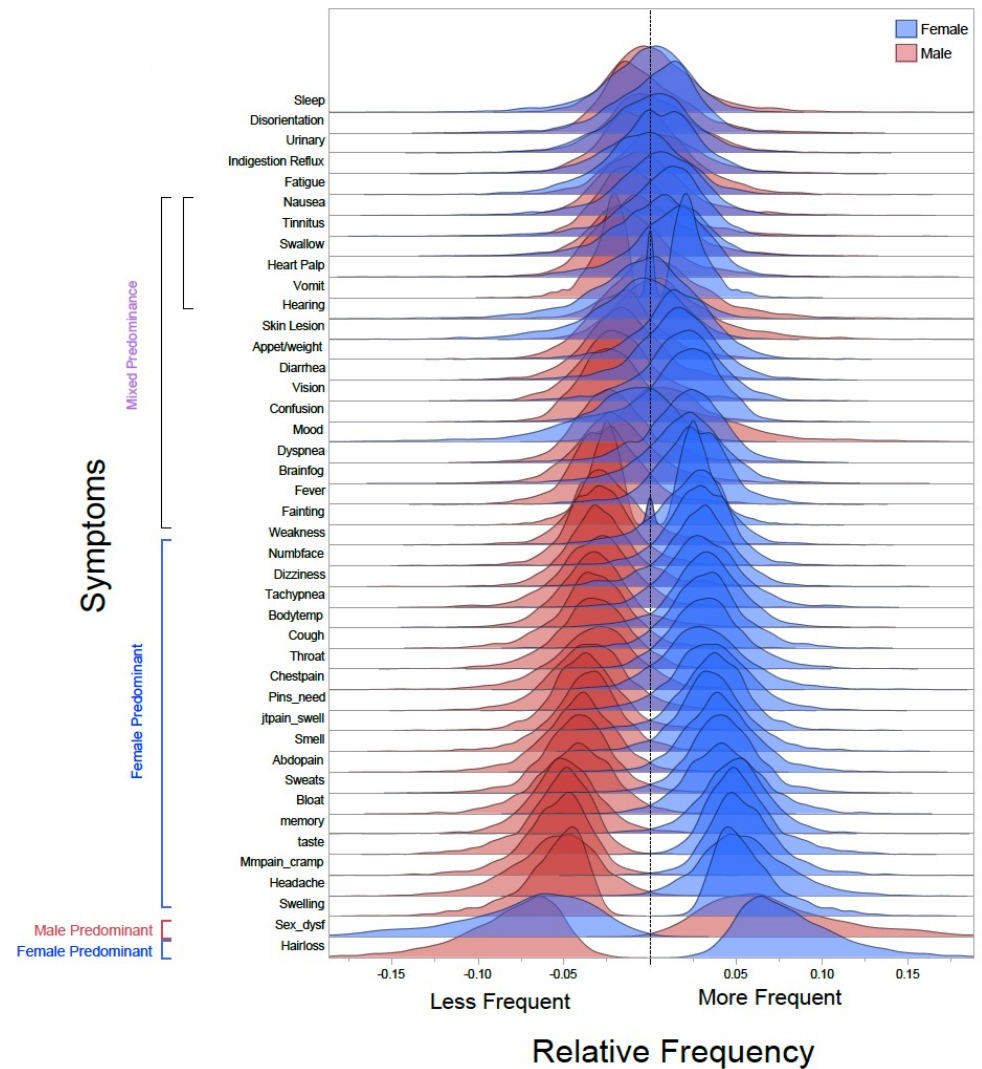
Appelman et al (2024); Nature Comms

# Long COVID is associated with significant reductions in morning cortisol levels



Klein et al. *Nature* (2023)

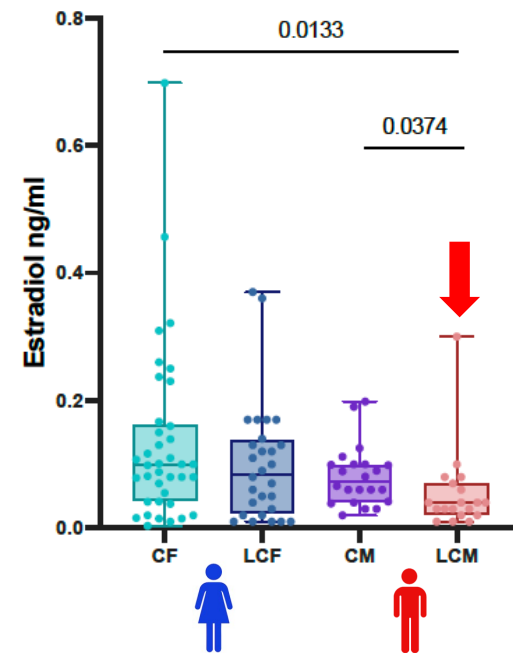
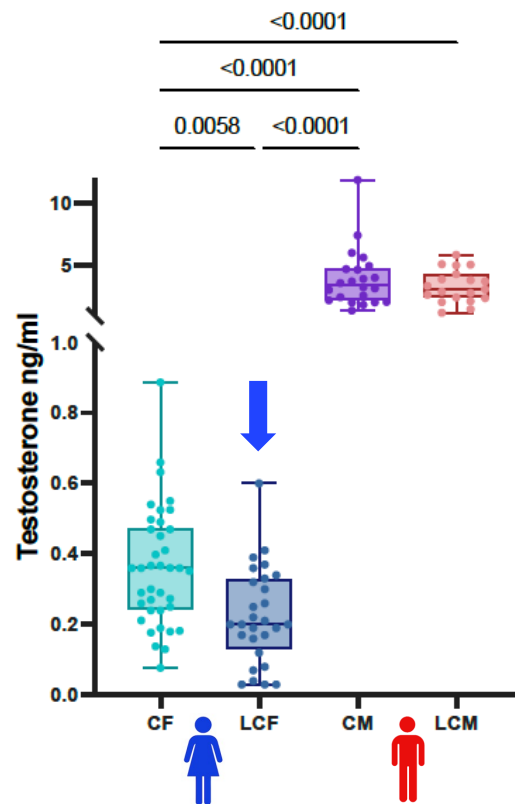
Women and men with Long COVID and other IACCs present with sex-linked symptoms



Silva et al (in review); Nature



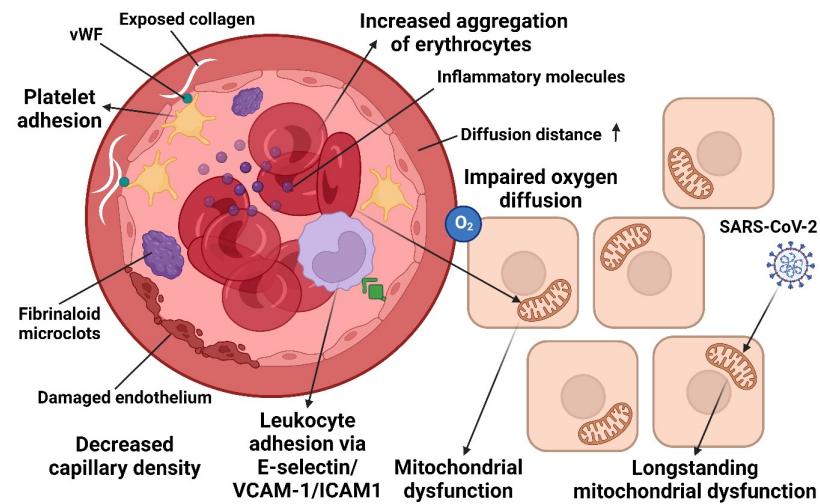
Clear sex hormone differences are emerging in men and women with Long COVID that correlate with symptom presentation patterns



Silva et al. *Nature* (in review)

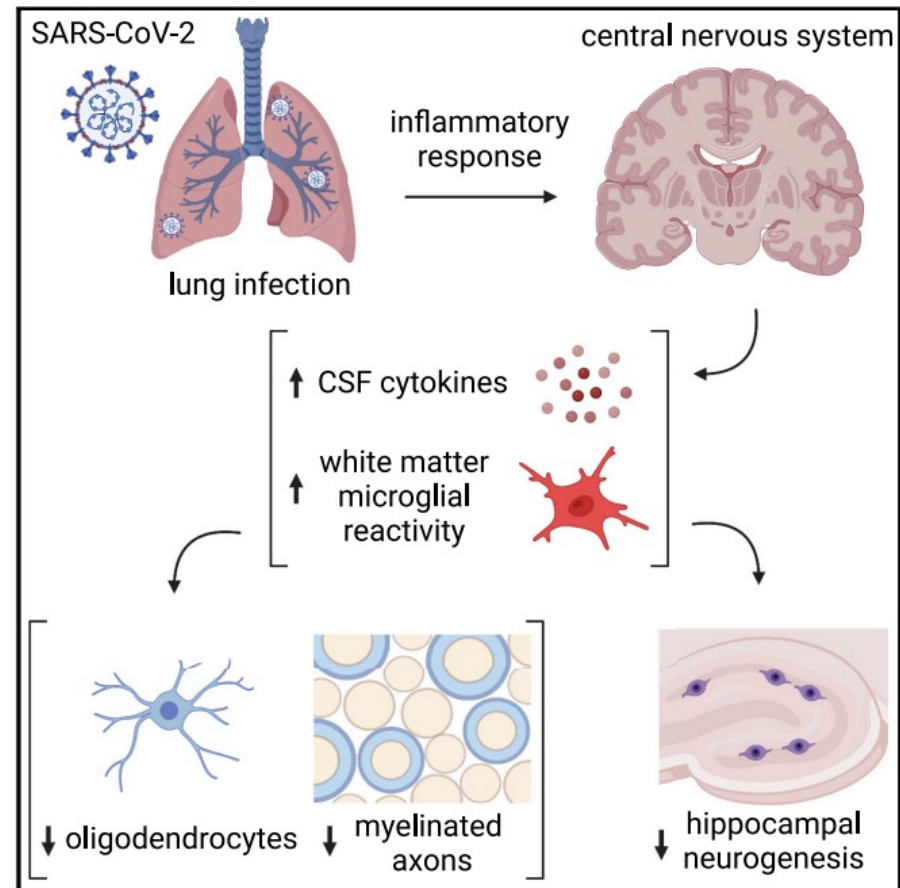
Endothelial dysfunction is a crucial dimension of Long COVID pathobiology

### Capillary and cellular tissue in Long COVID

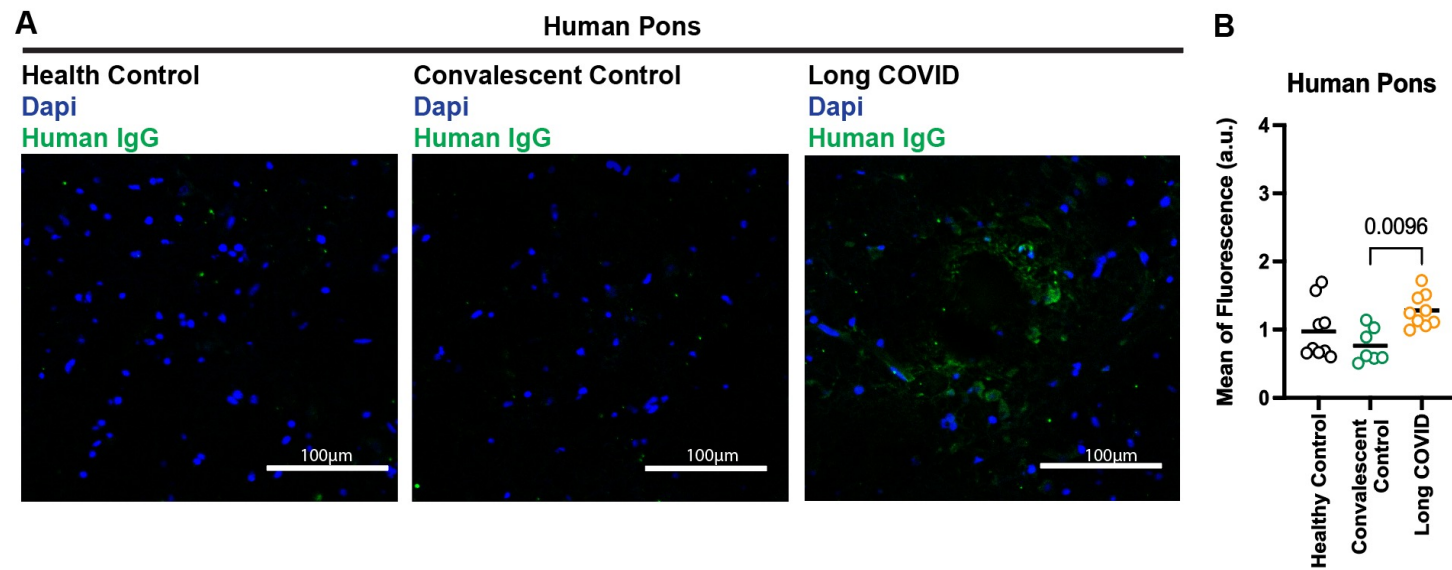
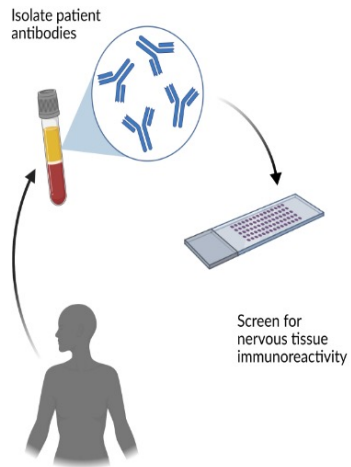


Arneaux et al. (2024); *Thrombosis and Hemostasis*

**Even mild acute illness can lead to neurological damage through neuroinflammation**



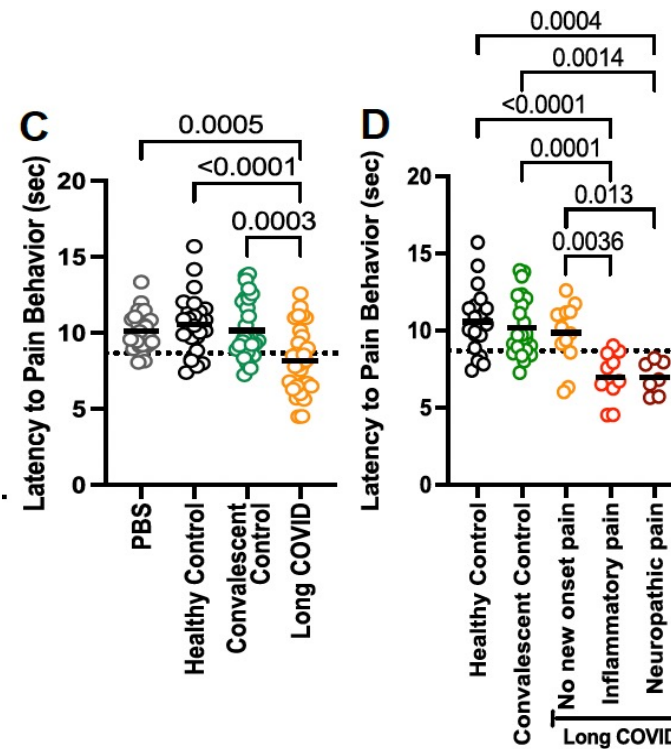
# *Long COVID participants have AABs against human neural tissues*



# Long COVID AABs increase sensitivity to thermal pain...



Hot Plate Test

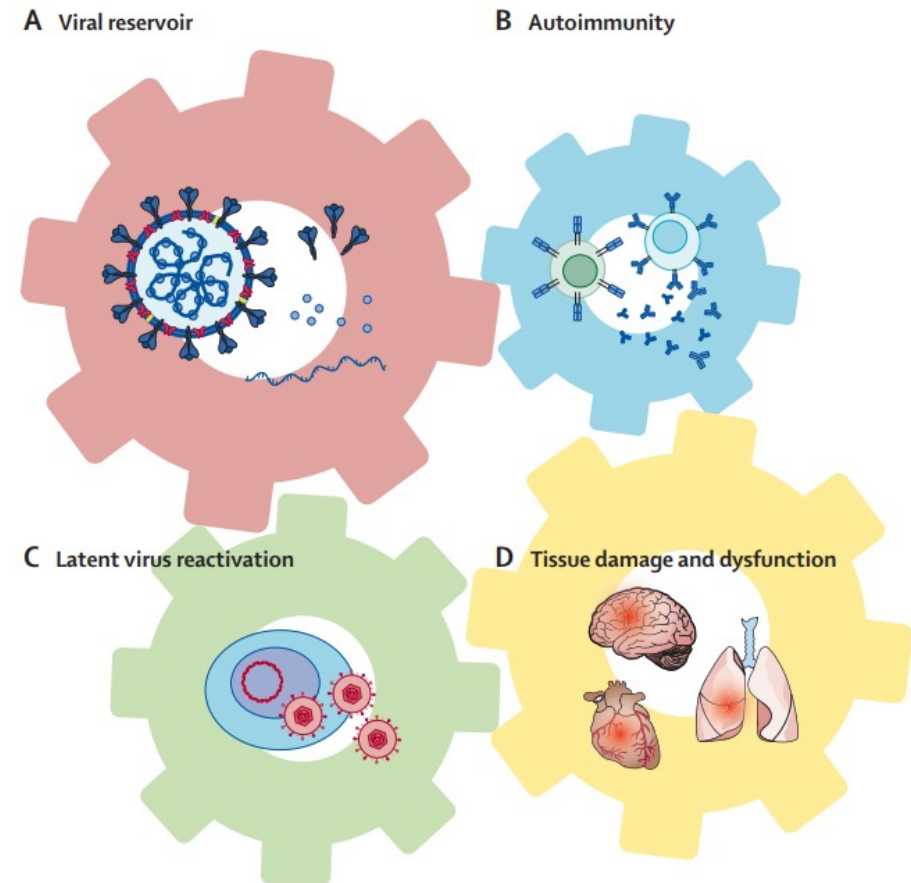


...but only in  
LC patients  
with new-  
onset pain!



Final comment on pathobiology:

IACCs are **complex** chronic illnesses – the dynamics of the pathobiology can be a moving target



# Acknowledgements

## **Mount Sinai Team**

Joe Herrera  
Lori McKenna  
Mariam Zakhary  
Angela Riccobono  
Emily Fatakhov

## **Cohen CoRE**

Jenna Tosto-Mancuso  
Aidan Rogers  
Abbey Sawyer  
Alex Canori  
Arianna Fiorentino  
Val Iovine  
Mackenzie Doerstling  
Patrycja Graczyk  
Lily Cooke  
Nadja Roberson  
Nasya Rose  
Marta Lapinska  
Denise Javier  
Shadan Nolaco  
Myranda Oettel  
Abdullah Ridwan  
Raquel Selgado

## **Long COVID Research**

### **Collaborators**

Akiko Iwasaki  
Amy Proal  
Harlan Krumholz  
Mike Van Elzakker  
Resia Pretorius  
Asad Kahn

### **Our caring doctors and therapists**

### **Our amazing interns and past lab members**

### **All of our patients and the incredible patient-led groups**



**balvi.io**



@PutrinoLab

