EAGER: Documenting and Analyzing Use of Robots for COVID-19

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RoboticsForInfectiousDiseases.org started at NRI 2020!

Good Job, Everyone!

Open Dataset:

- 338 instances of actual robots in use explicitly for COVID-19 between Jan 24, 2020, and Jan 23, 2021
- 48 countries on six continents: Africa, Asia, Australia, Europe, North America, and South America

Areas of Major Findings

- International trends
- Policy
- Use Cases
- Robot morphology
- Responsible Innovation
- Ethics

Collection Methodology: Through Jan 23, 2021

COLLECT
Collect Data from Press, Social Media, Journals

→ 424 Reports →

FILTER
Filter Reports for Actual, Explicit Use for COVID-19

→ 400 Reports →

MERGE
Merge Duplicate Reports into Entries

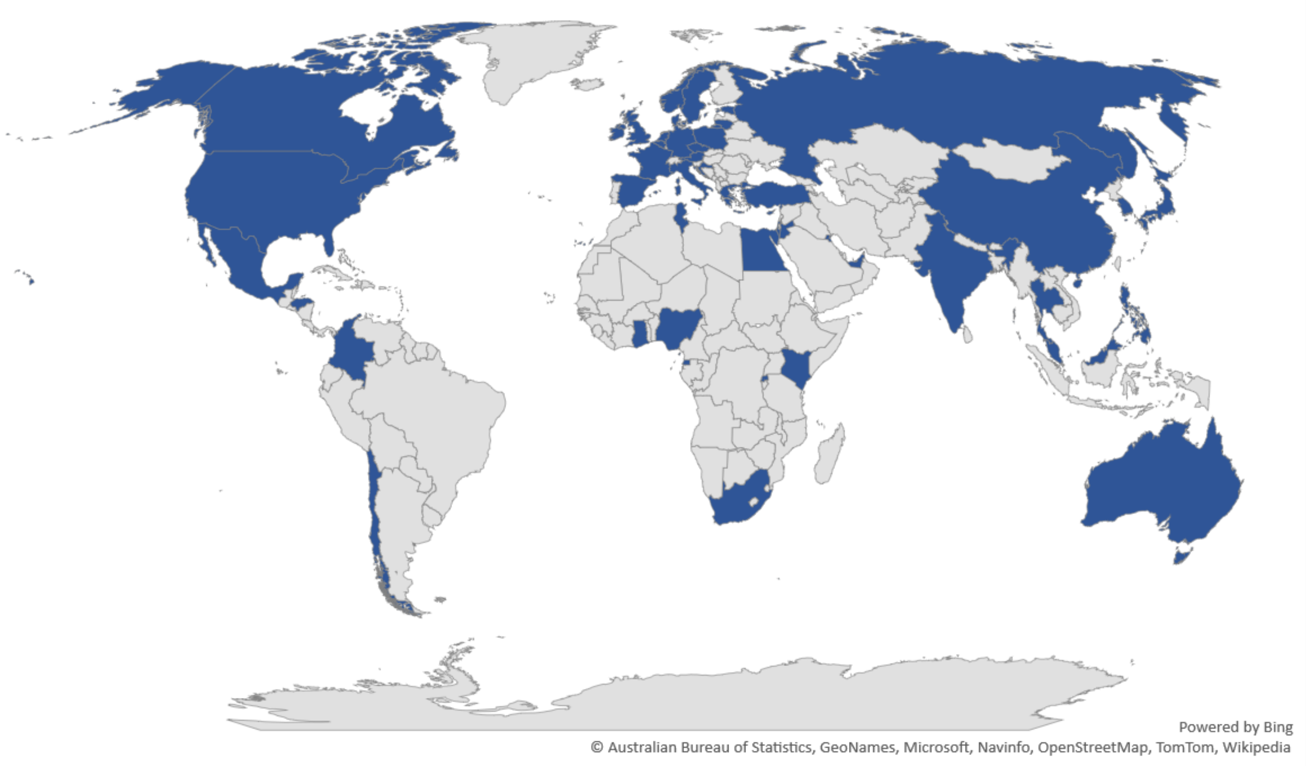
→ 272 Entries →

SPLIT
Split into Specific Robots and Use Cases within Entry

→ 338 Instances

- *Data is incomplete, noisy– but large enough to suggest trends*
- *No indication of whether use was for a few days or months*
- *Do not know which of these use cases will persist- currently we are seeing adoption based on local initiative ("individual") not long-term institutional commitment*

338 Instances in 48 Countries



Top 8 Countries by # of Robot Instances

US	95
China	72
India	33
Great Britain	16
Italy	13
South Korea	12
Spain	12
Singapore	7

Country	Total	Date of Reported Use
US	**95**	**1/24/2020**
China	**72**	**1/26/2020**
India	**33**	**3/23/2020**
Great Britain	**16**	**3/26/2020**
Italy	**13**	**3/23/2020**
South Korea	**12**	**2/11/2020**
Spain	**12**	**3/13/2020**
Singapore	**7**	**3/5/2020**
Thailand	7	3/19/2020
Japan	6	3/28/2020
Canada	5	3/1/2020*
United Arab Emirates	5	3/16/2020
Kenya	4	1/22/2021
France	3	3/19/2020
Ireland	3	4/6/2020
Nigeria	3	4/6/2020
Philippines	3	3/19/2020
Australia	2	9/14/2020
South Africa	2	11/1/2020
Belgium	2	3/16/2020
Colombia	2	4/14/2020
Equatorial Guinea	2	9/24/2020
Greece	2	5/16/2020
Germany	2	4/4/2020

Country	Total	Date of Reported Use
Rwanda	2	5/19/2020
Austria	1	2/1/2020*
Chile	1	4/20/2020
Croatia	1	3/1/2020*
Cyprus	1	3/23/2020
Czech Republic	1	11/16/2020
Denmark	1	6/9/2020
Egypt	1	11/25/2020
Estonia	1	4/30/2020
Ghana	1	4/17/2020
Honduras	1	4/6/2020
Israel	1	4/16/2020
Jordan	1	5/5/2020
Kuwait	1	3/12/2020
Lithuania	1	5/13/2020
Malaysia	1	3/1/2020*
Mexico	1	4/17/2020
Netherlands	1	6/1/2020
Norway	1	4/1/2020*
Poland	1	11/16/2020
Russia	1	11/6/2020
Sweden	1	5/15/2020
Tunisia	1	3/25/2020
Turkey	1	4/14/2020
Total	338	

Clustering By Socio-Technical Work Domains*

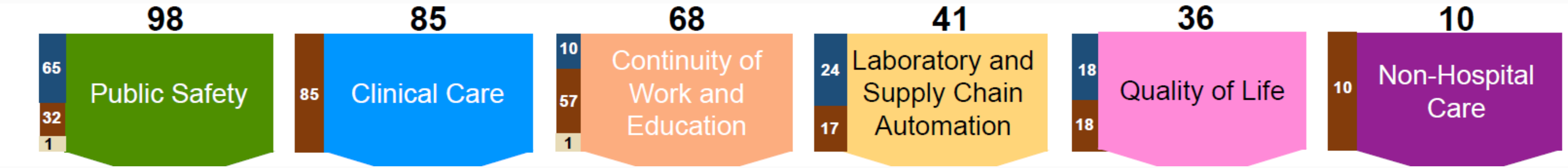
SOCIAL

TECHNICAL

- Stakeholders who make the adoption decision
- Interactants, their skills and expectations
- Regulatory or budget constraints
- Overall objectives
- Work envelope
- Types of use cases

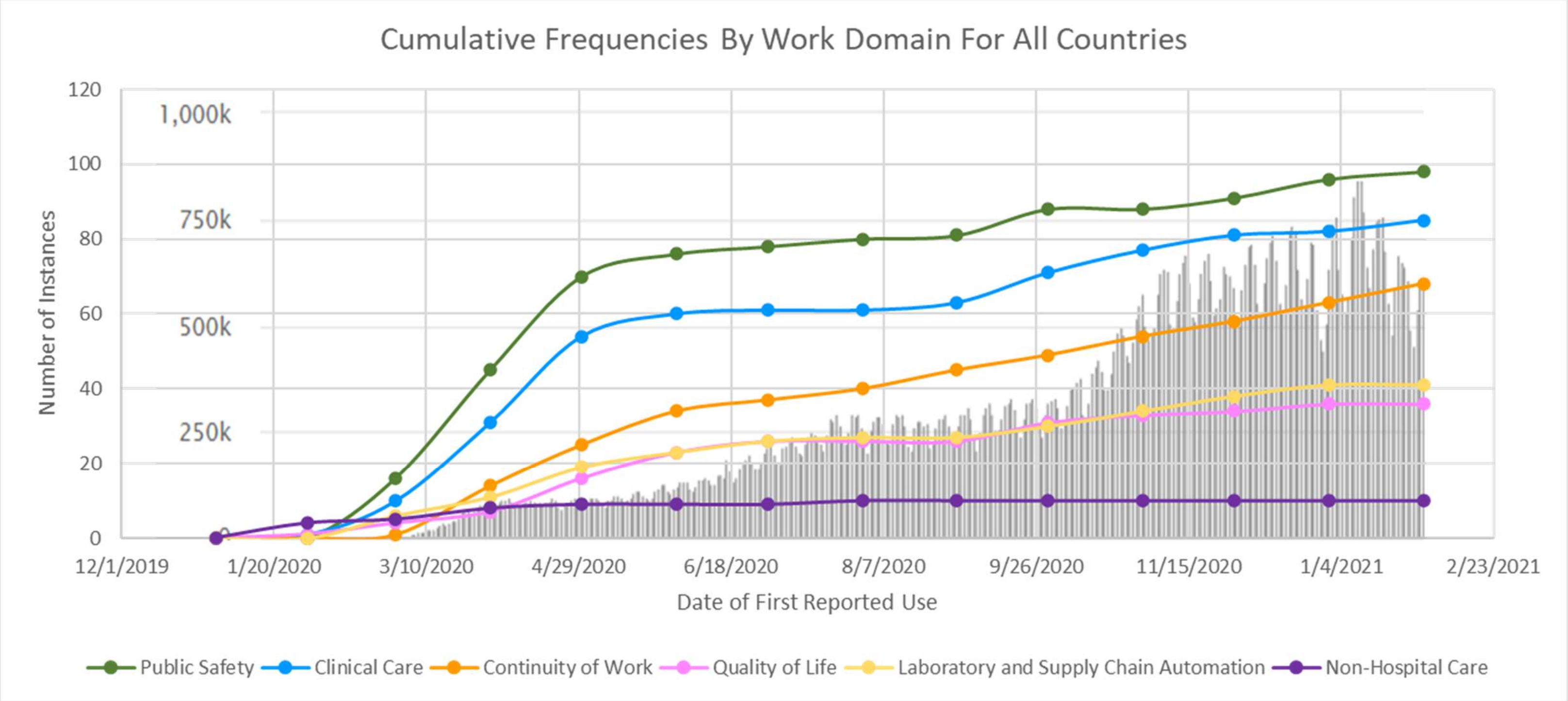
*Glaser, B. G. (1965). The constant comparative method of qualitative analysis. Social Problems, 12(4):436– 445.

Six Sociotechnical Work Domains and UGV (219), UAS (117), UMV (2) Distribution



- Public Safety was the largest: social distancing, disinfecting public spaces
- Public Safety has access to lots of general purpose drones
- Hospitals, Non-Hospital (Nursing Homes and Quarantine Camps) are indoors and cluttered, so favor UGV

International Trend: Breadth of Use From the Beginning



International Trend: Largest Use is Typically Broadest Use

US	20	18	25	13	19	0	95
CN	21	17	12	9	6	7	72
IN	15	15	2	1	0	0	33
GB	5	2	6	3	0	0	16
IT	4	7	0	1	0	1	13
KR	1	5	3	1	1	1	12
ES	4	2	3	3	0	0	12
SG	2	2	2	1	0	0	7

- China and South Korea reported for all 6 domains
- *But* US only 5 with no reports for Non-hospital Care

Country	Public Safety	Clinical Care	Continuity of Work & Education	Laboratory & Supply Chain Automation	Quality of Life	Non Hospital Care	Total
US	20	18	25	13	19	0	95
CN	21	17	12	9	6	7	72
IN	15	15	2	1	0	0	33
GB	5	2	6	3	0	0	16
IT	4	7	0	1	0	1	13
KR	1	5	3	1	1	1	12
ES	4	2	3	3	0	0	12
SG	2	2	2	1	0	0	7
TH	1	3	3	0	0	0	7
JP	1	0	5	0	0	0	6
CA	0	1	1	2	1	0	5
AE	4	1	0	0	0	0	5
KE	2	2	0	0	0	0	4
FR	3	0	0	0	0	0	3
IE	0	1	0	0	2	0	3
NG	1	2	0	0	0	0	3
PH	1	0	1	0	1	0	3
AU	2	0	0	0	0	0	2
ZA	0	0	1	0	1	0	2
BE	1	0	0	0	0	1	2
CO	1	0	0	0	1	0	2
GQ	1	1	0	0	0	0	2
GR	1	0	0	1	0	0	2
DE	1	0	0	1	0	0	2

Country	Public Safety	Clinical Care	Continuity of Work & Education	Laboratory & Supply Chain Automation	Quality of Life	Non Hospital Care	Total
RW	1	1	0	0	0	0	2
AT	0	0	0	0	1	0	1
CL	0	0	0	0	1	0	1
HR	0	1	0	0	0	0	1
CY	0	0	0	0	1	0	1
CZ	0	1	0	0	0	0	1
DK	0	0	0	1	0	0	1
EG	0	1	0	0	0	0	1
EE	0	0	0	1	0	0	1
GH	0	0	0	1	0	0	1
HN	1	0	0	0	0	0	1
IL	0	1	0	0	0	0	1
JO	0	0	1	0	0	0	1
KW	1	0	0	0	0	0	1
LT	0	0	0	0	1	0	1
MY	1	0	0	0	0	0	1
MX	1	0	0	0	0	0	1
NL	0	0	1	0	0	0	1
NO	0	0	1	0	0	0	1
PL	0	0	0	1	0	0	1
RU	0	0	1	0	0	0	1
SE	0	0	0	1	0	0	1
TN	1	0	0	0	0	0	1
TR	0	1	0	0	0	0	1
Total	98	85	68	41	36	10	338

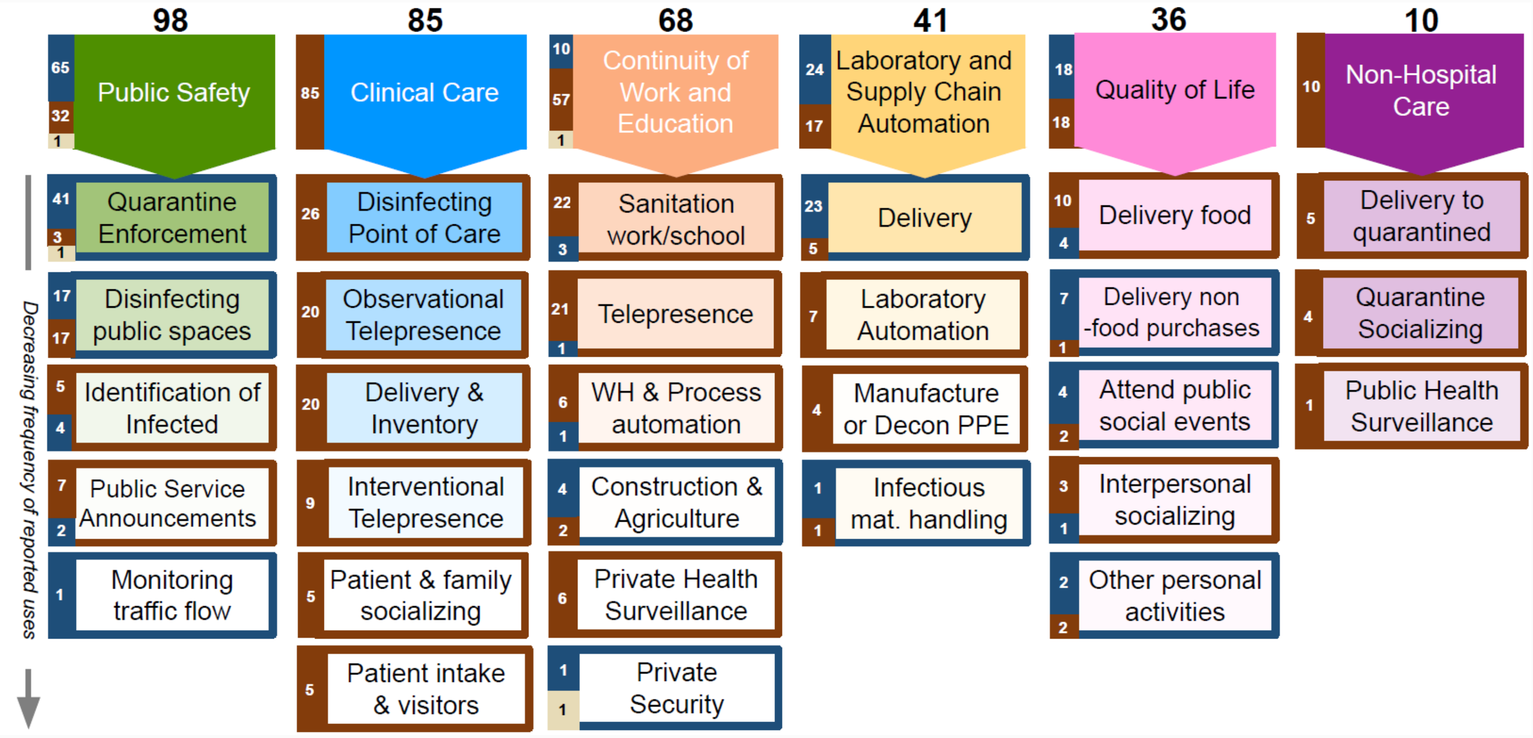
Policy: Countries with a National Policy Used More Robots

Countries with a National Robotics Policy or Initiative:

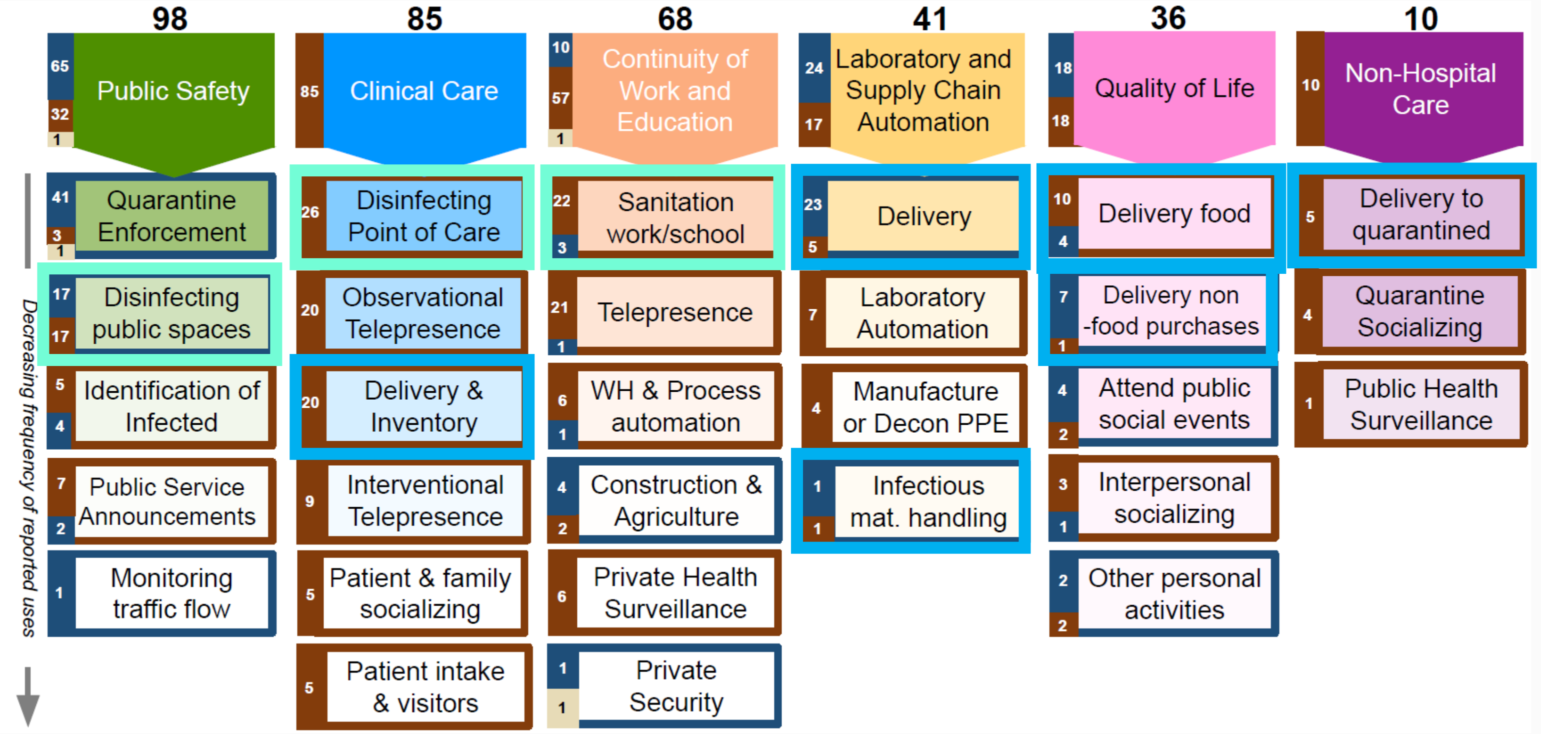
- China
- European Union
- Germany (in addition to the EU)
- Japan
- South Korea
- US

			Cont	Laborat		No	
US	20	18	25	13	19	0	95
CN	21	17	12	9	6	7	72
IN	15	15	2	1	0	0	33
GB	5	2	6	3	0	0	16
IT	4	7	0	1	0	1	13
KR	1	5	3	1	1	1	12
ES	4	2	3	3	0	0	12
SG	2	2	2	1	0	0	7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

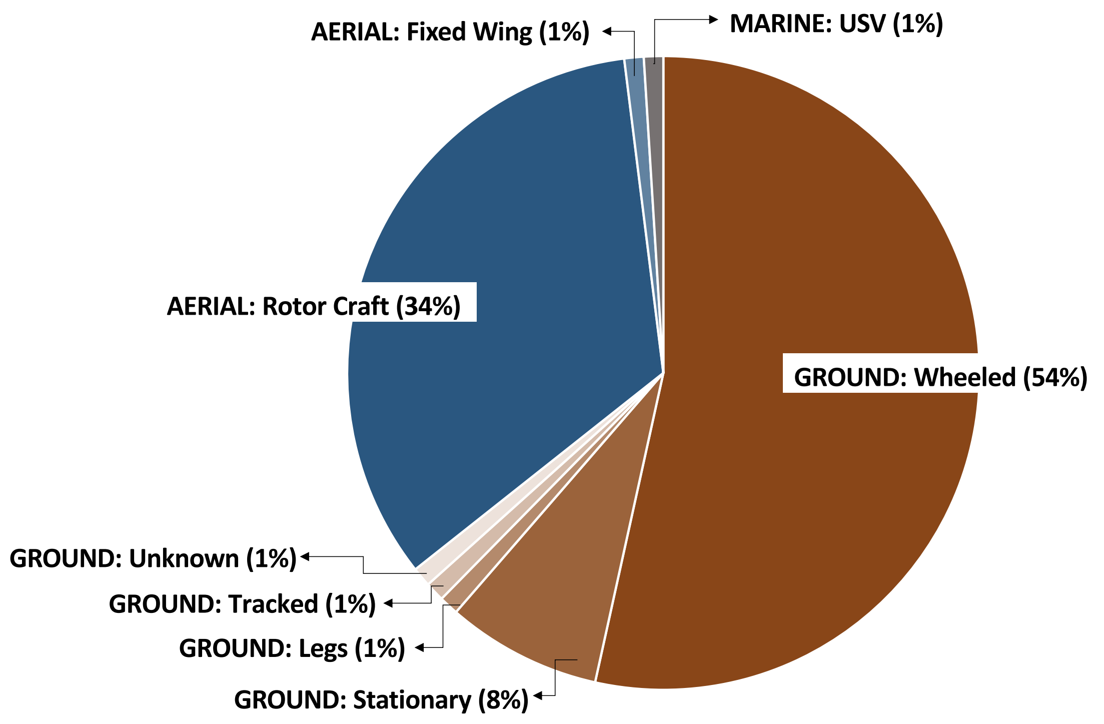
Use Cases: 29 Clusters



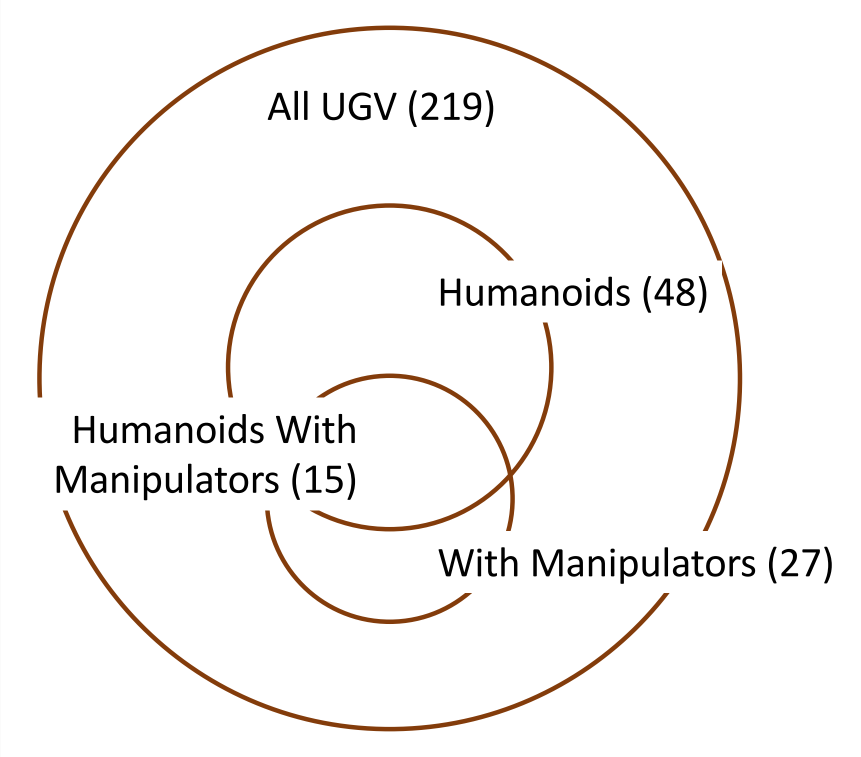
Largest Uses: Disinfection (85), Delivery (77)



Morphology: Ground Robots Tend to Be Wheeled, Aerial Robots Tend to Be Quadcopters



Morphology: Many Humanoids, Many Manipulators, Few Humanoids with Manipulation

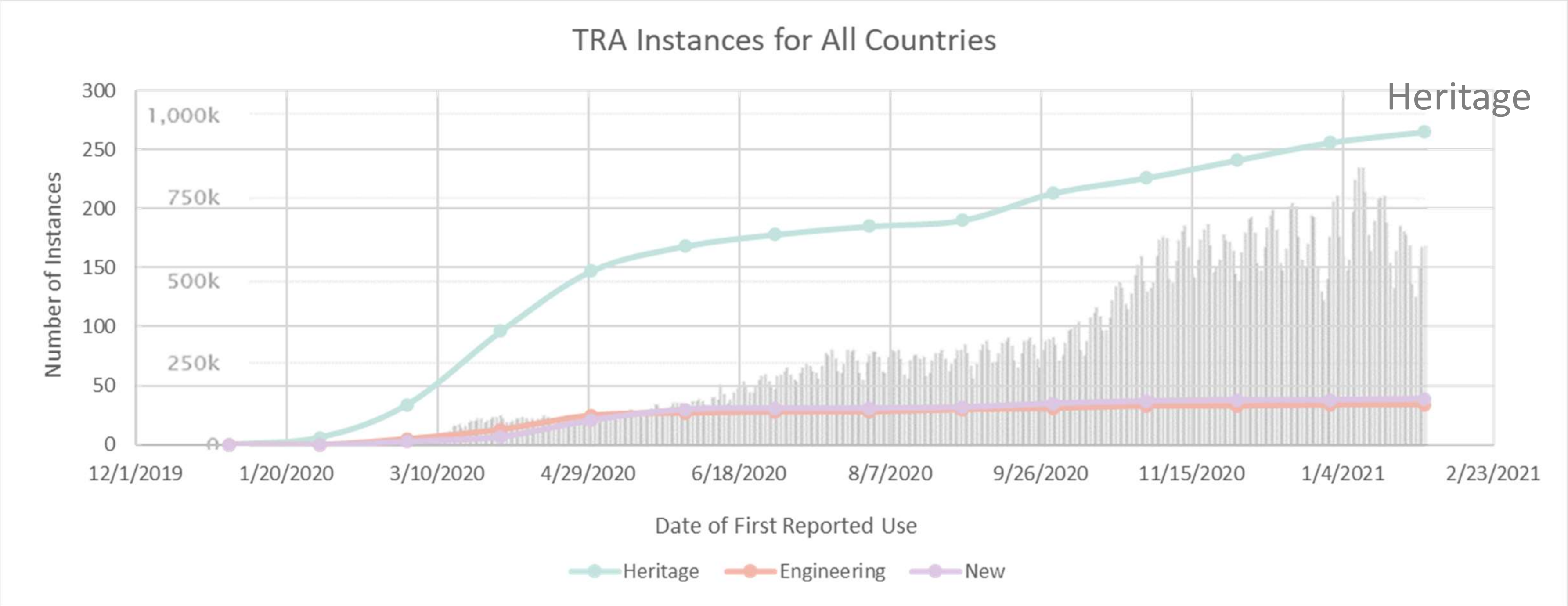


Responsible Innovation: Measuring Degree of Innovation with NASA Technical Readiness Assessment (TRA)*

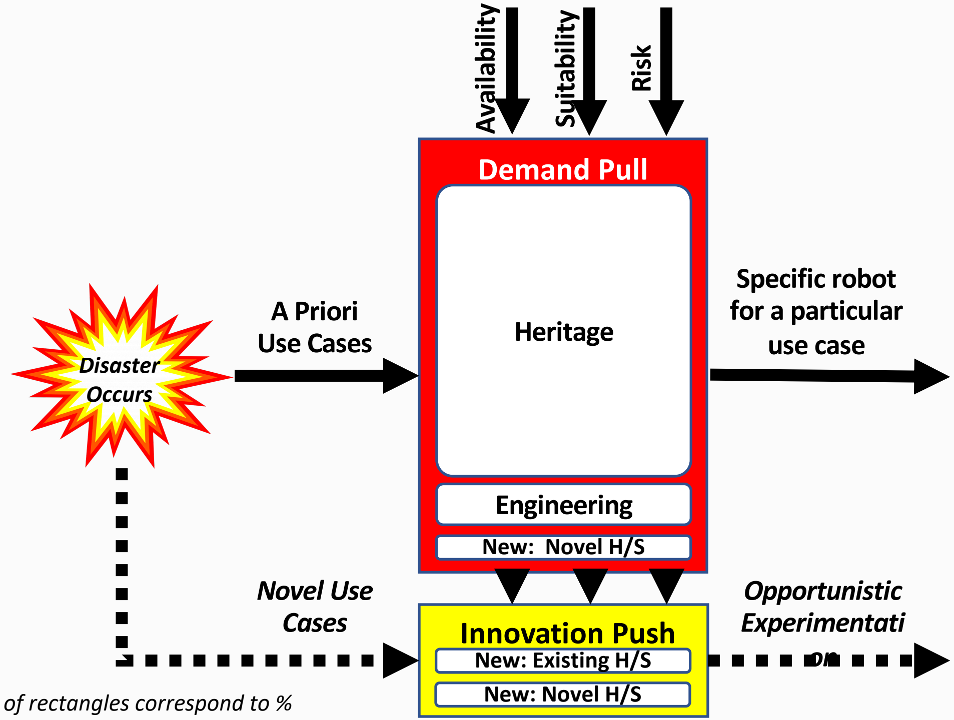
	Suitability			Risk
	HW/SW Mature (TRL 9)	Basically the Same Task/ Mission	Fits Existing Work Processes	Low Potential of Failures, Unintended Consequences
Heritage	Yes	Yes	Yes	Yes
Engineering	Yes/Maybe	Yes/Maybe	Yes/Maybe	Maybe
New	No	No	No	No

*Hirshorn, S. R. and Jefferies, S. A. (2016). Final report of the nasa technology readiness assessment (tra) study team)

Responsible Innovation During a Disaster is Not Improvisation: 78% Heritage, 10% Engineering, 12% New

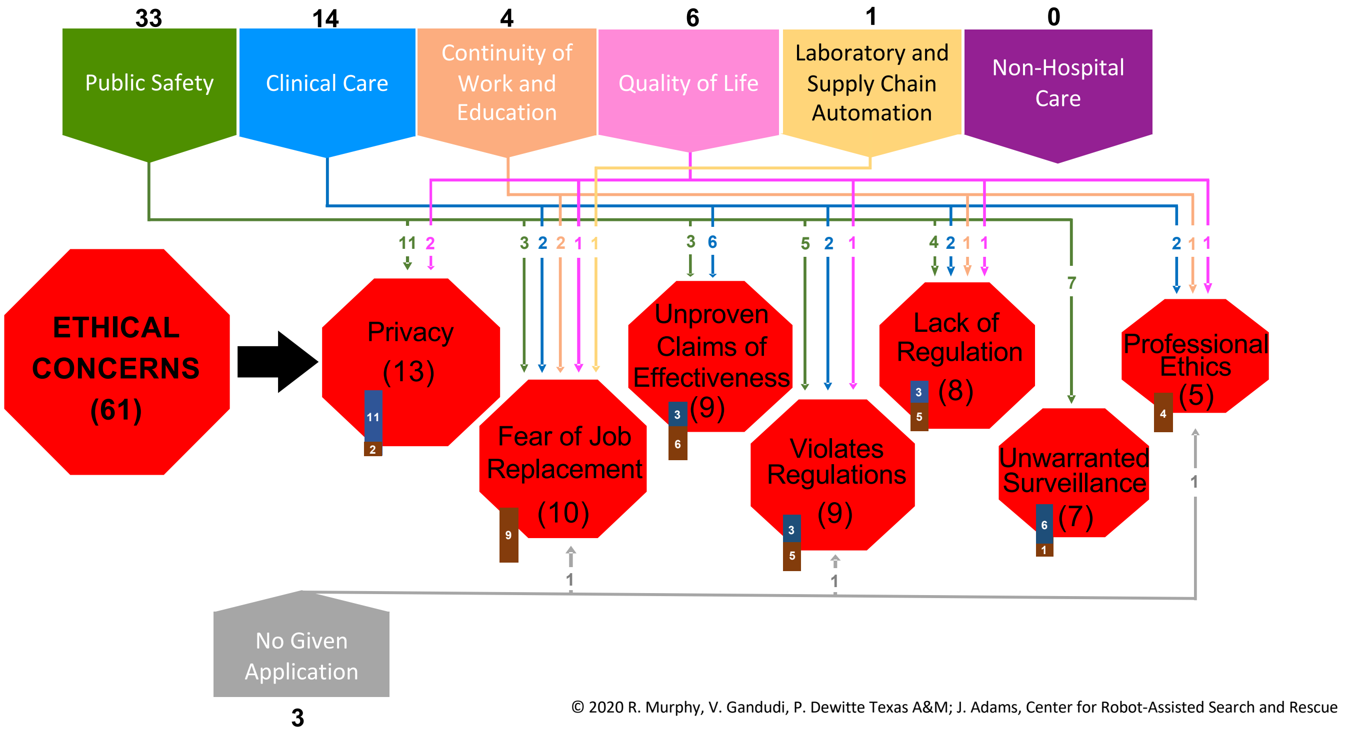


Model of Adoption: Demand Pull, Not Innovation Push



Size of rectangles correspond to % distribution of robots from COVID-19

61 Ethical Concerns: The Public Doesn't Trust Us. Or the Robots.



Takeaways for Pandemics and Disasters in General

- For disasters, need to **increase availability of existing robots**
  - Create new designs/workflows/processes to rapidly manufacturing proven, reliable robots (Heritage)
  - Create general purpose robots that can be easily adapted without increasing risk (Engineering)

- To innovate means **understanding beforehand work domain**– including ethics-- and have established partnerships with stakeholders

- Research opportunities appear to be in **delivery, dexterous manipulation, quantitatively predicting risk**

National Robotics Initiative may have put the US in the #1 position!

Resources (and Join Us)!

roboticsForInfectiousDiseases.org

- **Interview Series with Healthcare Experts and Robot Practitioners**
- **National Academy of Engineering/CCC Study (G. Hager, V. Kumar, R. Murphy, D. Rus, R. Taylor)**
- **Science Robotics articles**
- **ICRA Plenary (K. Goldberg)**
- **IFRR Panel (R. Murphy)**
- **Special Issues of IEEE RAM, Robotics and Autonomous Systems (H. Su)**

Chair, Robin Murphy, Texas A&M
Dr. Antonio Bicchi, I-RIM, Italian Institute of Robotics and Intelligent Machines (Italy)
Dr. Cindy Bethel, Mississippi State University
Dr. Angela Clendenin, Texas A&M
Dr. Murray Cote, Texas A&M
Dr. Brittany Duncan, UNL
Dr. Rebecca Fischer, Texas A&M
Dr. Ken Goldberg, UC Berkeley
Dr. Greg Hager, JHU
Dr. Serena Ivaldi, Inria (France)
Dr. Michael Lee, Science Robotics
Dr. Jason Moats, TEEX
Dr. Taskin Padir, Northeastern
Dr. Russ Taylor, JHU
Dr. Bill Smart, Oregon State University
Dr. Stefano Stramigioli, DIH-HERO (Netherlands)
Dr. Hao Su, CUNY
Dr. Richard Voyles, Purdue