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Radiofrequency DNA Damage Literature Review Electromagnetic Radiation Spectrum

Presentation · March 2022

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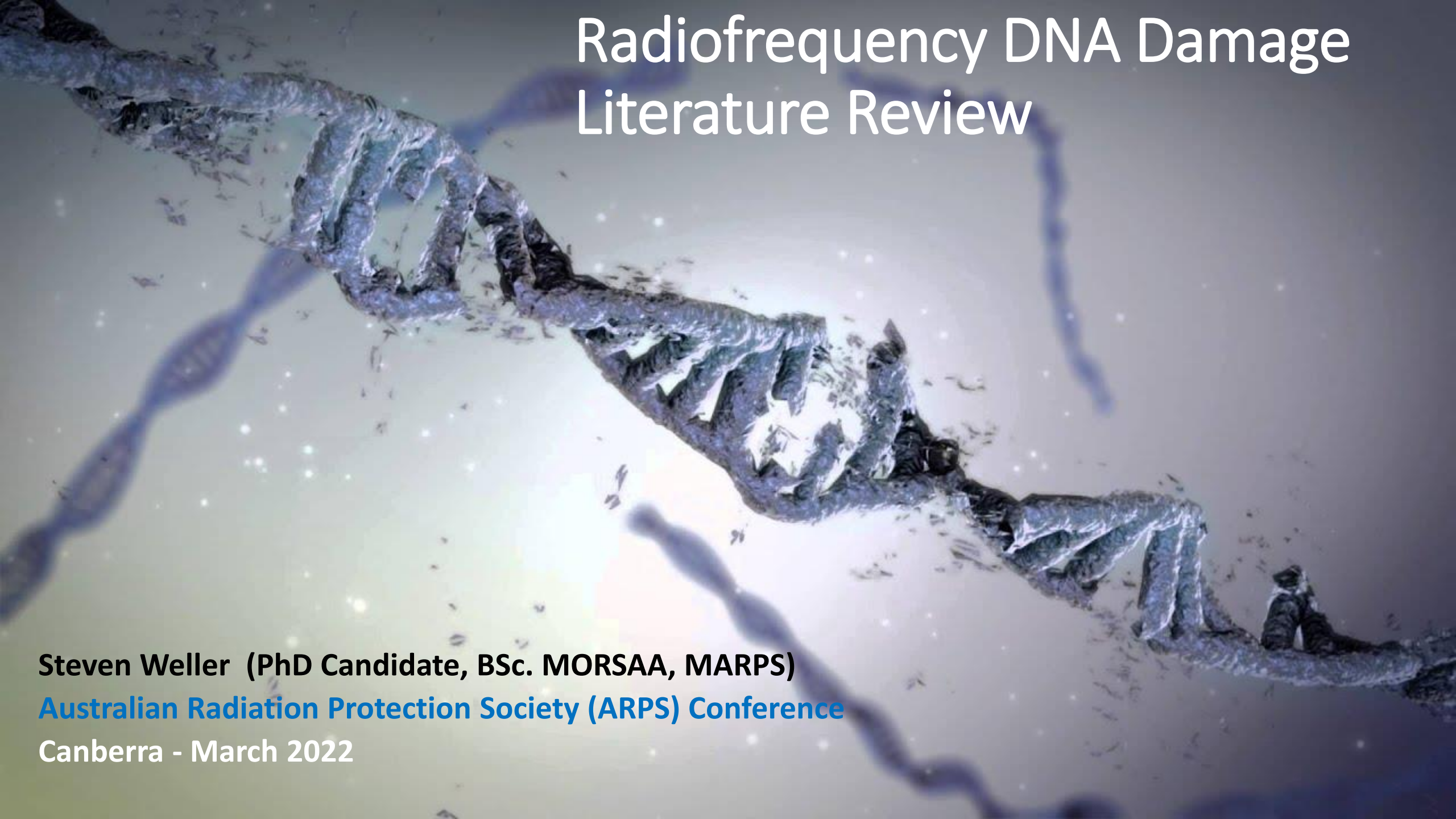
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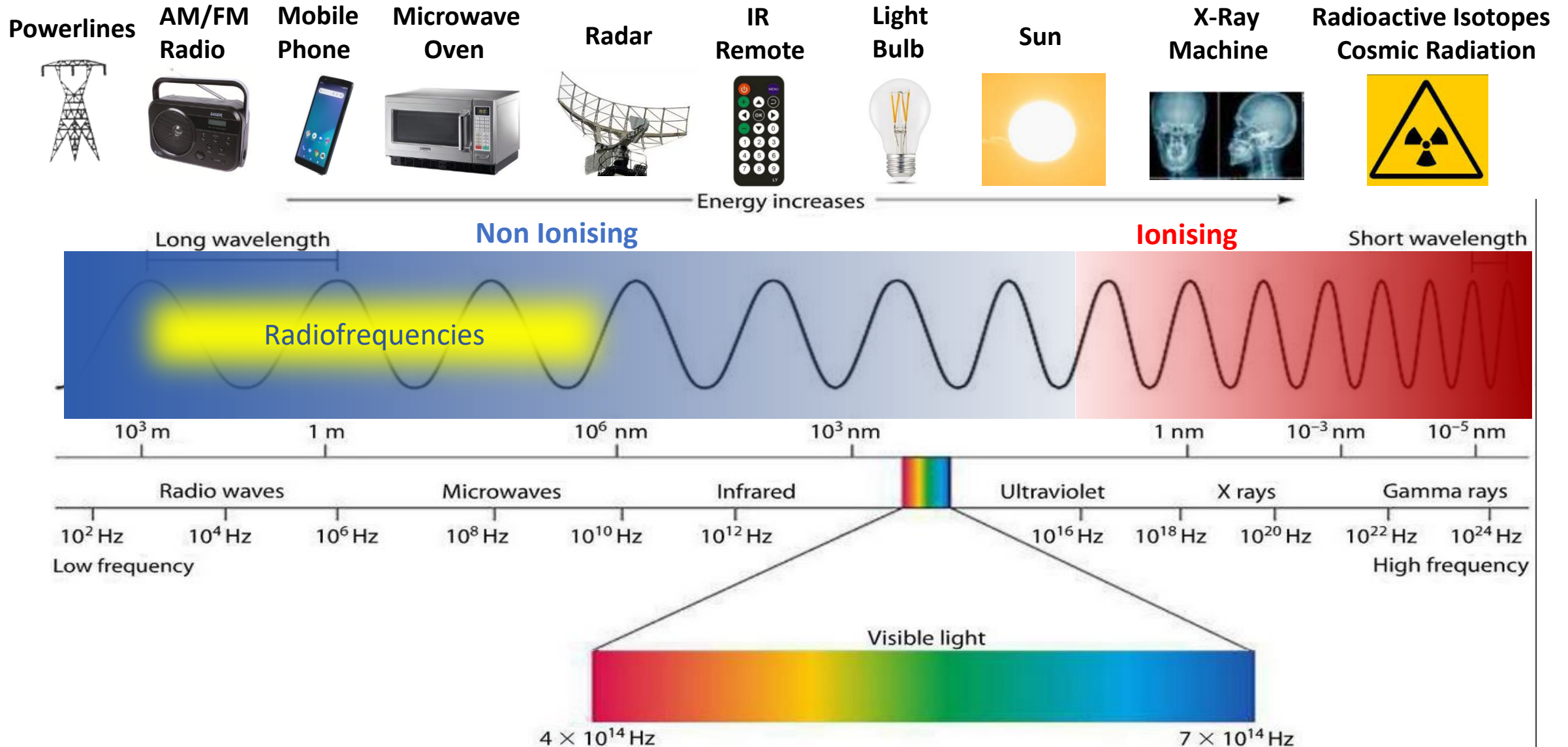
RF-EMR [View project](#)

Radiofrequency DNA Damage Literature Review



Steven Weller (PhD Candidate, BSc. MORSA, MARPS)
Australian Radiation Protection Society (ARPS) Conference
Canberra - March 2022

Electromagnetic Radiation Spectrum



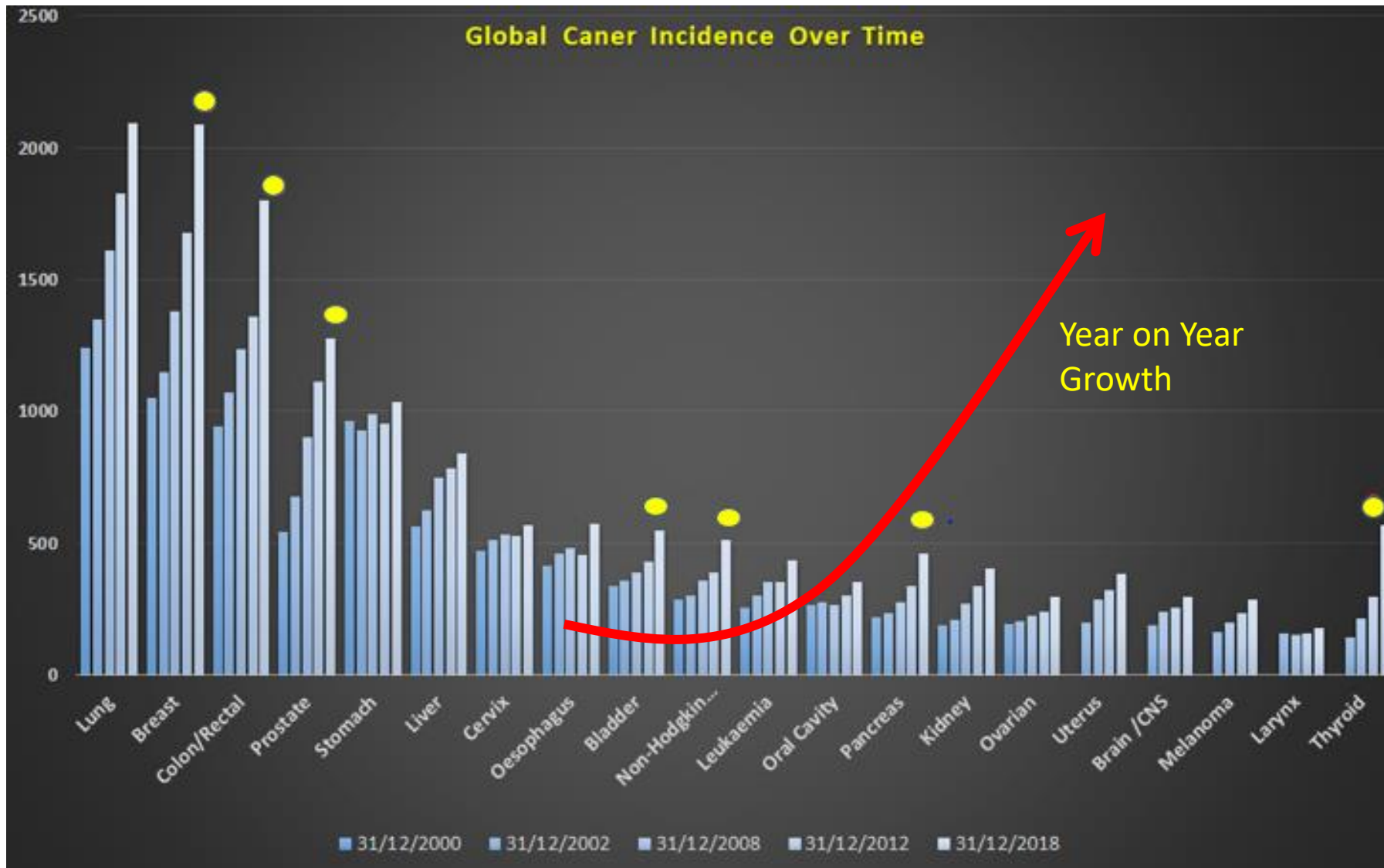
Background

IARC Perspective

- Classified all radiofrequencies (RF) as a Group 2B possible carcinogen (2011)
- Suggested evidence is credible but bias and confounding could not be ruled out
- Mechanism for cancer was unknown
- IARC classification was controversial and downplayed by authorities and industry (comparing RF to pickled vegetables)
- More recently, two important life time exposure studies on rats has provided clear evidence of carcinogenicity (NTP, Ramazzini 2018)
- IARC has nominated RF as a priority for review



Global Cancer: A Rising Health Burden for Humanity



Source: World Cancer Reports 2000, 2002, 2008, 2012 and 2018

Rationale for RF genotoxicity review

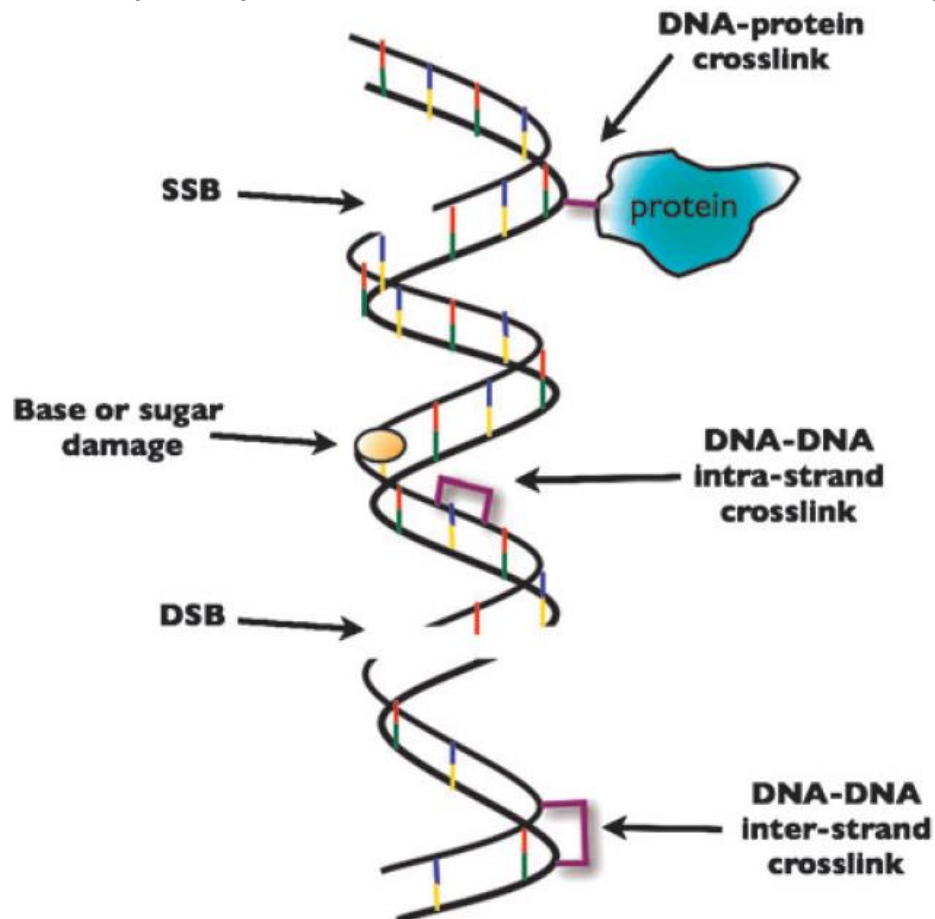
- Genotoxicity (DNA Damage) is a recognised pathway to cancer
- If RF is carcinogenic, evidence of genotoxicity should be present
- Existing literature base is quite substantial but results appear inconsistent
- Past reviews suffer from limitations:
 - Scope is either too narrow (i.e., investigation of in vitro studies only)
 - Too broad (narrative reviews that don't delve into the detail)
 - Some have used biased paper selection methods
 - Do not investigate possible mechanisms in most cases

4 Types of DNA Damage Investigated

Types of DNA Damage

1. DNA Breaks/Fragmentation

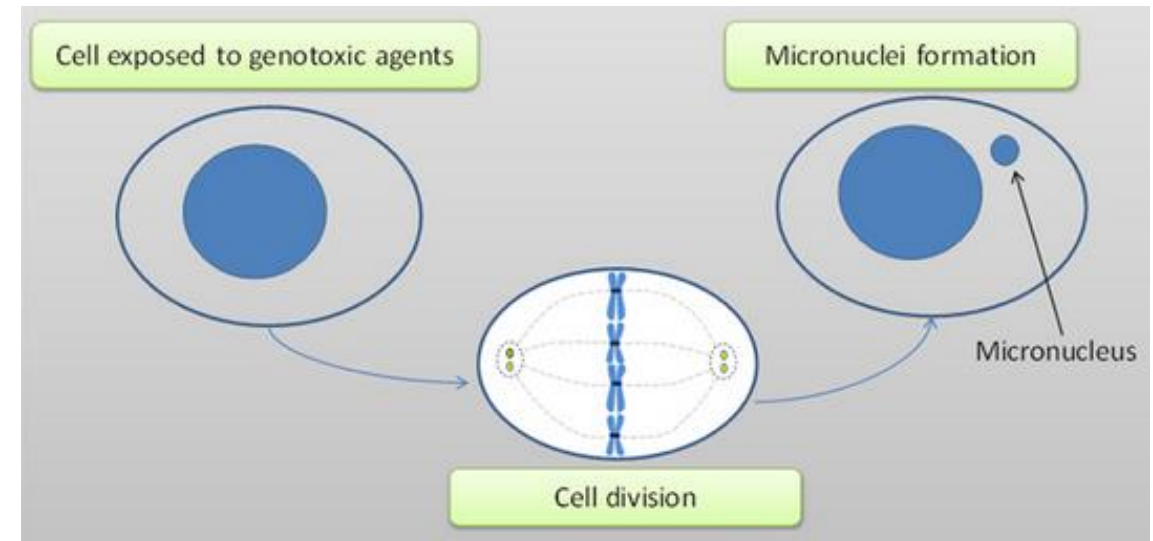
- Appear in the form of single strand (SSB) and double strand breaks (DSB)



<https://doi.org/10.1089/ars.2012.5151>

2. Micronuclei Induction

- Are extra-nuclear bodies containing whole or fragmented chromosomes



<https://doi.org/10.3389/fgene.2013.00131>

Types of DNA Damage

3. Chromosome Aberrations

- Structural changes due to chromosome breakage and abnormal reunion of broken chromosomes

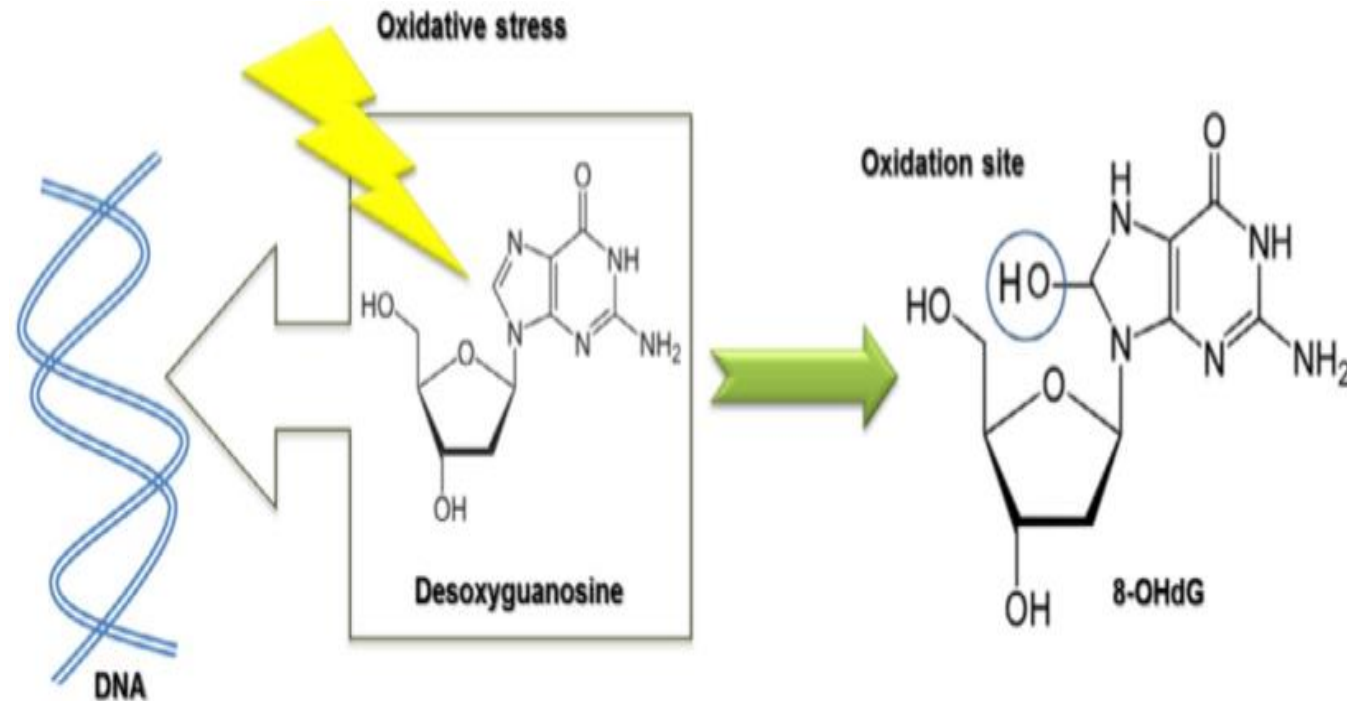
Examples of 2-lesion *Chromosome-type* aberrations

INTERCHANGE	INTER-ARM INTRACHANGE	INTRA-ARM INTRACHANGE	"BREAK" DISCONTINUITY
 dicentric	 centric-ring	 interstitial deletion	
 reciprocal translocation	 pericentric inversion	 paracentric inversion	

Atlas Genet Cytogenet Oncol Haematol. 1999;3(2):110-115.

4. DNA Base Damage

- DNA base damage can occur from exposure to free radicals



<https://doi.org/10.1016/B978-0-444-63406-1.00005-2>

Research Approach

Radiofrequency DNA Damage Literature Review

- Method: Used specific keywords related to topic and searched International research databases (Medline, EMF-Portal, ORSAA ODEB) + Lai 2021 reference list
- 370 papers were identified
- Included papers published from the 1970's to 2022 covering:
 - DNA Breaks (Single Stranded and/or Double Stranded Breaks) – 199 papers*
 - Micronuclei Induction – 113 Papers
 - Chromosome Aberrations – 89 Papers
 - DNA Base Damage – 37 Papers
- A future paper will include a comprehensive meta-analysis using mixed methods (qualitative and quantitative)

*Covered in detail in this presentation

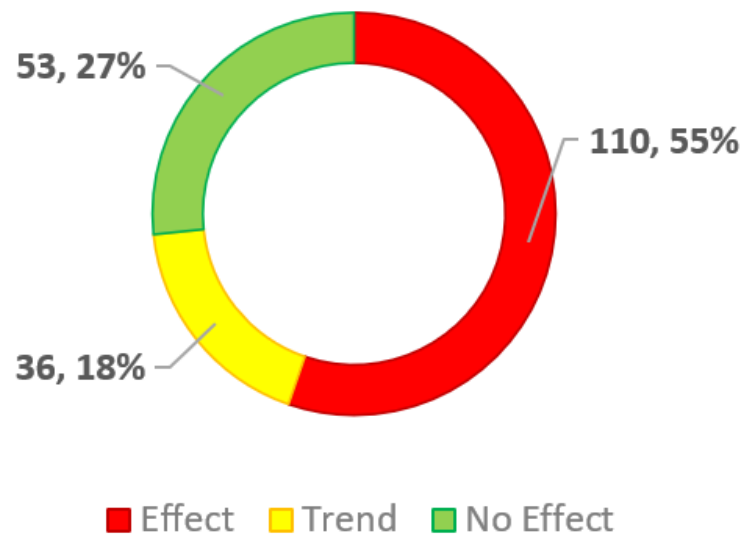
Assumptions

- All papers reviewed contain legitimate findings (no false data)
- All experimental findings were published, no data withheld
- Recorded measurements are accurate
- Funding sources when declared are fully disclosed

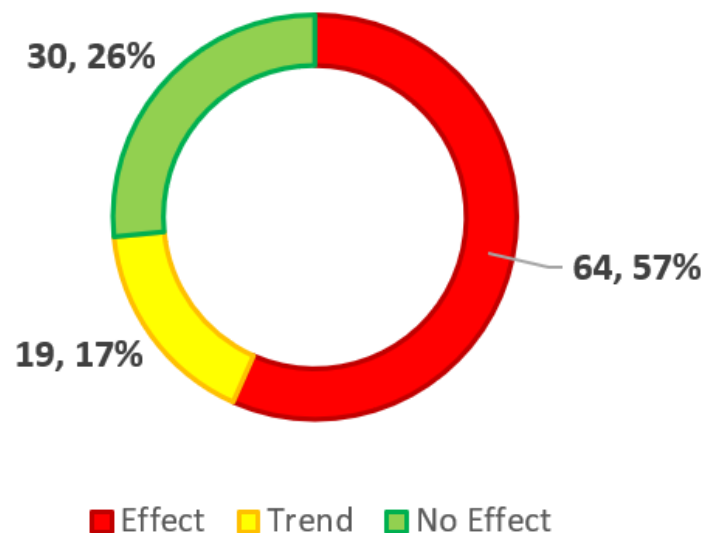
Overall Summary Findings

Balance of Evidence – Paper Level

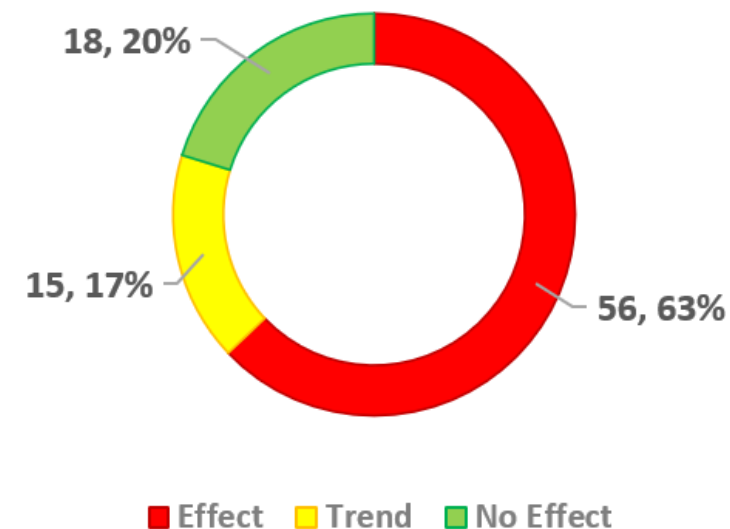
DNA Breaks - 199 Papers



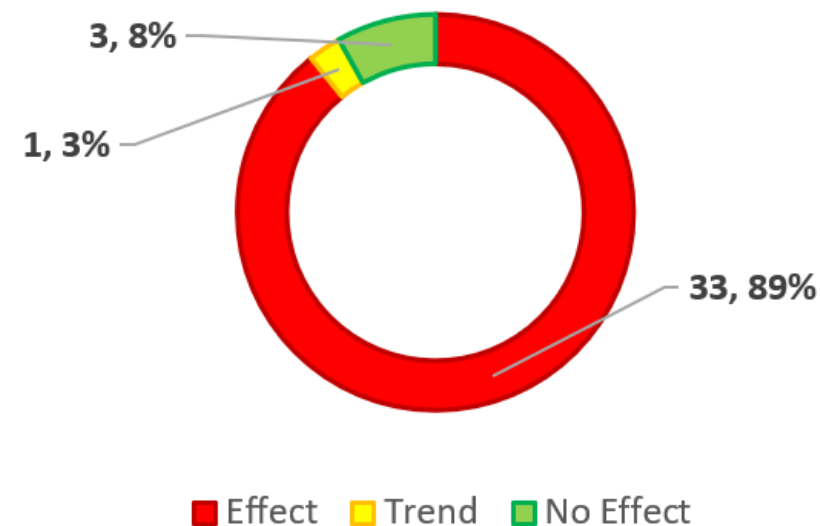
Micronuclei Induction - 113 Papers



Chromosome Aberrations - 89 Papers



DNA Base Damage - 37 Papers



A significant effect is recorded when p value < 0.05

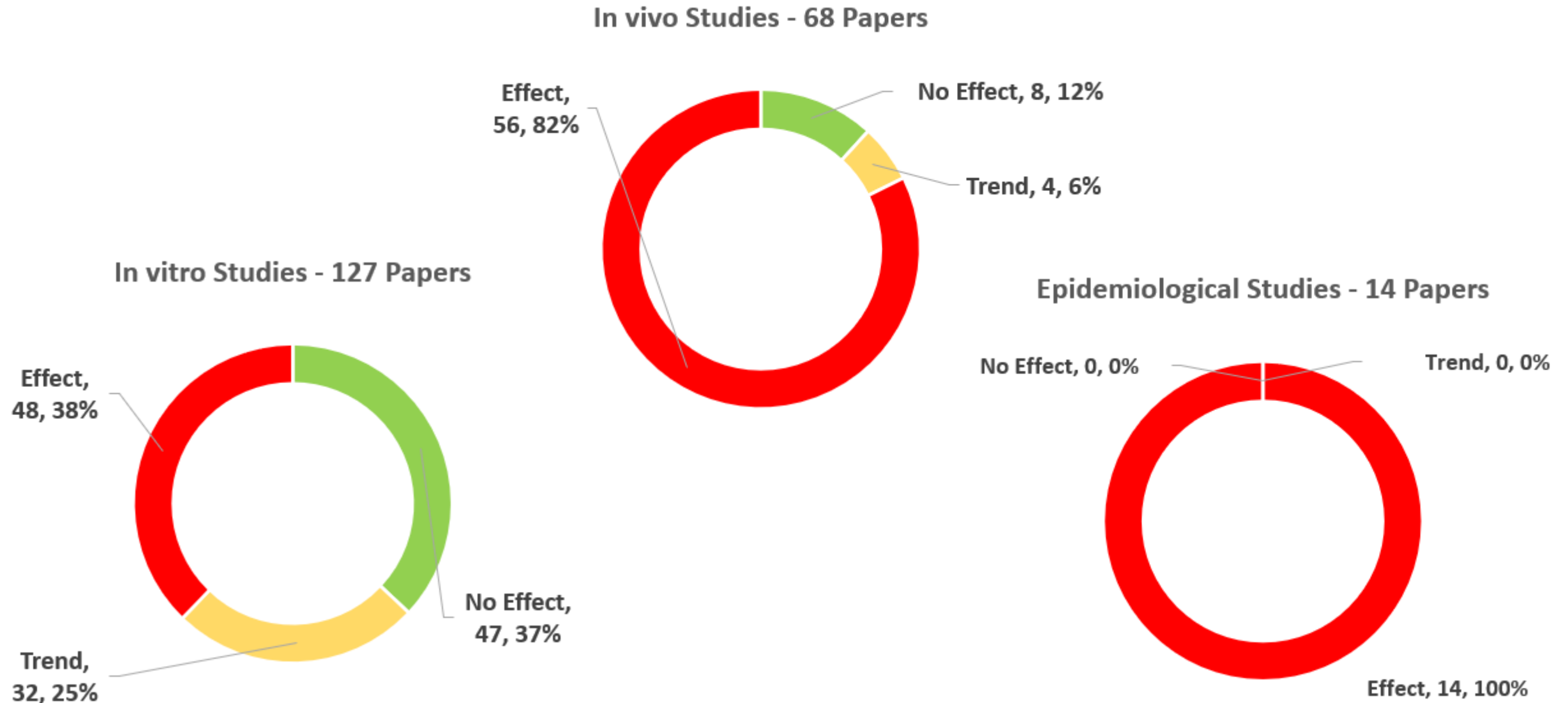
Exposure duration - A factor for DNA damage

Exposure Time	DNA Breaks		Micronuclei Induction		Chromosome Aberrations		DNA Base Damage		Key
	# Papers		#Papers		# Papers		#Papers		
	Effect	%	Effect	%	Effect	%	Effect	%	
<1 Minute	1	100.0	1	100.0	3	60.0	0	0.0	No papers
1 - 5 Min	2	100.0	1	100.0	2	40.0	0	0.0	
6 -15 Min	5	100.0	8	80.0	7	53.8	0	0.0	
16 -30 Min	7	35.0	9	60.0	11	55.0	1	50.0	70% > Effect
31 - 40 Min	4	80.0	2	66.7	0	0.0	0	0.0	
41- 60 Min	12	46.2	8	66.7	9	50.0	2	66.7	55 - 69% Effect
61 min - 2 Hours	17	34.0	5	27.8	11	52.4	6	85.7	
3 - 4 Hours	9	40.9	7	46.7	13	76.5	3	75.0	45 - 54% Effect
5 - 8 Hours	8	38.1	2	28.6	6	75.0	6	85.7	
9 - 16 Hours	8	61.5	4	33.3	3	60.0	1	50.0	30 - 44% Effect
17 - 24 Hours	10	28.3	8	30.8	5	38.5	3	100.0	
25 -48 Hours	4	33.3	8	57.1	3	75.0	2	66.7	< 29 % Effect
49 - 96 Hours	12	70.6	10	58.8	4	66.7	4	100.0	
97 Hours - 7 Days	8	80.0	3	100.0	1	100.0	3	100.0	
7 Days - 2 Weeks	4	80.0	2	100.0	1	50.0	1	50.0	
2 Weeks - 4 Weeks	5	100.0	1	33.3	0	0.0	5	83.3	
4 Weeks - 8 Weeks	3	75.0	4	100.0	2	66.7	2	66.7	
8 Weeks - 3 Months	3	100.0	1	100.0	1	50.0	1	100.0	
3 Months - 1 Year	3	100.0	1	50.0	2	66.7	1	100.0	
>1 Year	12	100.0	13	86.7	7	77.8	1	100.0	

Findings

Specific focus on DNA breaks and fragmentation

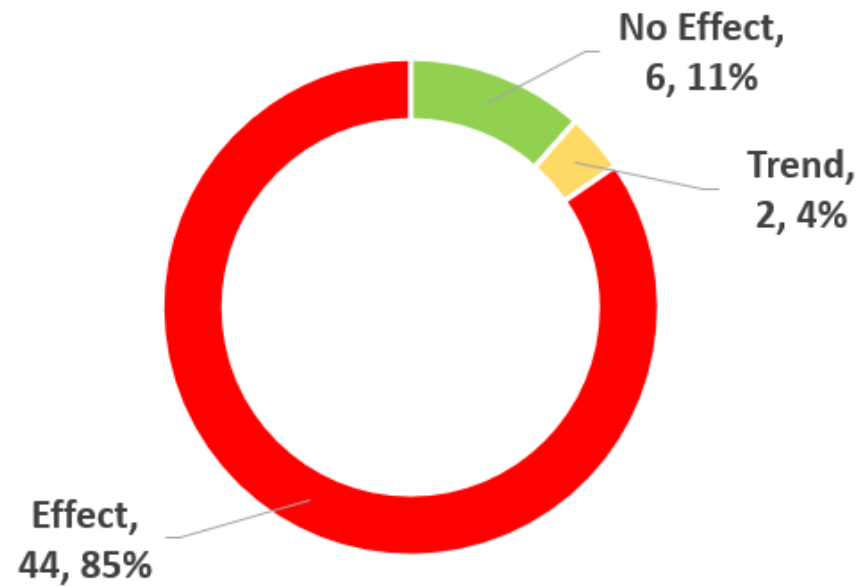
Findings by Experimental Type – DNA Breaks



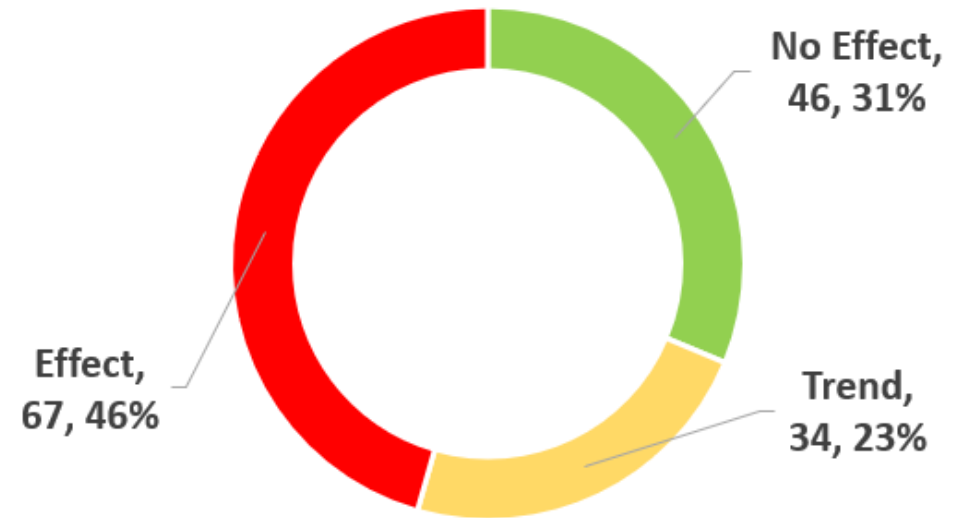
A significant effect is recorded when $p \text{ value} < 0.05$

Real vs Simulated Signals

Real World Wireless Transmitter Signals

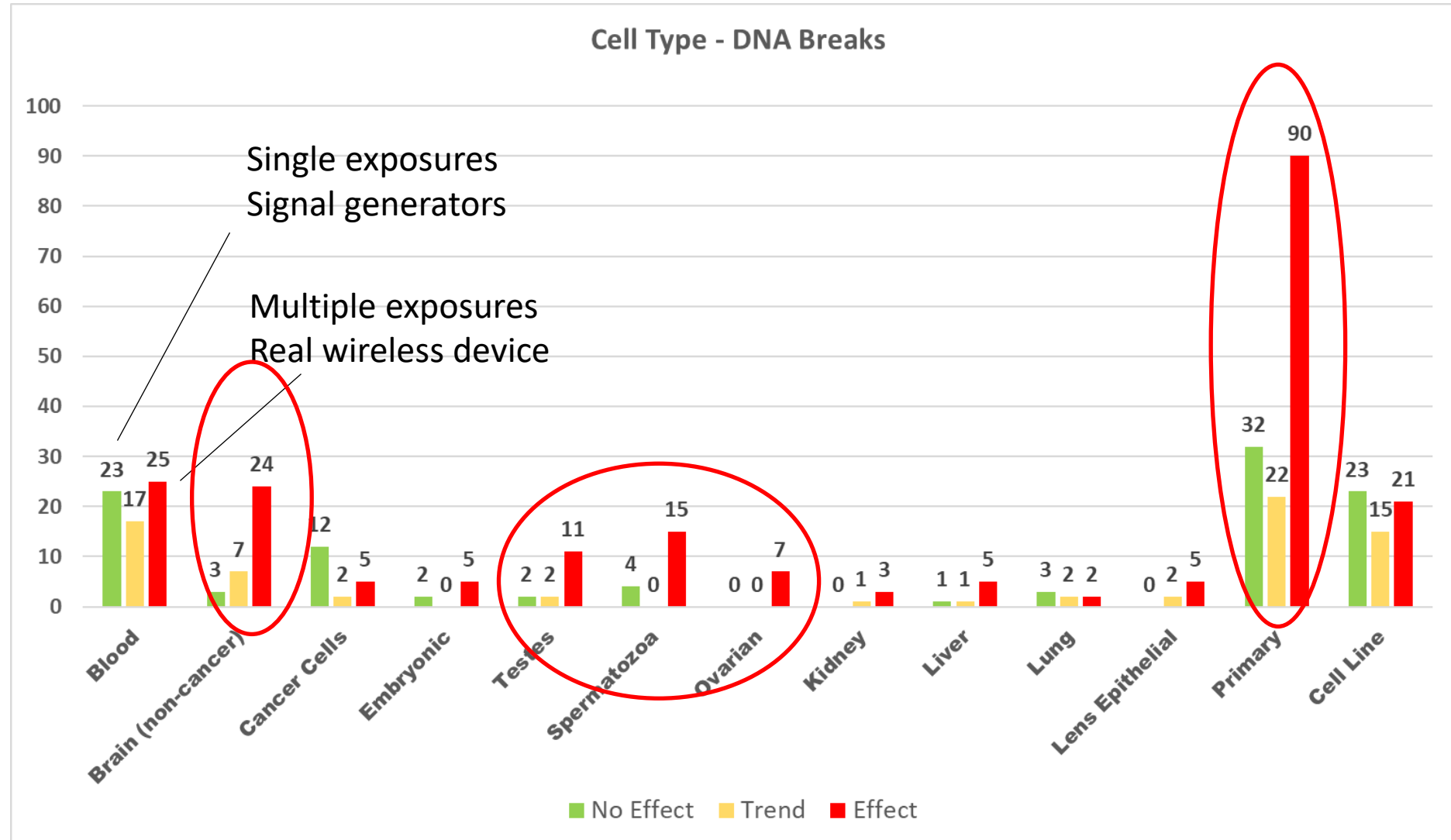


Simulated using Signal Generator



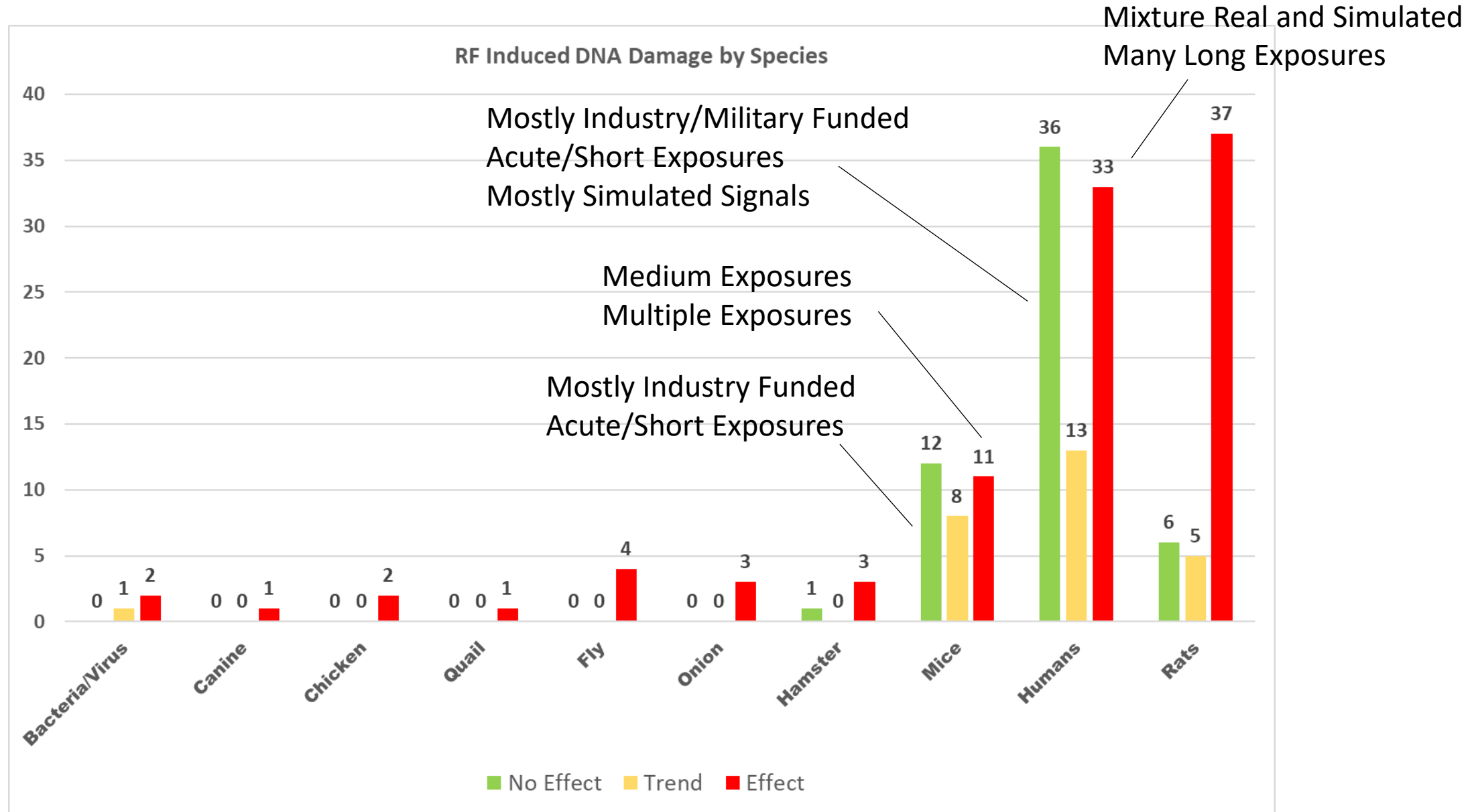
- Real world wireless transmitters show strong evidence for causing DNA damage
- The evidence for signal generators is less convincing

Cell Types – RF Induced DNA Breaks Assessment



Results shown have not accounted for potential biases and methodological limitations – all DNA break papers used

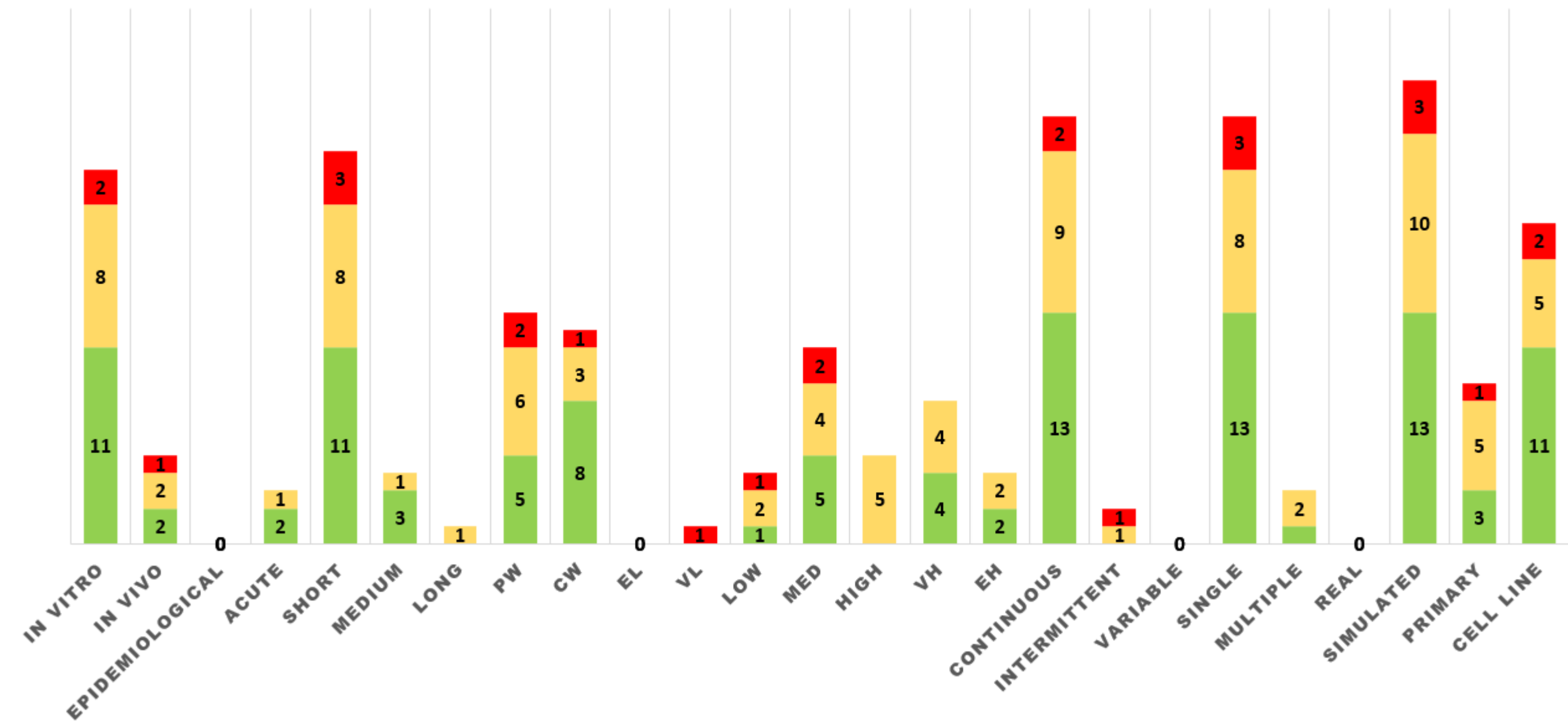
Species - RF Induced DNA Breaks Assessment



Funding Source Matters

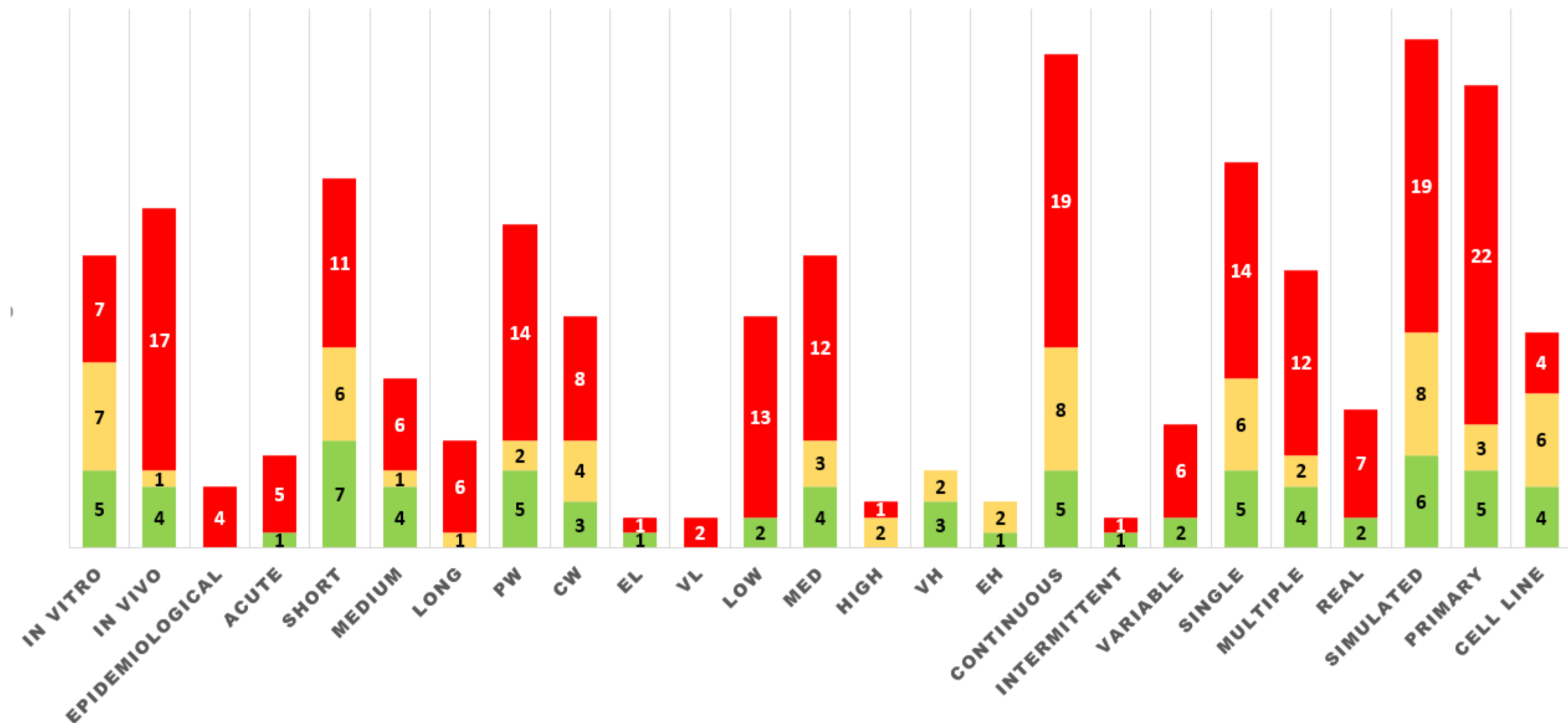
EXPERIMENT ATTRIBUTES - INDUSTRY FUNDED WITH PARTNERS

■ No Effect ■ Trend ■ Effect



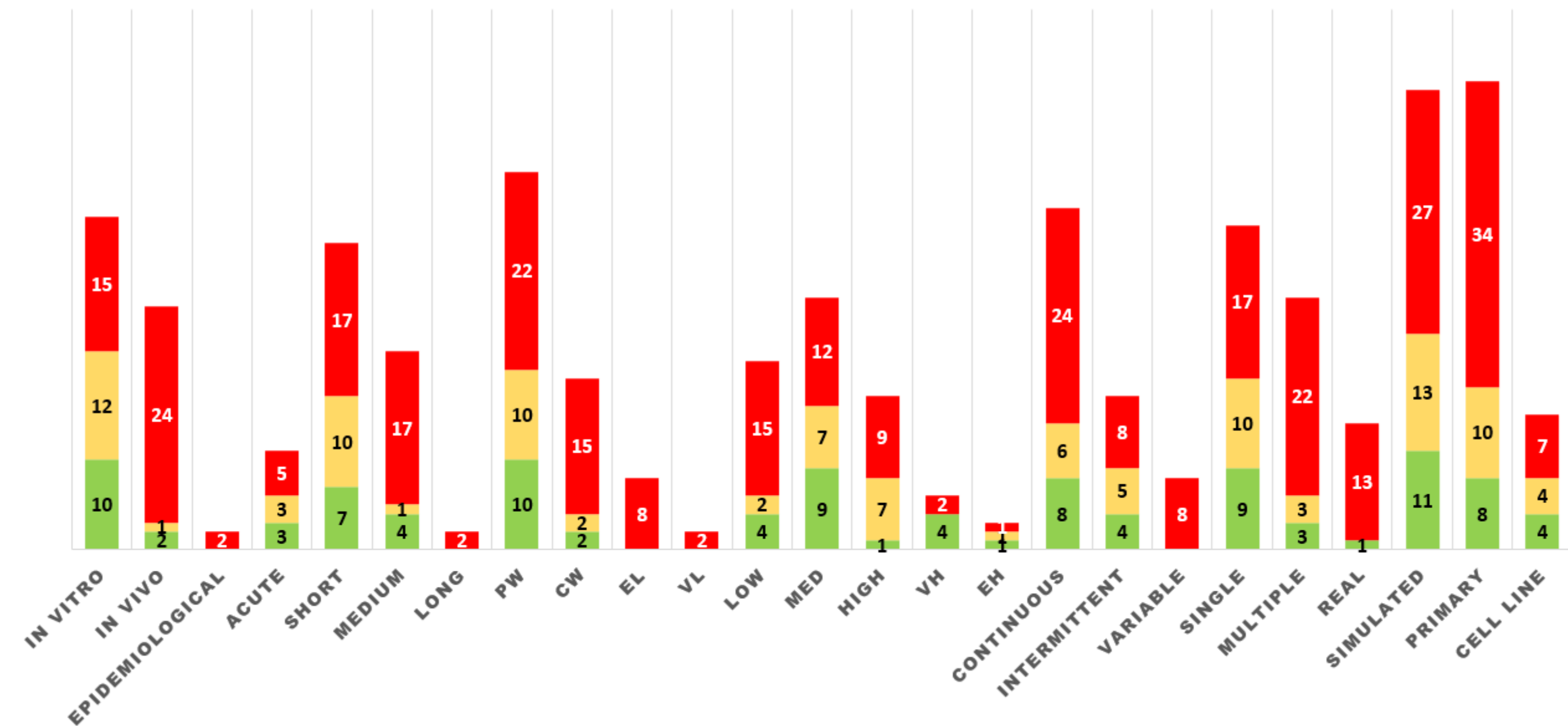
EXPERIMENT ATTRIBUTES - INSTITUTIONALLY FUNDED WITH PARTNERS

No Effect Trend Effect



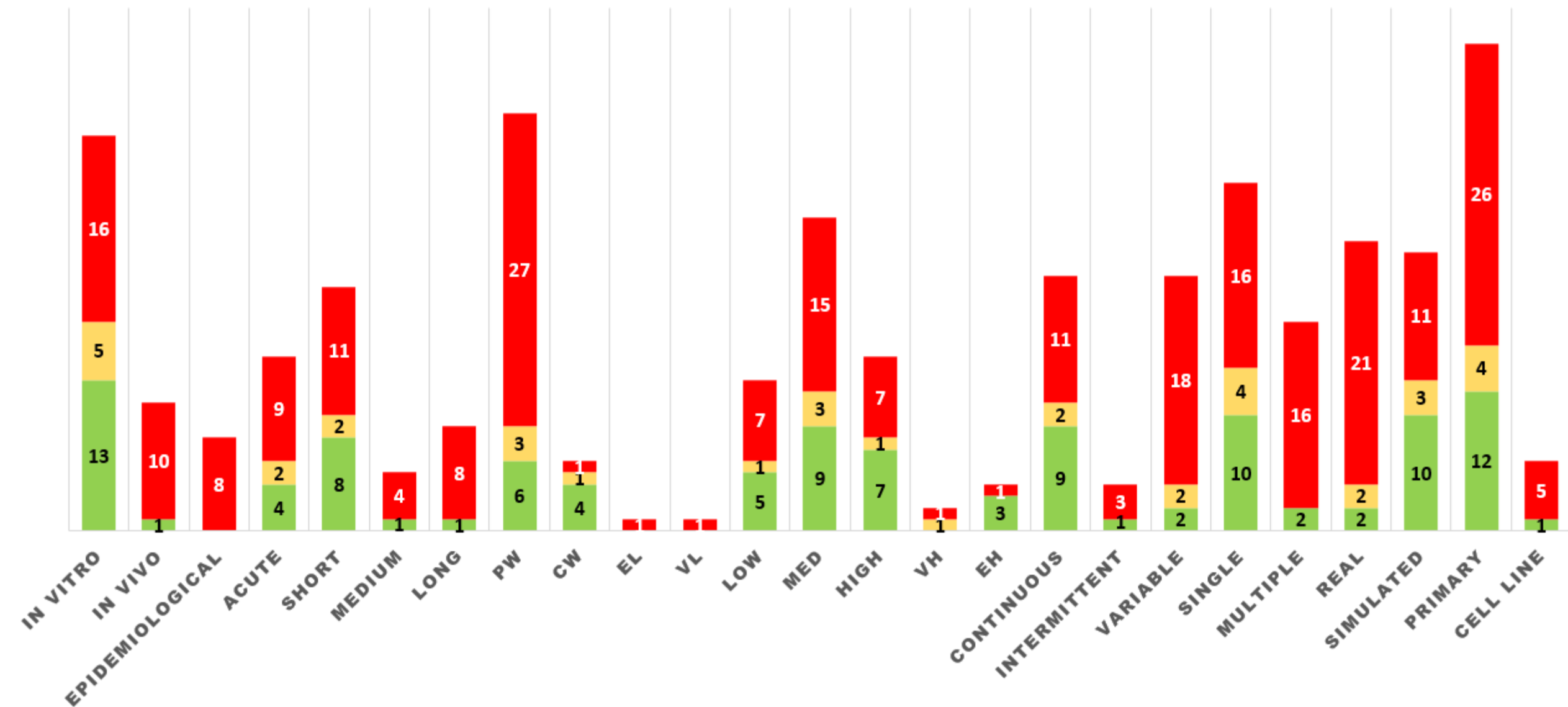
EXPERIMENT ATTRIBUTES - GOVERNMENT FUNDING EXCL. MILITARY AND COMMS

■ No Effect ■ Trend ■ Effect



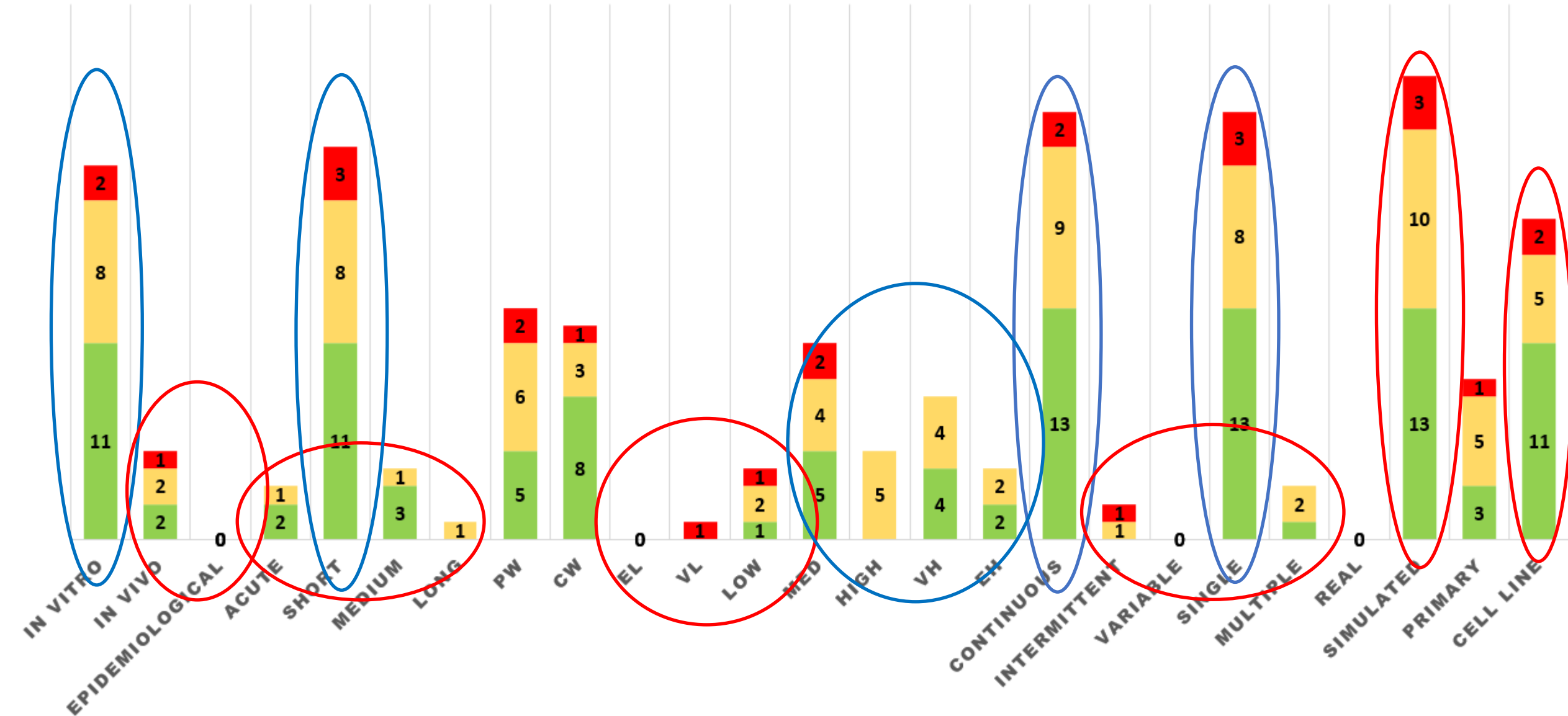
EXPERIMENT ATTRIBUTES - UNKNOWN FUNDING

■ No Effect ■ Trend ■ Effect



EXPERIMENT ATTRIBUTES - INDUSTRY FUNDED WITH PARTNERS

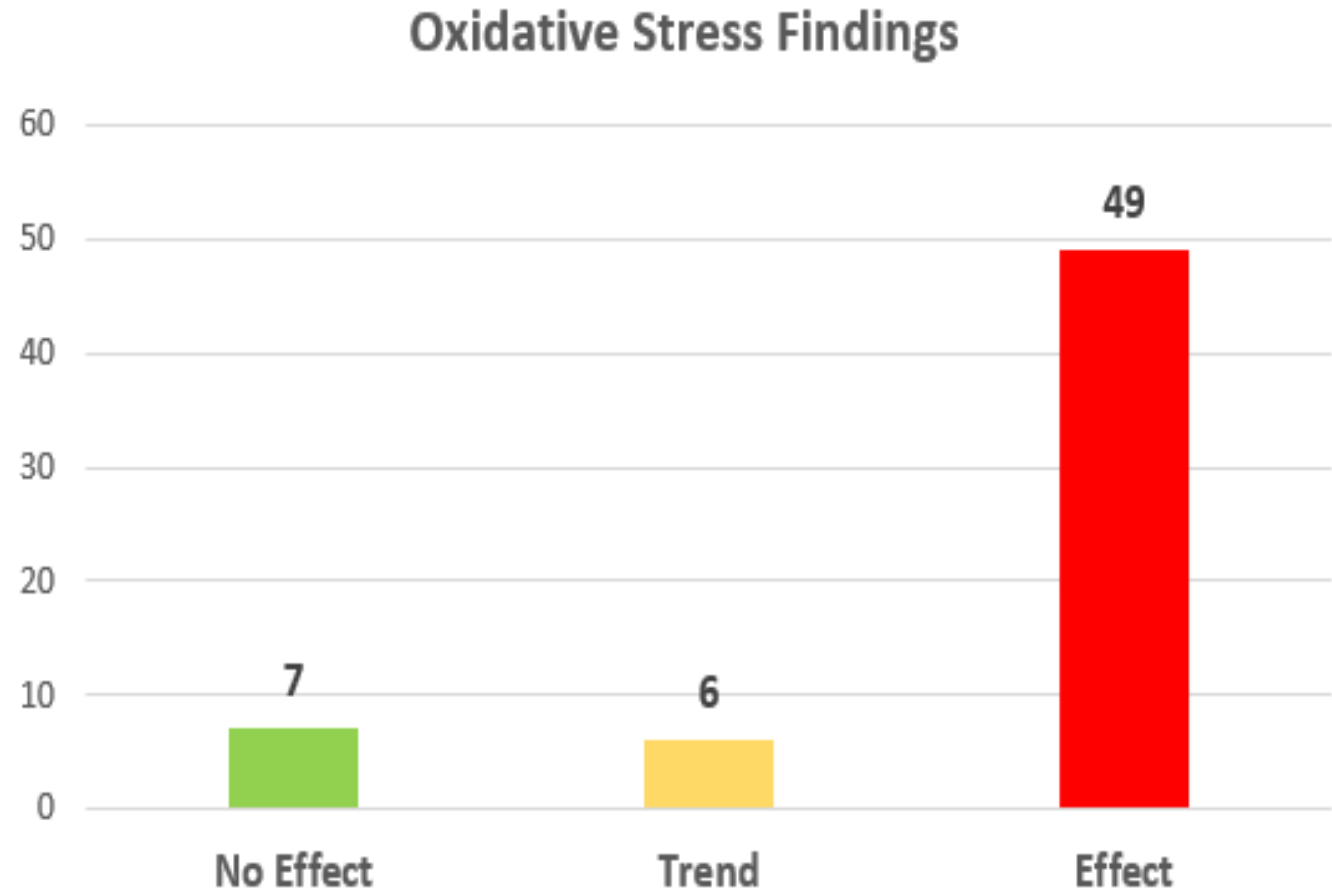
■ No Effect ■ Trend ■ Effect



DNA Damage – Mechanism?

Free Radicals – Oxidative Stress

- Of the 199 papers looking at DNA strand breaks, 62 papers also looked at free radical production
- Free radicals can:
 - Break chemical bonds
 - Cause single strand breaks
 - Cause double strand breaks
 - Cause DNA Base damage
- 89% of papers (216 of 242) investigating RF and OS find it (Bandara *et al.* 2018)



Result Summary

Summary Findings

- DNA damage is associated with field intensity and exposure duration
 - Non linear intensity response (Lower intensities vs Higher intensities)
 - Non thermal effects are obvious
 - Higher number of papers report damage at lower intensities
 - Non thermal action via oxidation/free radical damage, conformation changes (DNA/Proteins) and possibly repair Inhibition?
 - Dose response tendency noted – longer the exposure higher chance of DNA damage
 - Some studies show heterogenous populations exist with varying sensitivity to EM fields (pooling of data will hide those who are sensitive)
 - DNA damage caused by RF is comparatively lower than other known genotoxic agents (ionising radiation, chemicals etc.)

Exposure to RF is occurring 24x7, unlike other agents which are typically sporadic

Closing Statements

Controversial findings and issues

- Results show a real risk for genotoxicity, particularly long exposures
- Case for carcinogenicity is made stronger
- All species are at risk as we blanket the earth with RF
- ARPANSA and ICNIRP do not consider these risks because they
 - Require consistency in results
 - and confirmed evidence of harm (proof)
- No pre-market health testing when rolling out new wireless technology
- Safety is assumed if operating within public limits
- Precaution is absent, ARPANSA explicitly removed precautionary principle from latest RF Standard (RPS S-1), was present in RPS 3 (previous version)
- Sensitive populations are not considered

Recommendations

- A precautionary approach is required
- RF Standards are inadequate and need larger safety margins
- Future experiments should consider
 - Longer and multiple exposures
 - Use real life devices and signals that include data transmission
 - Perform assays at different time intervals
 - Use primary cells
 - Investigate mechanisms by also measuring
 - Free radical production/damage
 - Gene expression (anti oxidant enzymes, DNA repair proteins)

Thank You

Future Publication

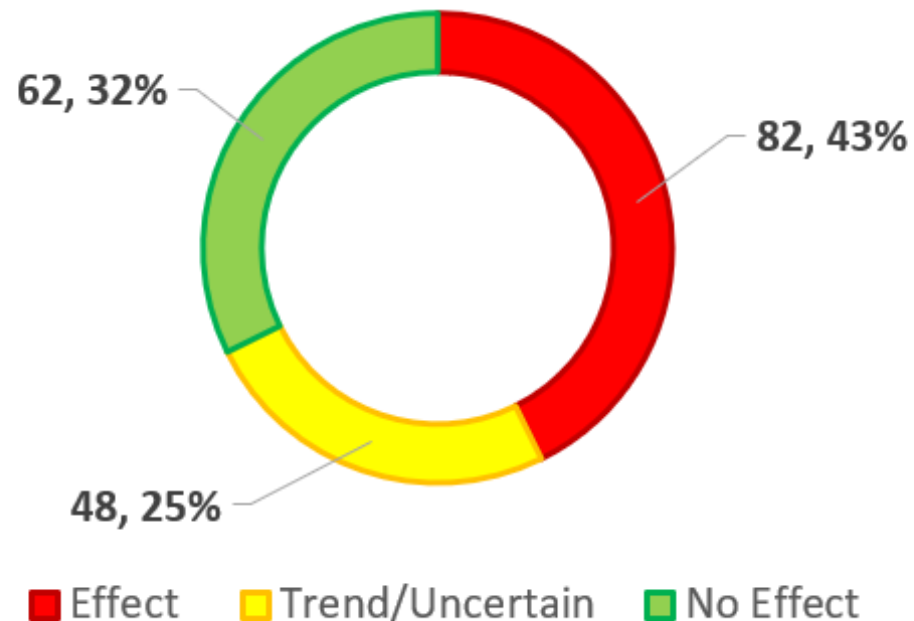
Other's Work – A Prediction

Genotoxicity of radiofrequency electromagnetic fields: Protocol for a systematic review of in vitro studies (2021)

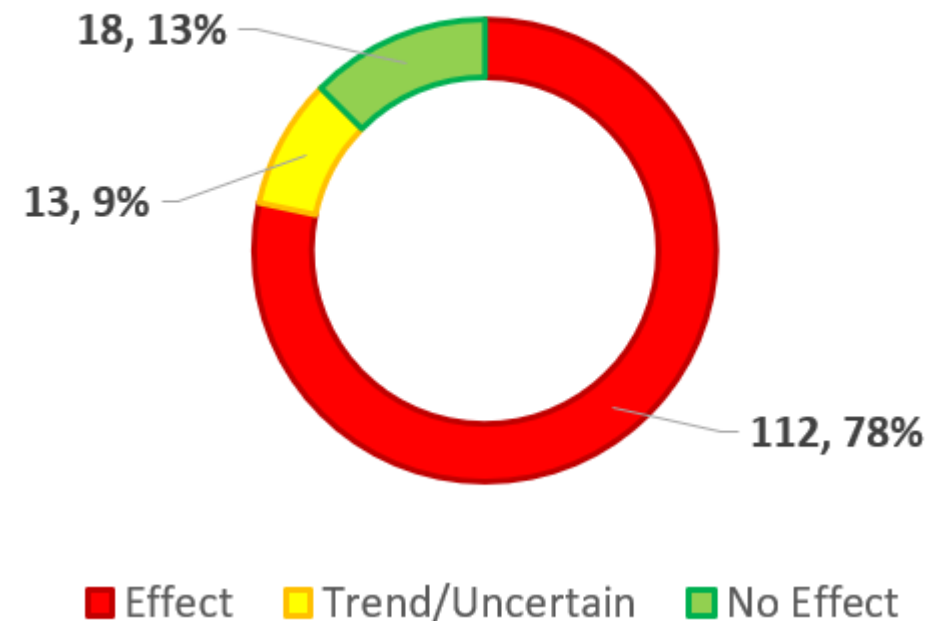
Stefania Romeo, Olga Zeni , Anna Sannino, Susanna Lagorio, Mauro Biffoni, Maria Rosaria Scarfi

Eligibility criteria (taken from abstract): We will include experimental in vitro studies addressing the relationship between **controlled exposures** to RF-EMF and genotoxicity in mammalian cells only. (English papers only)

Romeo *et al.* Systematic Review 2021 - Preview



Evidence Missed - Epi + In vivo



Late Lessons from early warnings

ON BEING WRONG: Environmental and health sciences and their main directions of error.

Scientific studies	Some methodological features	Main ^a directions of error-increases chances of detecting a:
Experimental Studies (Animal Laboratory)	• High doses • Short (in biological terms) range of doses • Low genetic variability • Few exposures to mixtures • Few Foetal-lifetime exposures • High fertility strains	• False <i>positive</i> (negative for low dose effects) • False negative • False negative • False negative • False negative • False negative (developmental/reproductive endpoints)
Observational Studies (Wildlife & Humans)	• Confounders • Recall bias • Inappropriate controls • Non-differential exposure misclassification • Inadequate follow-up • Lost cases • Simple models that do not reflect complexity	• <i>False positive</i> • <i>False positive/negative</i> • False negative • False negative • False negative • False negative
Both Experimental and observational studies	• Publication bias towards positives • Scientific cultural pressure to avoid false positives • Low statistical power (e.g. From small studies) • Use of 5% probability level to minimise chances of false positives • Much scrutiny of positive studies cf. negative studies	• <i>False positive</i> • False negative • False negative • False negative • False negative

^a Some features can go either way (e.g. inappropriate controls) but most of the features mainly err in the direction shown in the table.

Current view of WHO, ICNIRP and ARPANSA

- “Non-ionizing radiation is a general term for that part of the electromagnetic spectrum which has photon energies too weak to break chemical bonds”

Not completely relevant as UV (A/B) radiation is also non-ionising, damages DNA and is a recognised Group 1 carcinogen. Both RF and UV generate free radicals. Free radicals are proven to damage DNA.

- “Despite considerable research efforts, no mechanism relevant for carcinogenesis of radiofrequency electromagnetic fields has been consistently identified to date.”

This is incorrect – Free radical production provides a plausible mechanism with 89% of papers¹ showing RF exposures create free radicals, which can damage DNA. Accumulated DNA damage is a recognised pathway for carcinogenesis

- “Most of the epidemiological research does not indicate carcinogenicity of radiofrequency electromagnetic fields.”

This statement is factually challenged by epidemiological evidence for brain tumours which shows an association² and was the principle reason for the IARC to classify RF as a Group 2B carcinogen in May 2011. Animal evidence was seen to be limited at the time, however, clear evidence has since been found^{3,4} reinforcing the need to revisit the original IARC classification

Source of quotes: World Cancer Report Cancer Research for cancer prevention (2020)

1. Bandara *et.al.* 2018
2. IARC Monograph 2013
3. NTP Study 2018
4. Ramazzini Institute lifetime study 2018