

The genomic landscape of Acute Respiratory Distress Syndrome: a meta-analysis by information content of whole-genome studies of the host response.

Supplementary Material

Supplementary Methods

Search strategy

Inclusion criteria

Search Strategy

We used the following strategy to search MEDLINE and a direct translation to search Embase.

1 exp Respiratory Distress Syndrome, Adult/

2 “acute lung injury*”.ti,ab,kf,kw

3 1 OR 2

4 “gene*”.mp

5 “genome*”.mp

6 “transcript*”.mp

7 “protein*”.mp

8 4 OR 5 OR 6 OR 7

9 3 AND 8

10 (“COVID-19*” OR “COVID19*” OR “COVID-2019*” OR “covid”).ti,ab,kf,kw

11 (“SARS-CoV-2*” OR “SARSCov-2*” OR “SARSCoV2*” OR “SARS-CoV2”).ti,sh,kf,kw

12 (“2019-nCoV*” OR “2019nCoV*” OR “19- nCoV*” OR “19nCoV*” OR “nCoV2019*” OR “nCoV-2019*” OR “nCoV19*” OR “nCoV- 19*”).ti,ab,kf,kw

13 10 OR 11 OR 12

14 9 NOT 13

15 Letter.pt OR Conference Abstract.pt OR Conference Paper.pt OR Conference Review.pt OR Editorial.pt OR Erratum.pt OR Review.pt OR Note.pt OR Tombstone.pt

16 14 NOT 15

17 exp *adolescence/ or exp *adolescent/ or exp *child/ or exp *childhood disease/ or exp *infant disease/ or (adolescen* or babies or baby or boy? or boyfriend or boyhood or girlfriend or girlhood or child or child* or child*3 or children* or girl? or infan* or juvenil* or juvenile* or kid? or minors or minors* or neonat* or neo-nat* or newborn* or new-born* or paediatric* or peadiatric* or pediatric* or perinat* or preschool* or puber* or pubescen* or school* or teen* or toddler? or underage? or under-age? or youth*).ti,kw

18 16 NOT 17

19 ((exp animal/ or nonhuman/) NOT exp human/)

20 18 NOT 19

21 limit 20 to yr=“1967-Current”

Inclusion criteria

Inclusion:

- Human studies: *in-vivo* or *in-vitro*
- Adults (age \geq 18 years)
- Acute Respiratory Distress Syndrome (ARDS)
 - by any contemporaneous definition
- Accepted methodologies:
 - CRISPR screen
 - RNAi screen
 - Protein-protein interaction study
 - Host proteins incorporated into virion or virus-like particle
 - Genome wide association study
 - Transcriptomic study
 - Proteomic study

Exclusion:

- Children (age < 18 years)
- Animal studies
- Meta-analyses, *in-silico* analyses, or re-analysis of previously published data
- Excluded methodologies:
 - *In-vitro* human studies simulating ARDS
 - Candidate *in-vivo* or *in-vitro* transcriptomic or proteomic studies (defined as those investigating < 50 genes)
 - Candidate gene association studies
 - Studies including fewer than 5 individuals in either the control or ARDS arm

Supplementary Results

Supplementary Figures 1-7

Supplementary Tables 1-4

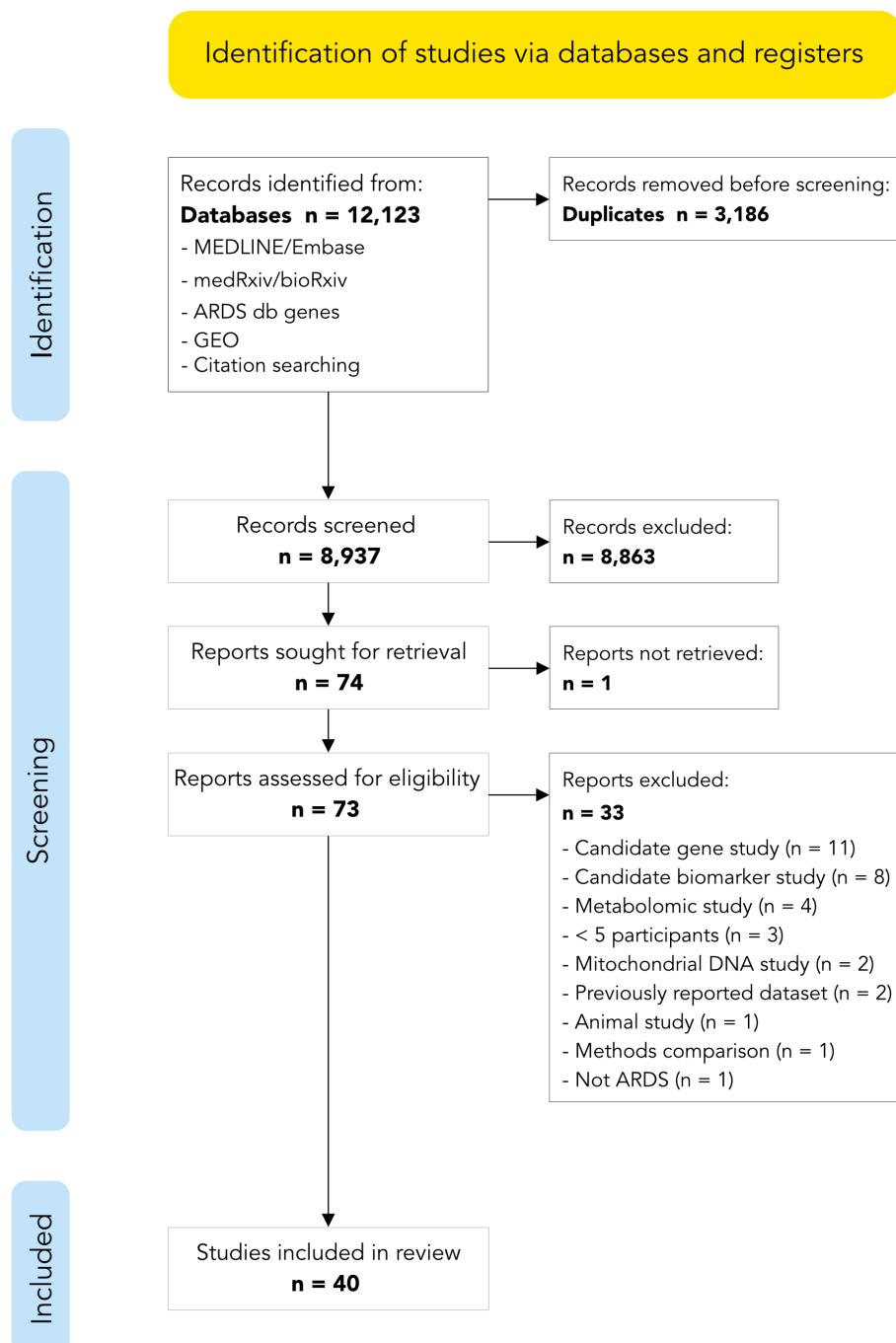


Figure 1: **Systematic review inclusion diagram.** Abbreviations: db - data base; GEO - NCBI Gene Expression Omnibus.

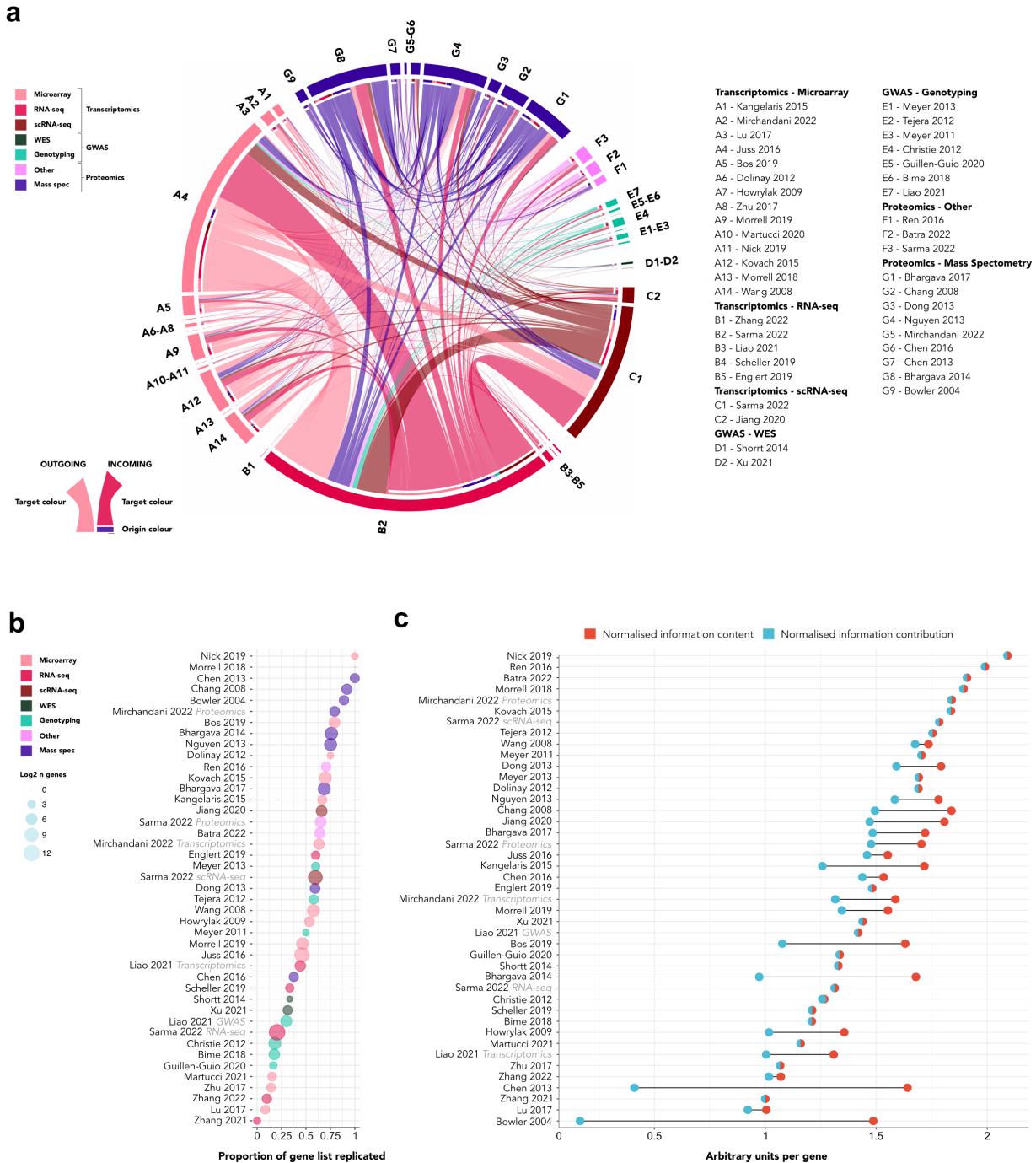


Figure 2: Attributing information in MAIC. (a) Shared information content (IC) between gene lists. Links indicate absolute IC (sum of common gene scores) between studies. (b) Proportion of replicated genes. Circle diameter is equal to logarithm (base 2) of gene number per list. (c) IC normalised by number of genes. Overlapping circles denote equal normalised IC and contribution (IC_{tb} - sum of common gene scores contributing to MAIC), indicating all gene scores contributed to MAIC.

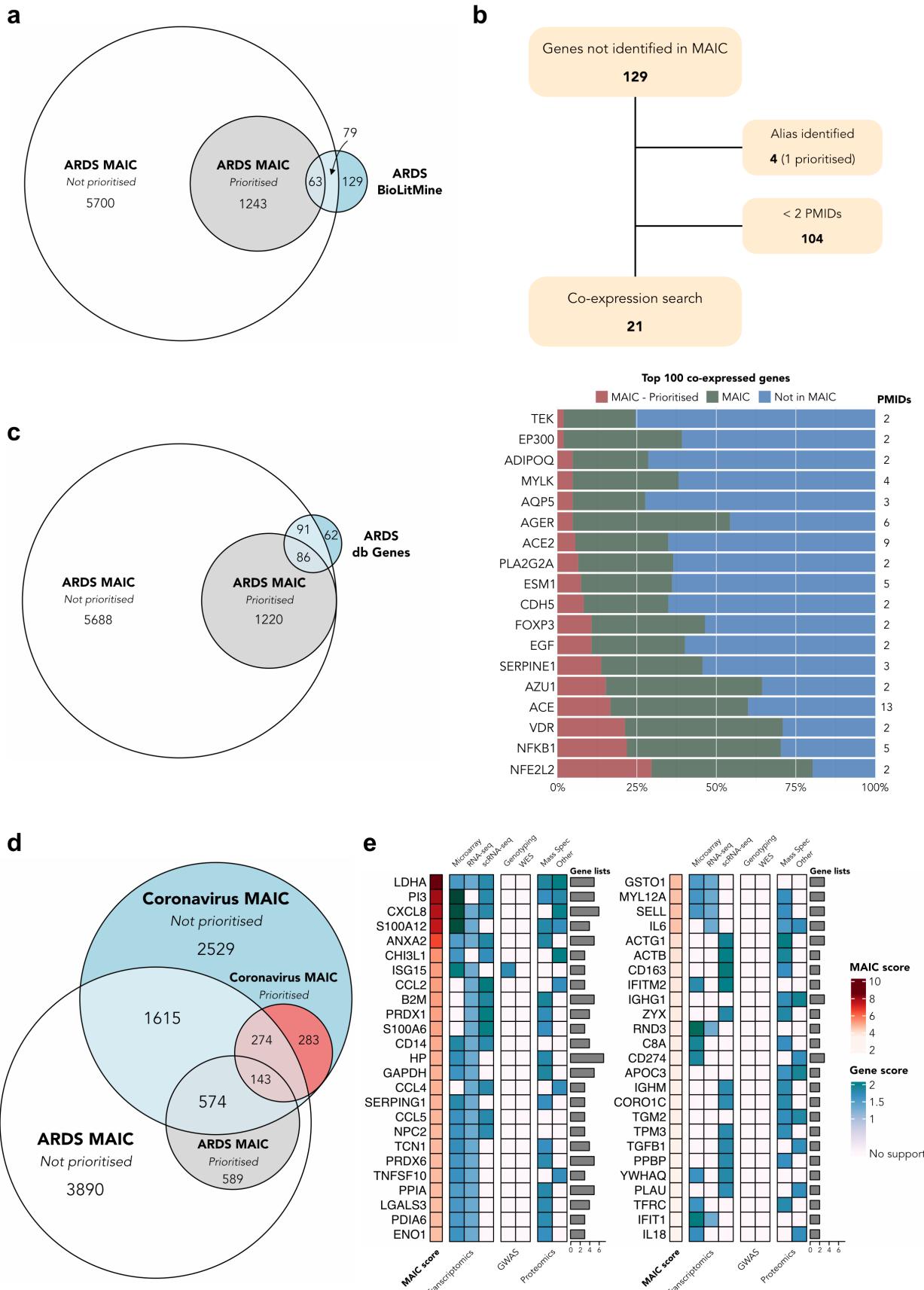


Figure 3: Overlap between ARDS MAIC and ARDS-associated genes and ARDS MAIC and coronavirus MAIC.

(a) Euler diagram of gene overlap between ARDS MAIC and a BioLitMine search using the ARDS MeSH term. (b) Schematic overview of a co-expression search for genes identified in the BioLitMine search but not present in ARDS MAIC and a stacked bar plot of the proportion of the 100 most co-expressed genes of this group and ARDS MAIC. (c) Euler diagram of gene overlap between ARDS MAIC and the ARDS Database of Genes. (d) Euler diagram of gene overlap between ARDS MAIC and a MAIC of COVID-19 host-response studies. (e) Heatmap of the 50 top ranked ARDS MAIC genes also prioritised by the coronavirus MAIC, displaying the ARDS MAIC score for each gene, highest gene score in each category, and the number of supporting gene lists.

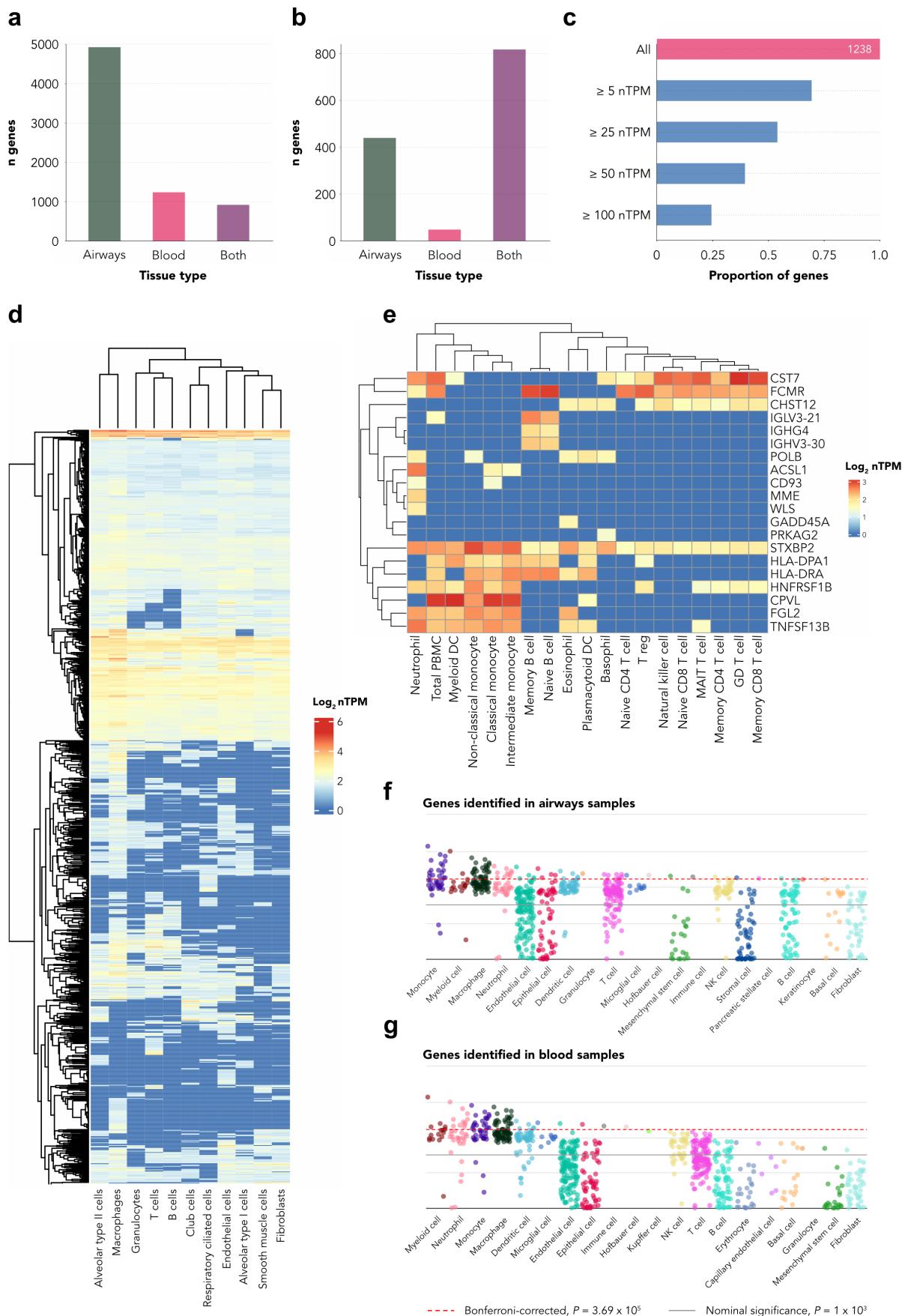


Figure 4: Tissue and cell-specific expression. (a) Bar plot of the tissue type in which genes are identified - all genes ($n=7,085$). (b) Bar plot of the tissue type in which genes are identified - prioritised genes ($n=1,306$). (c) Bar plot of the proportion of genes identified solely in blood meeting mRNA expression thresholds in bulk lung tissue. nTPM - normalised transcripts per million. (d) Heatmap of mRNA expression in lung cell-types for genes identified in studies based on airways sampling. (e) Heatmap of mRNA expression in blood cell-types for genes identified solely in studies based on blood sampling. (f) Manhattan plot of the top 20 cell types overenriched for expression of genes identified by studies based on airways sampling. (g) Manhattan plot of the top 20 cell types overenriched for expression of genes identified by studies based on blood sampling.

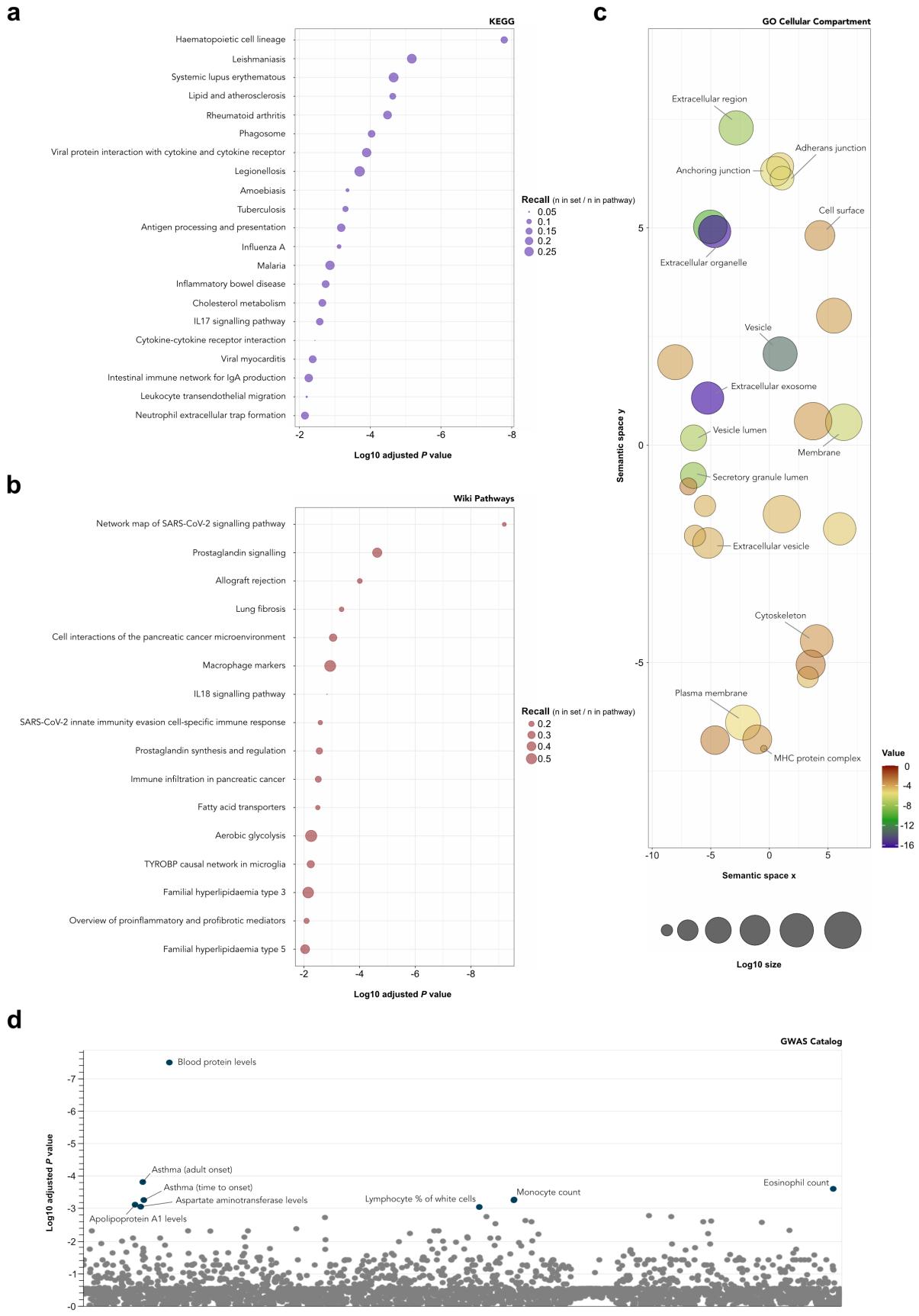


Figure 5: Functional enrichment. (a) Significantly enriched KEGG terms ($P < 0.01$) for prioritised genes. Terms size proportional to recall. (b) Significantly enriched WikiPathways terms ($P < 0.01$) for prioritised genes. Terms size proportional to recall. (c) Scatter plot of the semantic similarity between significantly enriched GO cellular component terms for prioritised genes (d) Manhattan plot of the overenrichment of prioritised genes against the GWAS catalog.

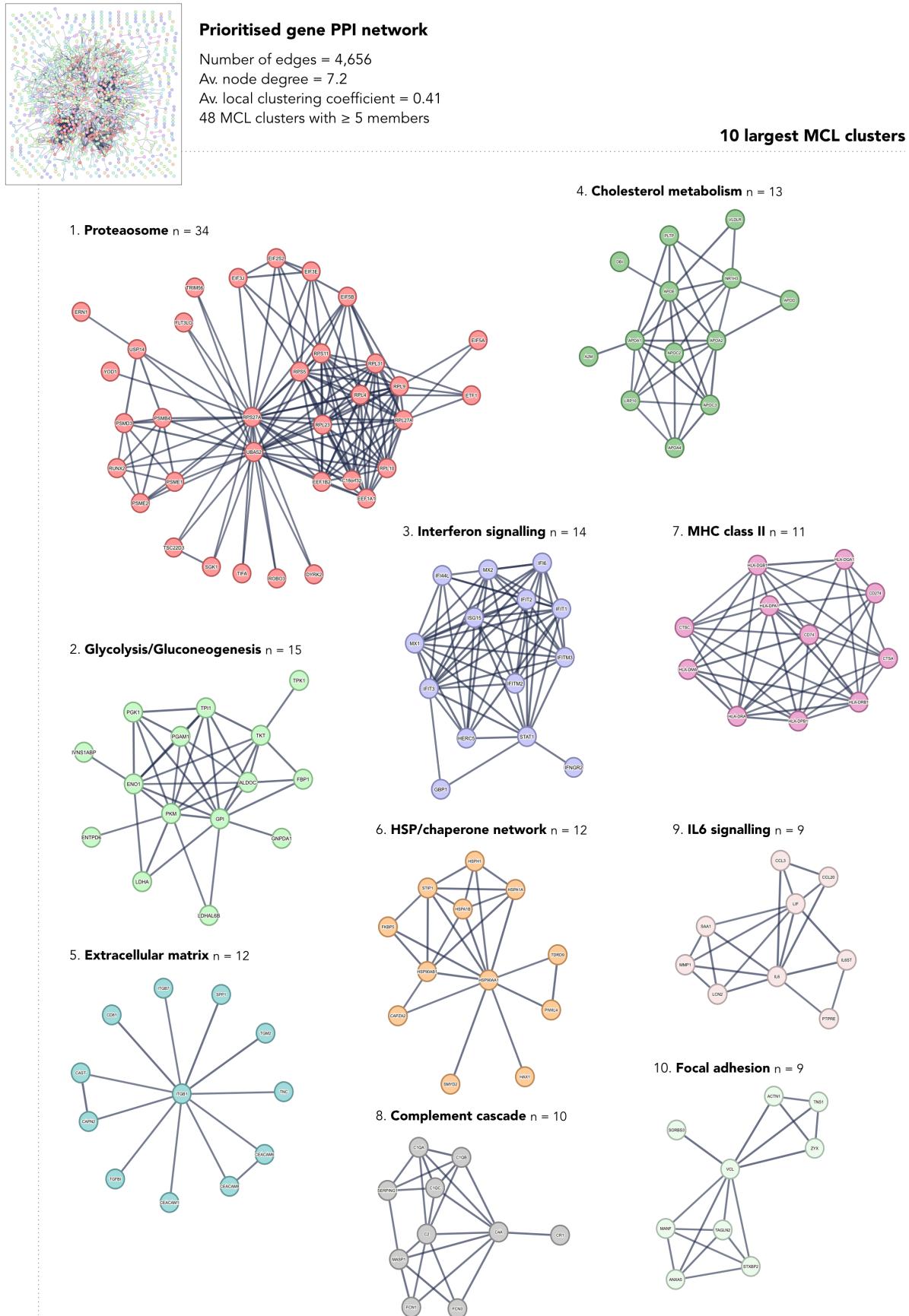


Figure 6: PPI clusters. A protein-protein interaction network of prioritised genes and the 10 largest graph-based clusters. Functional annotation by hand based on a concensus of enriched Reactome, KEGG, WikiPathways, and GO Biological Process terms.

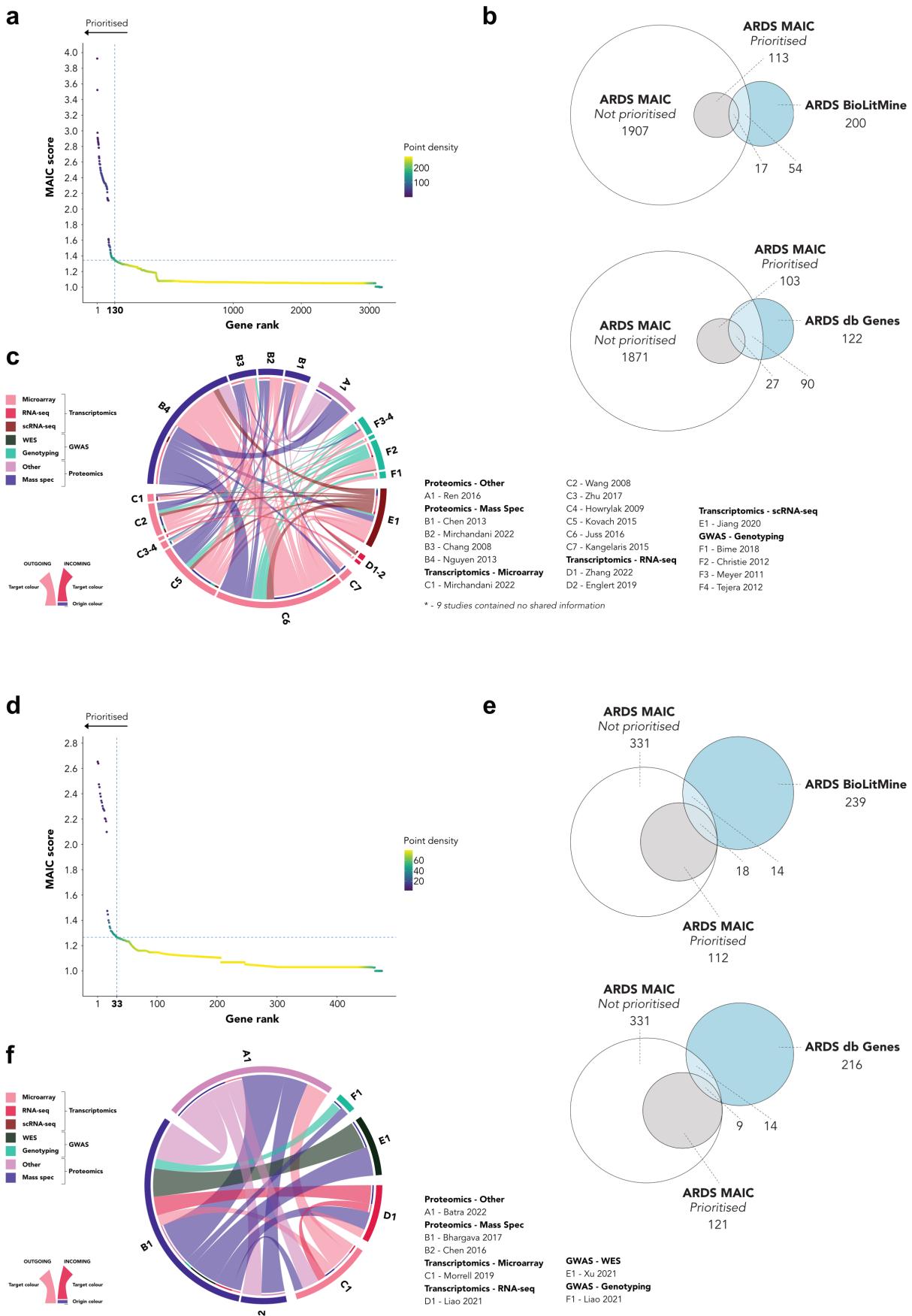


Figure 7: Details of MAIC on sub-groups. (a) Gene prioritisation for the ARDS MAIC ARDS vs. non-ARDS controls sub-group using the Unit Invariant Knee method. Intersection of lines identifies elbow point of best-fit curve. 130 genes in upper left quadrant were prioritised. (b) Euler diagrams of gene overlap between the ARDS vs. non-ARDS controls sub-group and a BioLitMine search using the ARDS MeSH term and the ARDS Database of Genes. (c) Shared information content (IC) between ARDS vs. non-ARDS controls gene lists. Links indicate absolute IC (sum of common gene scores) between studies. (d) Gene prioritisation for the ARDS MAIC survival sub-group using the Unit Invariant Knee method. Intersection of lines identifies elbow point of best-fit curve. 33 genes in upper left quadrant were prioritised. (e) Euler diagrams of gene overlap between the survival sub-group and a BioLitMine search using the ARDS MeSH term and the ARDS Database of Genes. (f) Shared information content (IC) between survival gene lists. Links indicate absolute IC (sum of common gene scores) between studies.

Supplementary Table 1. Gene list information content and contribution.

Study	Method	Category	N genes	rIC (%)	rICtb (%)
Sarma ¹	Transcriptomics	RNA-seq	4954	50.8	53.1
Juss ²	Transcriptomics	Microarray	1318	16	15.7
Sarma ¹	Transcriptomics	scRNA-seq	706	9.8	10.3
Nguyen ³	Proteomics	Mass Spec	161	2.2	2.1
Wang ⁴	Transcriptomics	Microarray	137	1.9	1.9
Bhargava ⁵	Proteomics	Mass Spec	233	3.1	1.9
Kovach ⁶	Transcriptomics	Microarray	123	1.8	1.9
Bhargava ⁷	Proteomics	Mass Spec	144	1.9	1.8
Morrell ⁸	Transcriptomics	Microarray	155	1.9	1.7
Christie ⁹	GWAS	Genotyping	143	1.4	1.5
Liao ¹⁰	GWAS	Genotyping	67	0.7	0.8
Sarma ¹	Proteomics	Other	60	0.8	0.7
Jiang ¹¹	Transcriptomics	scRNA-seq	53	0.7	0.6
Batra ¹²	Proteomics	Other	39	0.6	0.6
Bime ¹³	GWAS	Genotyping	51	0.5	0.5
Bos ¹⁴	Transcriptomics	Microarray	53	0.7	0.5
Chang ¹⁵	Proteomics	Mass Spec	37	0.5	0.5
Mirchandani ¹⁶	Transcriptomics	Microarray	41	0.5	0.4
Mirchandani ¹⁶	Proteomics	Mass Spec	29	0.4	0.4
Liao ¹⁰	Transcriptomics	RNA-seq	43	0.4	0.4
Dong ¹⁷	Proteomics	Mass Spec	27	0.4	0.4
Ren ¹⁸	Proteomics	Other	17	0.3	0.3
Tejera ¹⁹	GWAS	Genotyping	19	0.3	0.3
Howrylak ²⁰	Transcriptomics	Microarray	28	0.3	0.2
Xu ²¹	GWAS	WES	16	0.2	0.2
Chen ²²	Proteomics	Mass Spec	16	0.2	0.2
Zhang ²³	Transcriptomics	RNA-seq	20	0.2	0.2
Kangelaris ²⁴	Transcriptomics	Microarray	15	0.2	0.2
Meyer ²⁵	GWAS	Genotyping	10	0.1	0.1
Martucci ²⁶	Transcriptomics	Microarray	13	0.1	0.1
Zhu ²⁷	Transcriptomics	Microarray	14	0.1	0.1
Englert ²⁸	Transcriptomics	RNA-seq	10	0.1	0.1
Lu ²⁹	Transcriptomics	Microarray	12	< 0.1	< 0.1
Scheller ³⁰	Transcriptomics	RNA-seq	9	< 0.1	< 0.1
Nick ³¹	Transcriptomics	Microarray	4	< 0.1	< 0.1
Guillen-Guio ³²	GWAS	Genotyping	6	< 0.1	< 0.1
Meyer ³³	GWAS	Genotyping	4	< 0.1	< 0.1
Dolinay ³⁴	Transcriptomics	Microarray	4	< 0.1	< 0.1
Chen ³⁵	Proteomics	Mass Spec	16	< 0.1	< 0.1

Study	Method	Category	N genes	rIC (%)	rICtb (%)
Zhang ³⁶	Transcriptomics	RNA-seq	5	< 0.1	< 0.1
Shortt ³⁷	GWAS	WES	3	< 0.1	< 0.1
Bowler ³⁸	Proteomics	Mass Spec	18	< 0.1	< 0.1
Morrell ³⁹	Transcriptomics	Microarray	1	< 0.1	< 0.1

Abbreviations: GWAS - Genome-wide association study; Mass Spec - Mass spectrometry; rIC - Relative information content; rICtb - Relative information contribution; WES - Whole-exome sequencing.

Supplementary Table 2. ARDS MAIC prioritised genes found in common by BioLitMine with >= 2 associated publications.

Publication			MAIC
Gene	count	PubMed IDs	rank
TGFB1	8	30395619, 29083412, 28188225, 27309347, 22034170, 20142324, 16100012, 12654639	225
VEGFA	8	24356493, 23542734, 21797753, 19543148, 19349383, 17289863, 15920019, 15741444	320
IL10	8	32217834, 31936183, 30280795, 28432351, 22033829, 21138342, 18242340, 16585075	1268
SFTPB	6	21128671, 18679120, 16100012, 15190959, 14718442, 12490037	177
IL17A	6	34239039, 32795834, 32651218, 30655311, 26709006, 26002979	1294
PI3	5	28187039, 24617927, 19251943, 19197381, 18203972	2
CXCL8	5	22897124, 22080750, 21348591, 17498967, 14729508	3
IL6	5	34757857, 33250487, 32826331, 31261506, 18593632	144
TNF	5	31261506, 22507624, 21784970, 17034639, 16135717	651
NAMPT	4	24821571, 24053186, 18486613, 17392604	58
IL1RN	4	30095747, 29943912, 23449693, 18838927	175
SCGB1A1	4	32787812, 28548310, 18521628, 16215398	187
NPPB	4	28322314, 26359292, 21696613, 19830720	1239
HGF	3	18065658, 17702746, 11943656	343
IL33	3	33936076, 31147742, 23000728	385
CXCL10	3	31651197, 23542734, 23144331	671
S100A12	2	26274928, 24887223	5
MUC1	2	21418654, 17565019	69
PLAU	2	23064953, 17994220	244
EPAS1	2	28613249, 25574837	425
FASLG	2	30385692, 12414525	503
EDN1	2	27765761, 17875064	643
AKT1	2	27607575, 15961723	950
MMP8	2	24651234, 15187163	1223

Supplementary Table 3. ARDS susceptibility gene list information content and contribution.

Study	Method	Category	N genes	rIC (%)	rICtb (%)
Juss ²	Transcriptomics	Microarray	1318	54.7	54.7
Nguyen ³	Proteomics	Mass Spec	161	8.1	7.7
Christie ⁹	GWAS	Genotyping	143	6	6.3
Kovach ⁶	Transcriptomics	Microarray	123	5.8	6.1
Wang ⁴	Transcriptomics	Microarray	137	5.8	6
Jiang ¹¹	Transcriptomics	scRNA-seq	53	2.9	3
Bime ¹³	GWAS	Genotyping	51	2.2	2.3
Mirchandani ¹⁶	Transcriptomics	Microarray	41	1.7	1.6
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Ren ¹⁸	Proteomics	Other	17	1	1.1
Tejera ¹⁹	GWAS	Genotyping	19	0.9	1
Chen ³⁵	Proteomics	Mass Spec	16	0.9	0.9
Zhang ²³	Transcriptomics	RNA-seq	20	0.8	0.9
Zhu ²⁷	Transcriptomics	Microarray	14	0.6	0.6
Kangelaris ²⁴	Transcriptomics	Microarray	15	0.7	0.6
Englert ²⁸	Transcriptomics	RNA-seq	10	0.6	0.6
Lu ²⁹	Transcriptomics	Microarray	12	0.5	0.5
Meyer ²⁵	GWAS	Genotyping	10	0.4	0.4
Bowler ³⁸	Proteomics	Mass Spec	18	0.9	0.4
Scheller ³⁰	Transcriptomics	RNA-seq	9	0.4	0.3
Guillen-Guio ³²	GWAS	Genotyping	6	0.2	0.2
Zhang ³⁶	Transcriptomics	RNA-seq	5	0.2	0.2
Dolinay ³⁴	Transcriptomics	Microarray	4	0.2	0.2
Shortt ³⁷	GWAS	WES	3	0.1	0.1
Meyer ³³	GWAS	Genotyping	4	< 0.1	0.1
Morrell ³⁹	Transcriptomics	Microarray	1	< 0.1	< 0.1

Abbreviations: GWAS - Genome-wide association study; Mass Spec - Mass spectrometry; rIC - Relative information content; rICtb - Relative information contribution; WES - Whole-exome sequencing.

Supplementary Table 4. ARDS survival/severity gene list information content and contribution.

Study	Method	Category	N genes	rIC (%)	rICtb (%)
Bhargava ⁷	Proteomics	Mass Spec	144	30.4	30.3
Morrell ⁸	Transcriptomics	Microarray	155	29.7	29.7
Liao ¹⁰	GWAS	Genotyping	67	12.9	13
Batra ¹²	Proteomics	Other	39	9.4	9.4
Liao ¹⁰	Transcriptomics	RNA-seq	43	8.5	8.5
Xu ²¹	GWAS	WES	16	3.5	3.5
Chen ²²	Proteomics	Mass Spec	16	3.4	3.4
Lu ²⁹	Transcriptomics	Microarray	12	2.2	2.2

Abbreviations: GWAS - Genome-wide association study; Mass Spec - Mass spectrometry; rIC - Relative information content; rICtb - Relative information contribution; WES - Whole-exome sequencing.

Supplementary Data

Supplementary Data Files 1-8

Supplementary Data File 1. Raw gene list input to MAIC.

https://github.com/JonathanEMillar/ards_maic_manuscript/Supplementary_Data_File_1.csv

Supplementary Data File 2. MAIC output - overall.

https://github.com/JonathanEMillar/ards_maic_manuscript/Supplementary_Data_File_2.csv

Supplementary Data File 3. BioLitMine and ARDS Database of Genes results.

https://github.com/JonathanEMillar/ards_maic_manuscript/Supplementary_Data_File_3.csv

Supplementary Data File 4. MAIC output - ARDS vs. non-ARDS controls sub-group.

https://github.com/JonathanEMillar/ards_maic_manuscript/Supplementary_Data_File_4.csv

Supplementary Data File 5. MAIC output - survival sub-group.

https://github.com/JonathanEMillar/ards_maic_manuscript/Supplementary_Data_File_5.csv

Supplementary Data File 6. Functional enrichment results - overall.

https://github.com/JonathanEMillar/ards_maic_manuscript/Supplementary_Data_File_6.csv

Supplementary Data File 7. Functional enrichment results - ARDS vs. non-ARDS controls sub-group.

https://github.com/JonathanEMillar/ards_maic_manuscript/Supplementary_Data_File_7.csv

Supplementary Data File 8. Functional enrichment results - survival sub-group.

https://github.com/JonathanEMillar/ards_maic_manuscript/Supplementary_Data_File_8.csv

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