Assessing the Impact of Changes to Guidance on Evacuation from Fire in Multi-Occupancy High-rise Residential Buildings

Gwynne, Spearpoint, Templeton, Arnott, Xie, Nash, Ramsden

Fire and Evacuation Modeling Technical Conference, September 12-14, 2022

Two year, UK-government funded effort to identify how current guidance (Approved Document B) that focuses on physical structure might affect egress performance.

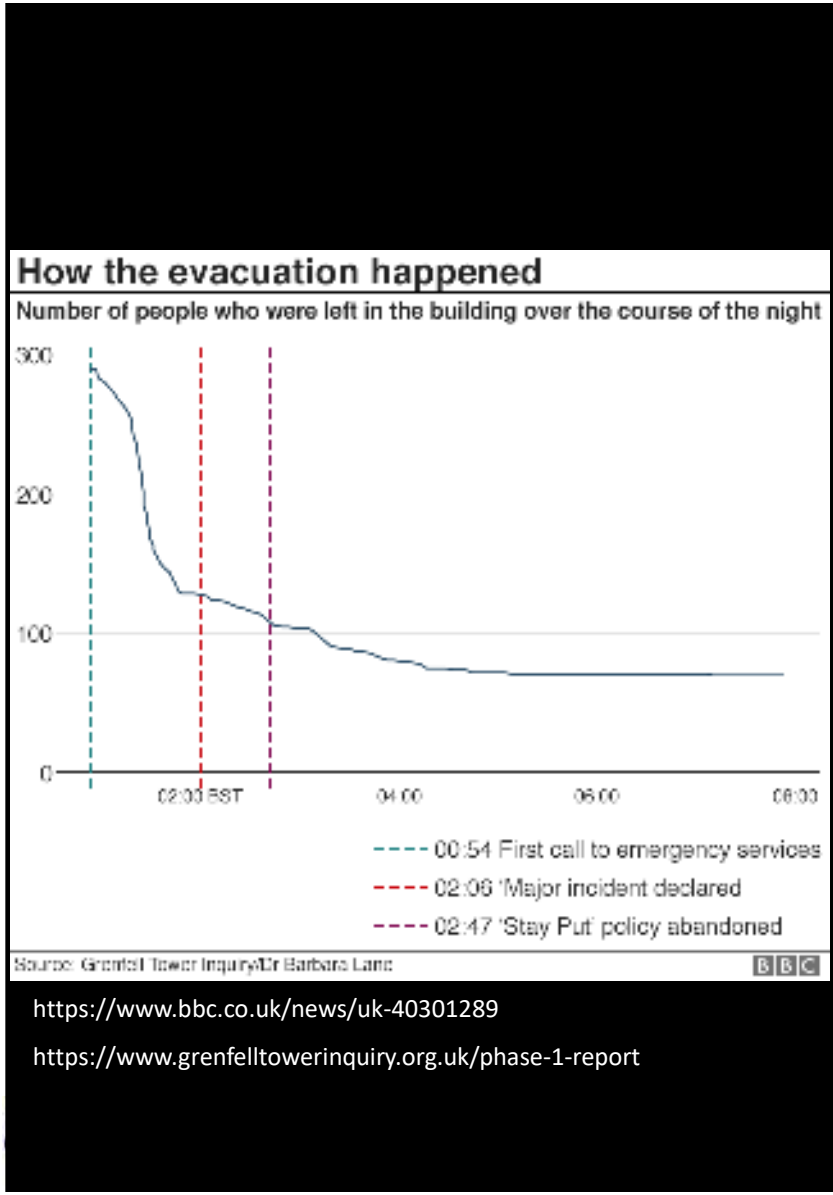
- 24 storey residential block in West London.
- Fire broke out in June 2017.
- 72 fatalities, approximately, 250 survivors.
- Fire caused by electrical fault on fourth storey.
- Fire spread across exterior via cladding / external insulation.

OFR FIRE & RISK CONSULTANTS

movement strategies
A GHD company

THE UNIVERSITY of EDINBURGH
School of Engineering

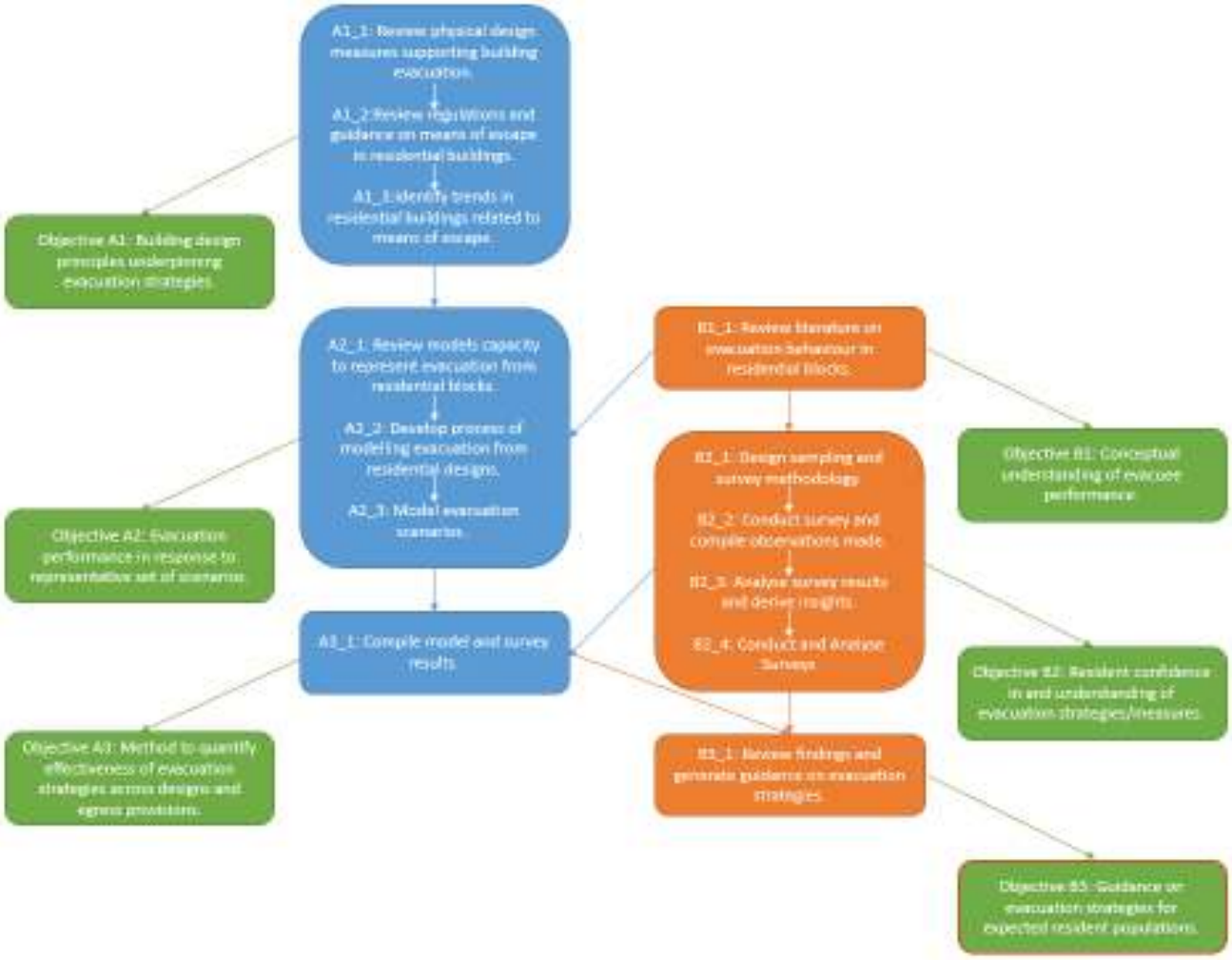
- 24 storey residential block in West London.
- Fire broke out in June 2017.
- 72 fatalities, approximately, 250 survivors.
- Fire caused by electrical fault on fourth storey.
- Fire spread across exterior via cladding / external insulation.
- Delayed evacuation.
- Delayed revocation of stay put policy.



https://www.bbc.co.uk/news/uk-40301289

https://www.grenfelltowerinquiry.org.uk/phase-1-report

OFR movement strategies THE UNIVERSITY of EDINBURGH School of Engineering



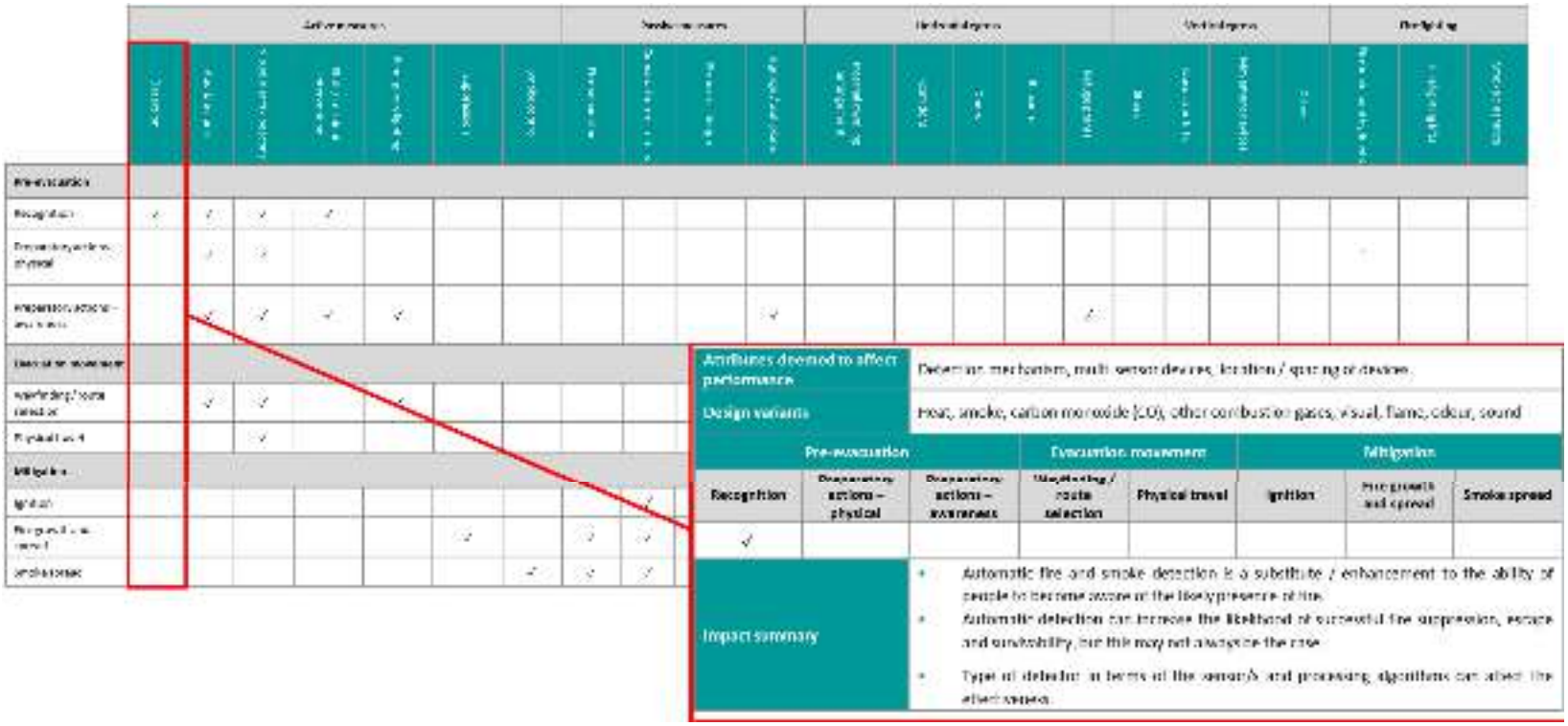
- Objective A
  - Establish building design principles underpinning evacuation strategies
  - Quantify evacuation performance in response to representative set of scenarios
  - Develop method to quantify effectiveness of evacuation strategies
- Objective B
  - Establish understanding of expected resident performance during evacuation and influential factors
  - Determine occupant understanding of evacuation strategies/fire safety measures, confidence in protection, risk perception and response
  - Guidance on evacuation strategy benefits for expected resident populations.

Using performance-based approaches to assess prescriptive guidance.

OFR movement strategies THE UNIVERSITY of EDINBURGH School of Engineering Efectis UCL

Task A1_1: Review physical design measures supporting building evacuation

- Mostly, **physical design measures** affect means of escape appear in building guidance.
- Design measures might be specifically for fire safety but also for other reasons; e.g. acoustics, energy use, access provisions, structural requirements, living arrangements, etc. These might have unintended consequences) on performance.



OFR · movement strategies · THE UNIVERSITY of EDINBURGH School of Engineering · Efectis · UCL

Task A1_2: Review regulations and guidance.

- Guidance documents and standards reviewed

Document short form	Primary jurisdiction / country	Full document title	Limits
ADB	England	Approved Document B Volume 1: Dwellings (2019)	Limited to common building situations
STH	Scotland	Building Standards Technical Handbook: Domestic (2019)	Only suitable up to 60 m
BS 9991	UK	BS 9991 Fire Safety in the Design, Management and Use of Residential Buildings (2015)	Buildings taller than 50 m should include a qualitative design review (QDR) to BS 7974 and consider performance-based evidence of solutions
NFPA 101	USA	NFPA 101 Life Safety Code (2021)	No limit
C/AS2	New Zealand	Acceptable Solutions for Buildings (2019)	Only suitable for buildings up to 20 storeys, 85 m
IBC	USA ('International')	International Building Code (2018)	No limit
NBC	Canada	National Building Code of Canada (2015)	No limit
NCC	Australia	National Construction Code Volume One, Building Code of Australia (2019)	No limit

- Tall building trigger heights

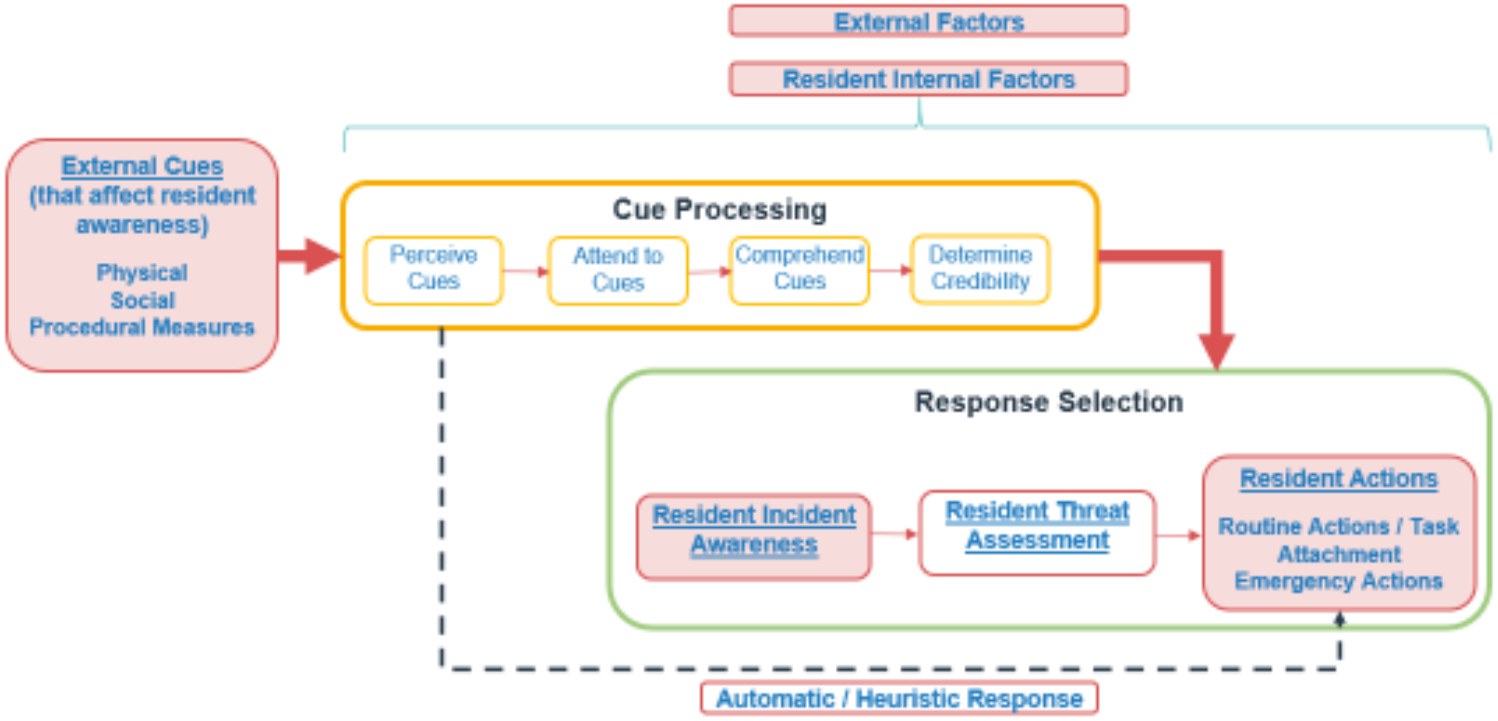
Document	Trigger Height 1	Trigger Height 2	Trigger Height 3
ADB	18 m	30 m	50 m
STH	18 m		
BS 9991	18 m	30 m	50 m
NFPA 101	18 m	23 m	51 m
C/AS2	10 m	25 m	
IBC	18 m	37 m	50 m
NBC	13 m	25 m	
NCC	17 m	25 m	

Obj. A1-3: Current trends in residential buildings

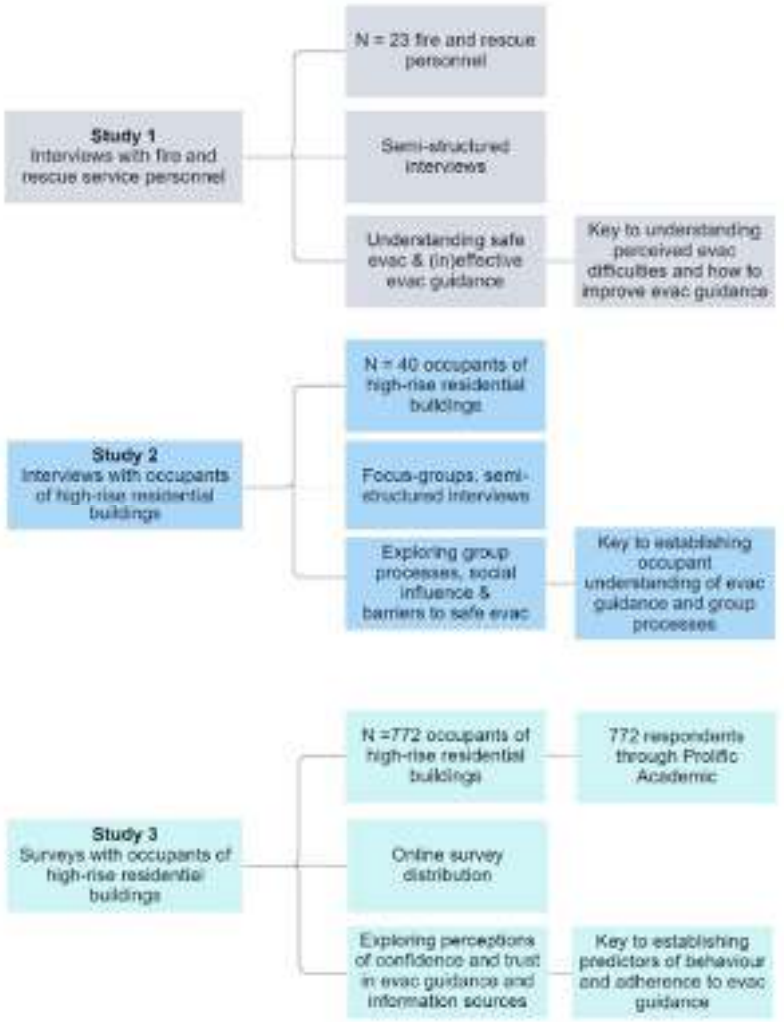
- Interviewed 16 people in 12 one-hour sessions – types of practice, building designs and expectations.
- Review of recent articles in trade publications and the media
- Impact on building evacuation
  - Appropriateness of ‘stay-put’
  - Resident engagement
  - Increase in amenity spaces
  - Modern methods of construction
  - Investor confidence
  - **Resident demographics**

Obj. B1-1: Resident decision-making

- Derived resident decision-making process – from **behavioural statements** – things learned from research literature.
- Simple model to structure elements and **inform scenario design** – and evacuee response (e.g. given information available).



Obj. B2-2: Resident decision-making

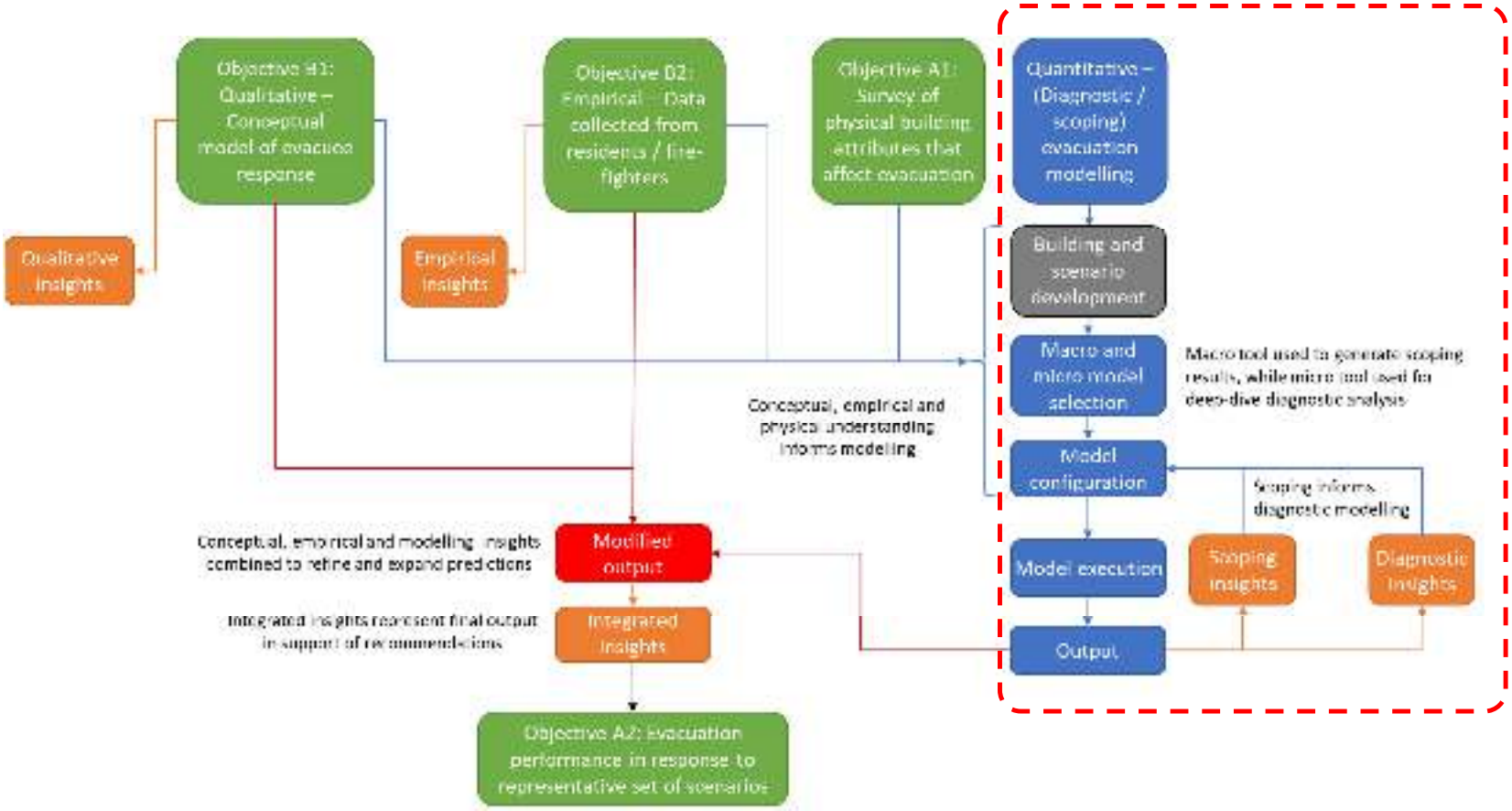


- Participants recruited through Prolific Academic (*N* = 769)
- Inclusion criteria
  - Participants had to be over the age of 18
  - Must currently live in a high rise of 6 or more stories
  - Must have fully completed the survey
  - Must pass survey attention check
- 8% of participants stated they had some form of health condition

Obj. B2-2: Resident decision-making

- Overall, 90% of participants stated they understood what actions were expected of them in the event of a fire.
  - However, **only 59% believed 'staying put' would keep them safe**
  - Only **21% felt that staying put was safer than evacuating**.
- What influenced decisions to stay put?
  - 81 % wanted to evacuate immediately
  - 37% stated they would not want to stay put at all
  - 86% would follow others
  - 98% would follow guidance
  - 99% would follow instructions from FRS
- If participants were aware of a fire in the building
  - 86% would evacuate immediately
  - 51% would be reluctant to stay in place
  - 29% would wait for further information
  - 90% would not continue as normal
  - 92% would prepare to evacuate

Obj. A2: Proposed exemplar building and model selection



Obj. A2: Proposed exemplar building and model selection

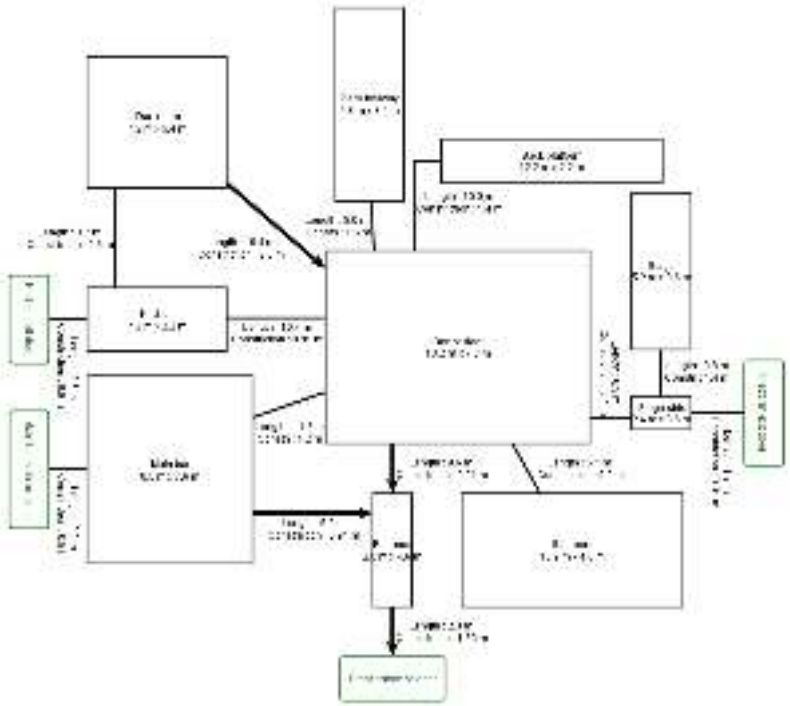
- Building geometries

Building height	Relevant ADB design implications
11 m	The height at which a sprinkler system should be provided in new building construction; and The minimum period of fire resistance is increased to 60 min from 30 min.
18 m	The height at which it is recommended to include a firefighting shaft; and The minimum period of fire resistance is increased to 90 min.
30 m	The minimum period of fire resistance is increased to 120 min.
50 m	n/a

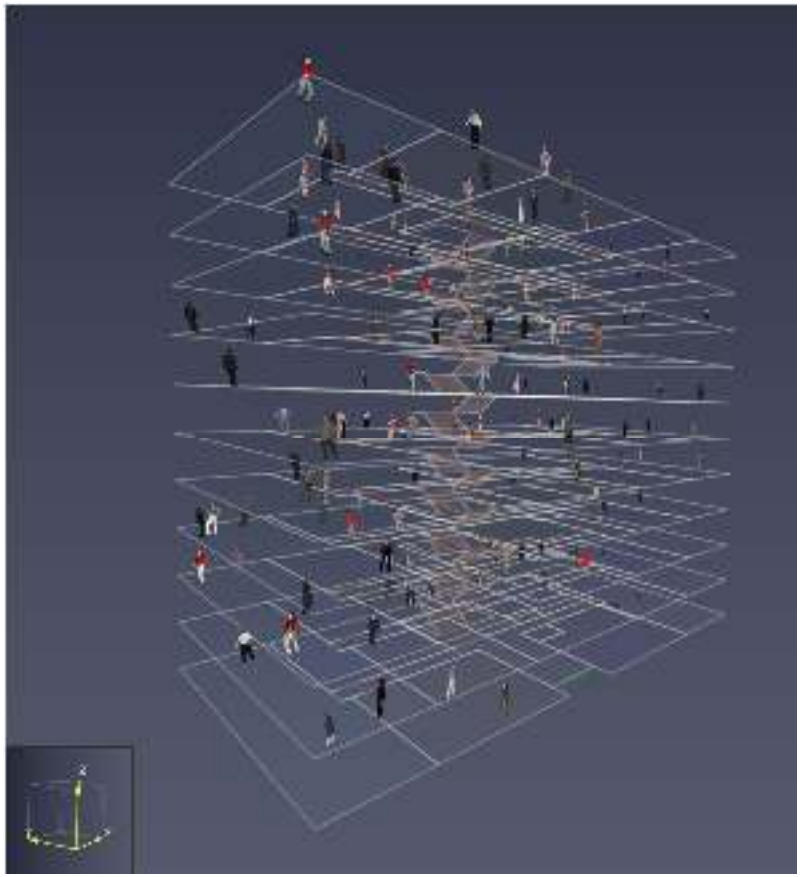
- Amenity spaces
- Warning systems
- Lifts
- Smoke management

Obj. A2: Proposed exemplar building and model selection

- Model A : Evacuationz



- Model B : Pathfinder



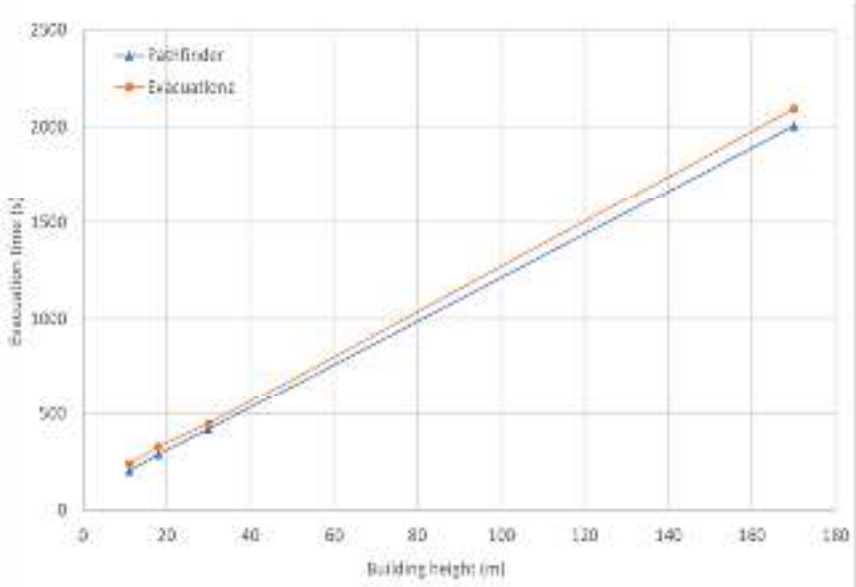
Obj. A2: Scenario variables

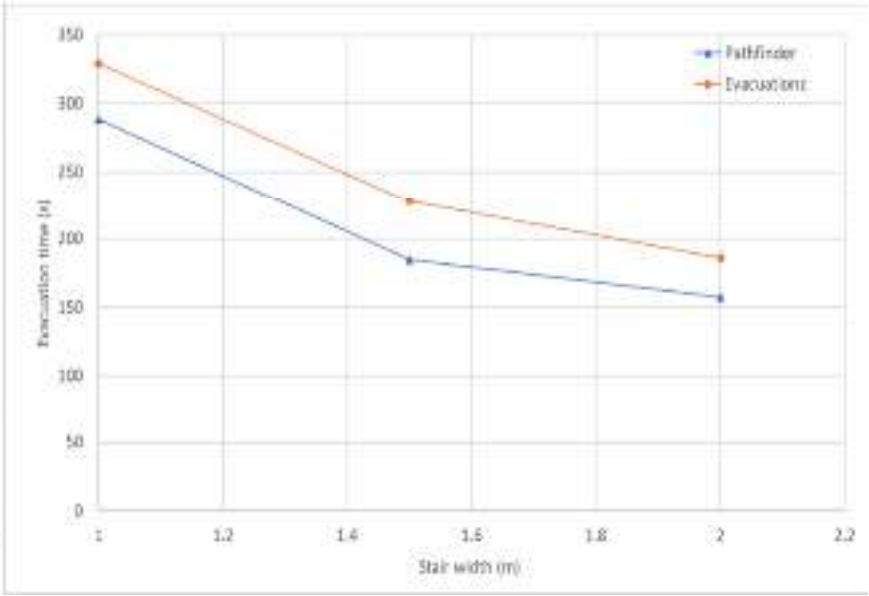
Parameter		Option A	Option B	Option C	Option D
			Event parameters		
1e	**Time of day**	Day	Evening	Night	-
	Impact on Response	*Baseline case*	*Baseline*	P-E↑↑	-
2e	**Weather Conditions**	Pleasant	Inclement	-	-
	Impact on Response	*Baseline case*	P-E↑ TS↓	-	-
3e	**Fire location**	Lower	Mid	Upper	-
	Impact on Response	Population potentially affected by fire and evacuation procedure			
4e	**Fire impact**	Flat of origin (FToO)	Floor of origin (FRoO)	Stair	-
	Impact on Response	*Baseline case* TS↓↓ (FToO) P-E↓↓ (FToO)	TS↓↓ (FToO/ FRoO) RA↓ (FToO/ FRoO) RU↓ (FToO/ FRoO)	TS↓↓ (FToO/FRoO/ AdjStair) RA↓ (FToO/FRoO/ AdjStair)	-
1b	**Building he**				
2b	**No. of Stair**				
	Impact on				
3b	**Stair width**				
4b	**Corridor ler**				
5b	**Amenity sp**				
1p	**Means of w**				
	Impact on				
2p	**Evacuation**				
	Impact on				
3p	**Evacuation**				
	Impact on				

Parameter		Option A	Option B	Option C	Option D
			Occupant parameters		
1o	**No. of residents**	*Baseline case* Maximum	Distribution	-	-
2o	**No. of visitors**	*Baseline case* Maximum	None	-	-
3o	**Demographics**	Optimistic	Representative	-	-
	Impact on Response	*Baseline*	P-E↑ TS↓	-	-
4o	**Population location**	In flats	Flats / amenity spaces	-	-
	Impact on Response	*Baseline*	No occupant in communal space will be asleep (P-E↓) OT↑ (e.g., return to flat)	-	-
		Affects sub-populations exposed to smoke conditions			

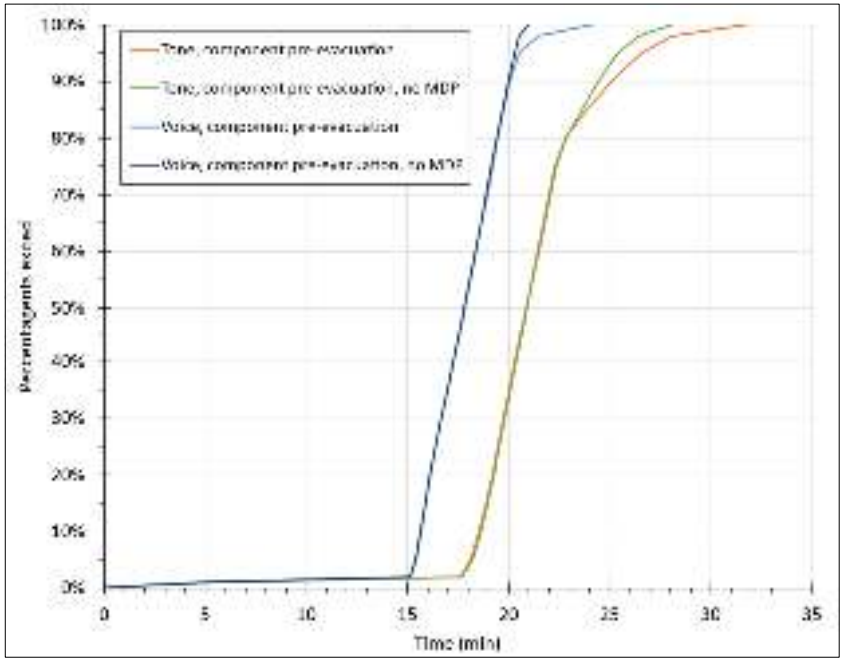
Level of impairment	Status	Implied Pre-Evacuation Time (s)				
		Voice	Tone/Bell	Person	FRS	Smoke Cues
Impaired	Asleep	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Awake	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Unimpaired	Asleep	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Awake	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Example Results: Model Comparison





Example Results: Design Analysis



Movement Capabilities	Building configuration	Total evacuation time (min)			
		Immediate	Tone	Voice	Reliant on inter-resident communication
No sub-population require assistance.	One stair	14.8	28.2	21.0	27.4
5% sub-population require assistance.	One stair	17.4	30.9	24.8	29.7

Conclusions / Ongoing Work

- Quantify impact of means of egress (as shaped by current guidance), on evacuation performance from residential towers.
- Using performance-based tools to assess prescriptive guidance. Luxury of research support.
- Will continue modelling the evacuation across the scenarios generated – using the Evacuationz and Pathfinder tools.
- Will derive insights from the survey results to establish resident perceptions of current and future guidance options – to provide insights into possible uptake of future guidance.
- Complete modelling activities to allow quantitative comparisons between intervention strategies / design options to be made.
- Likely completed by end of 2022.