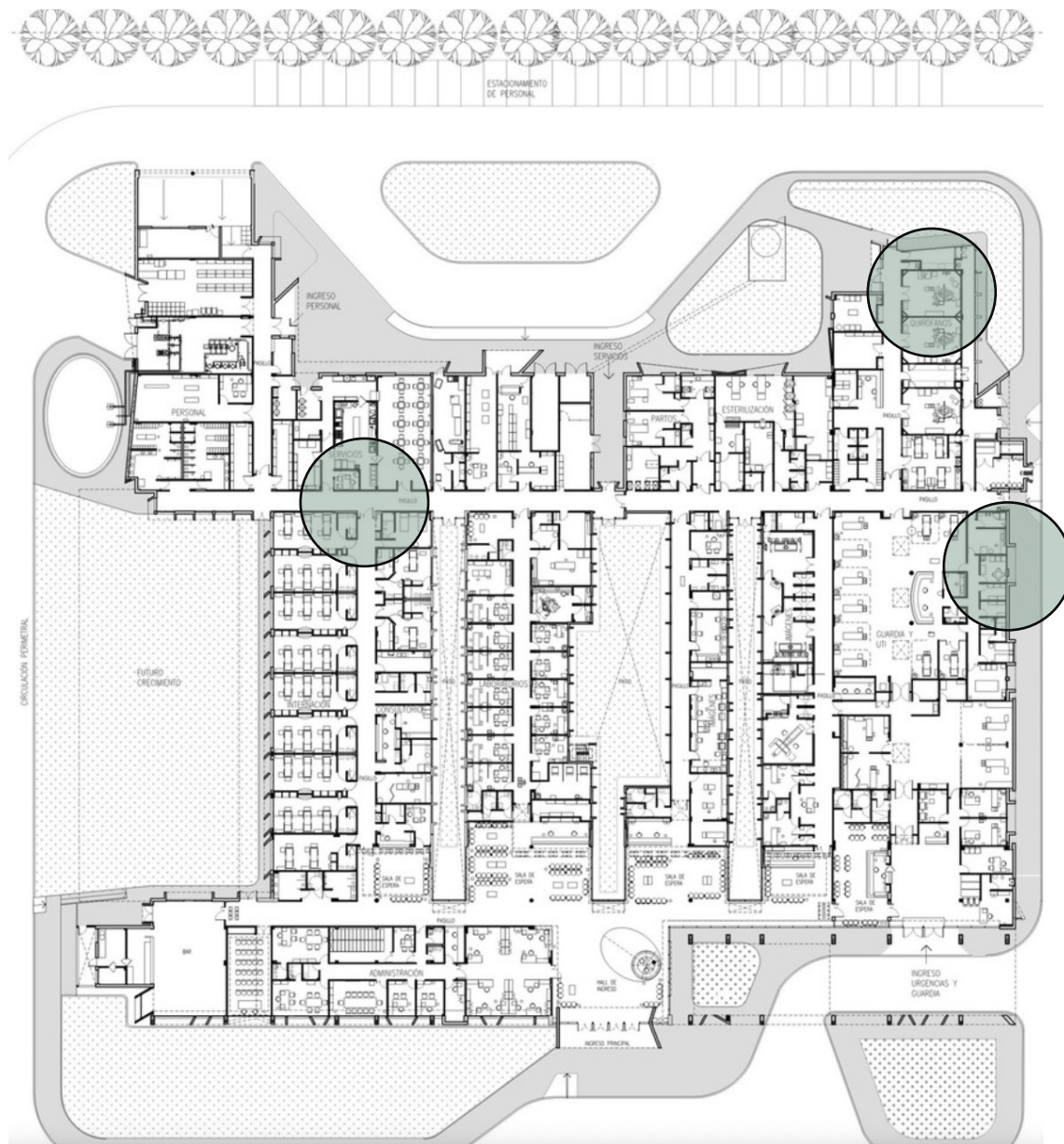


Visualisation tools in hospital real estate

Fieke Noordam
MSc thesis - June 21st 2021







Visualisation tools in hospital real estate

Exploring how the use of visualisation tools enhance stakeholder involvement in hospital (re)construction projects



Content

Introduction

Methodology

Findings

Conclusion

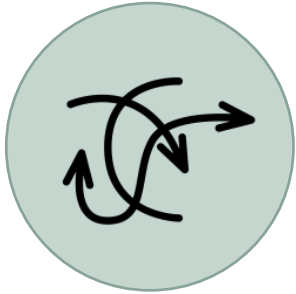
Recommendations

Content



Why?

The (re)construction of hospitals...



Complex processes



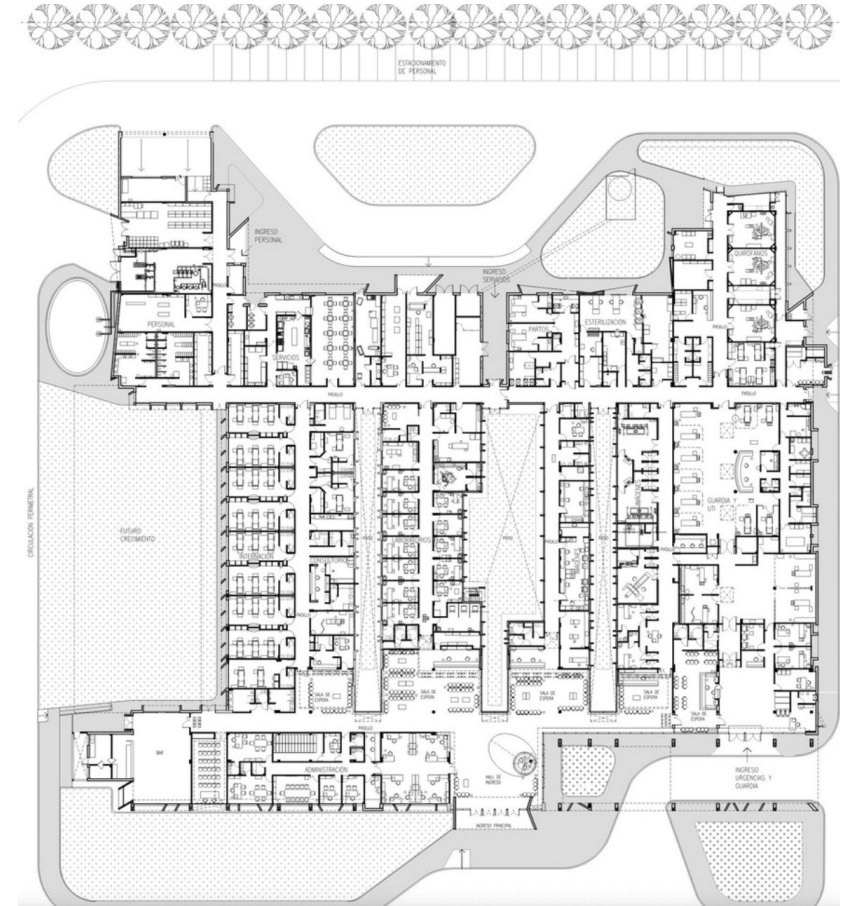
Different users



Different demands

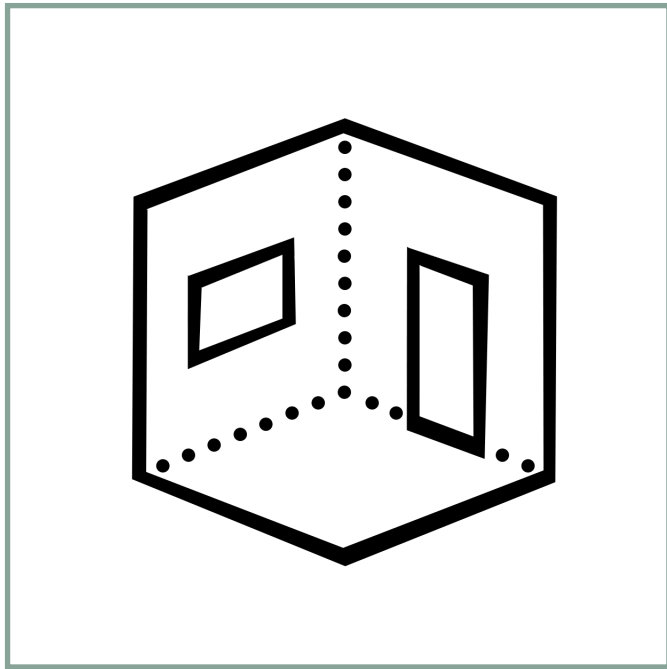
2D floorplans fall short in facilitating...

- Design understanding
- Design communication

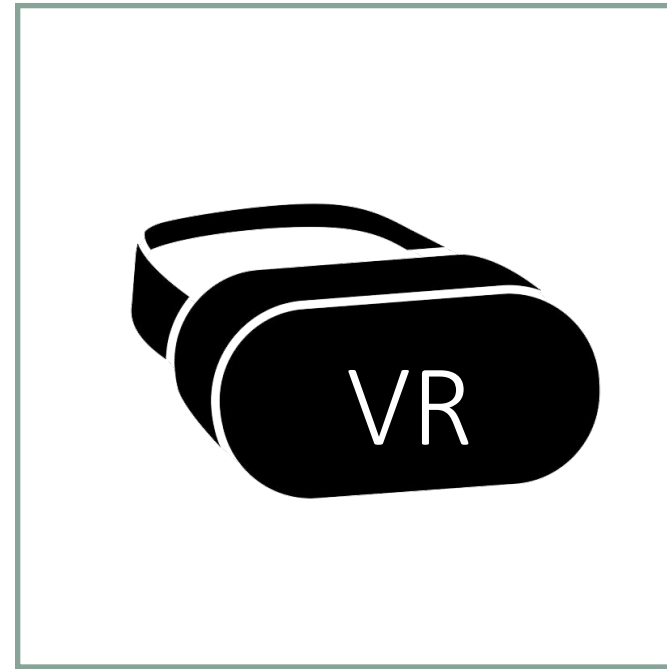


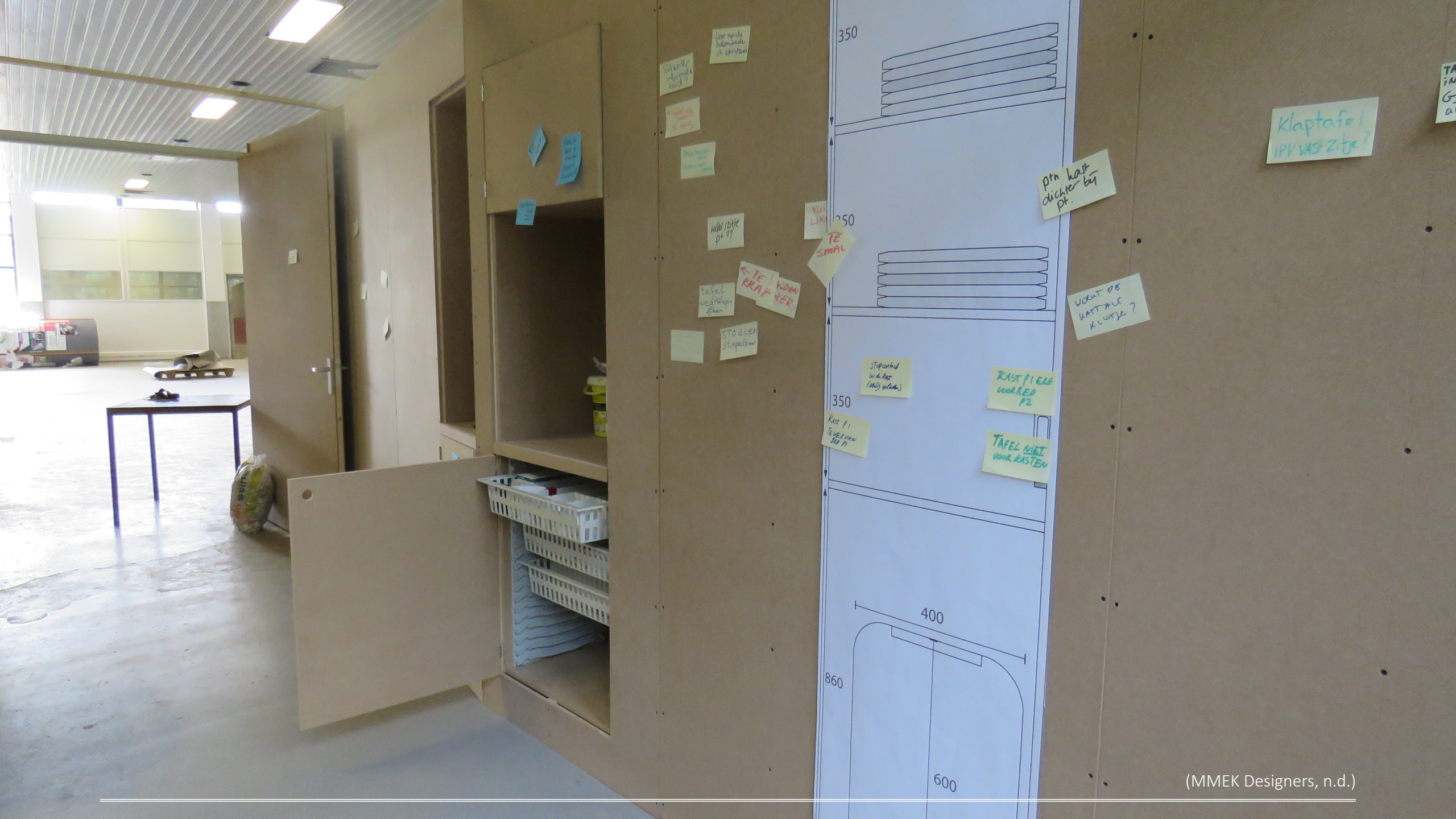
Visualisation tools

Physical mock-up



Virtual visualisation





Klaptafel
IPV vast zijtje?

pin kast
dichter bij
pt.

veruit de
kast als
kluisje?

KAST PIEK
WORKED
P2

TAFEL NIET
VOOR KASTEN

Stapcelheid
in de kast
(nietly geladen)

Kast P1
Teveel van
860 P1

TE
SMAL

← TE
KRAPP
KEER

tafel
wegklap-
baar

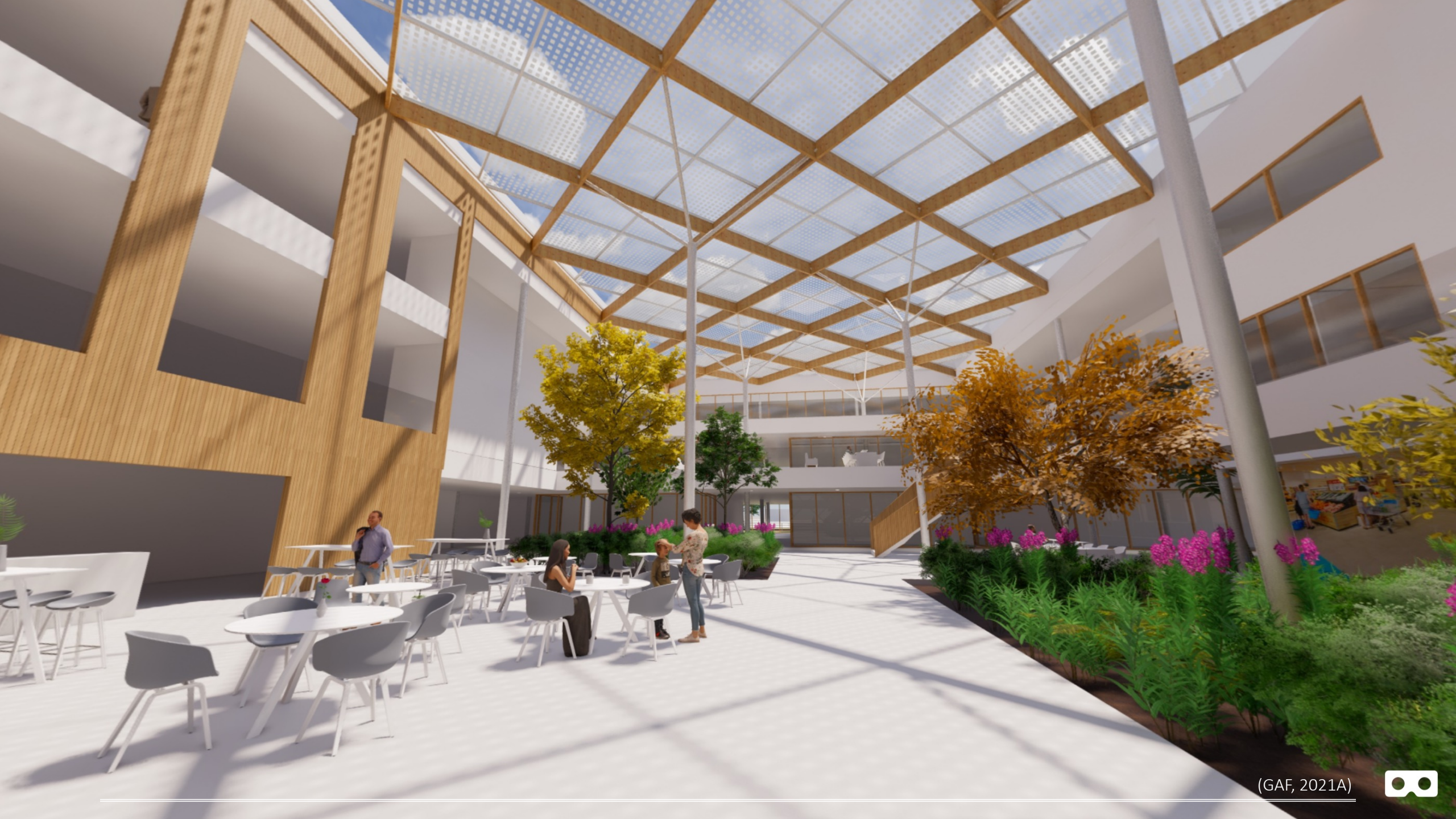
STOelen
stapelbaar

Waar zitje
dit op?

Waar zitje
niet op?

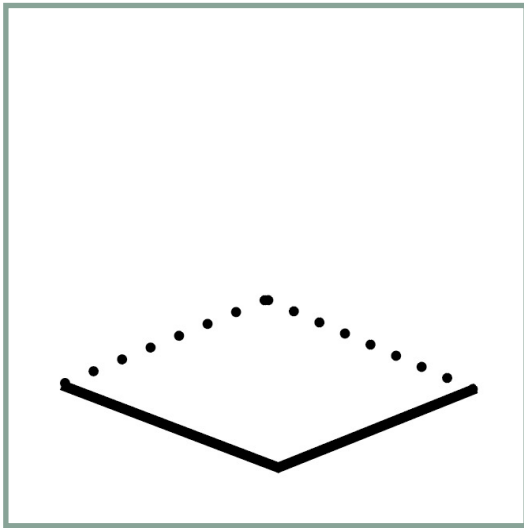
Waar zitje
niet op?

Waar zitje
niet op?

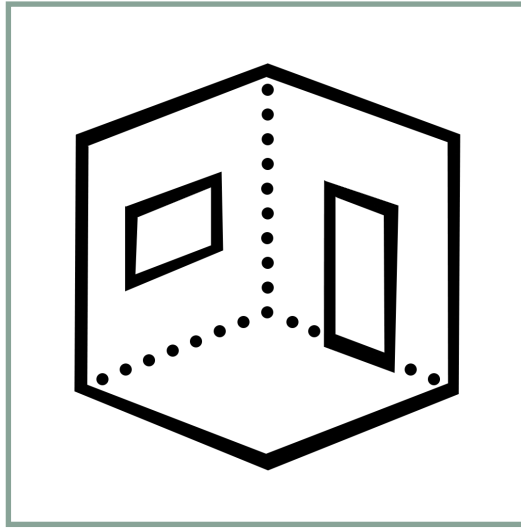


Visualisation tools

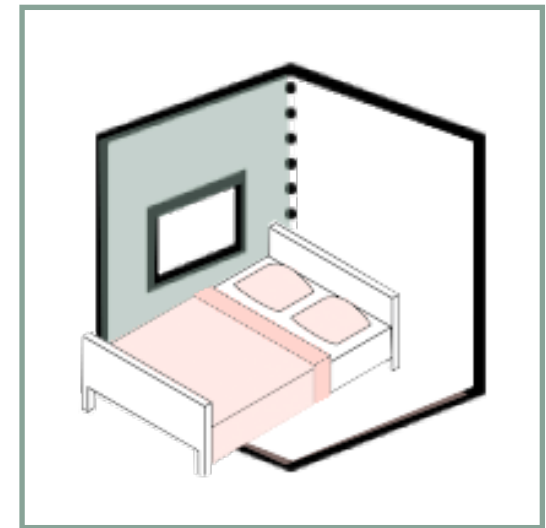
Physical mock-up



Tape



Wood/ Cardboard



Genuine materials



(GAF, 2021B)



(MMEK Designers, n.d.)



(GAF, 2021B)



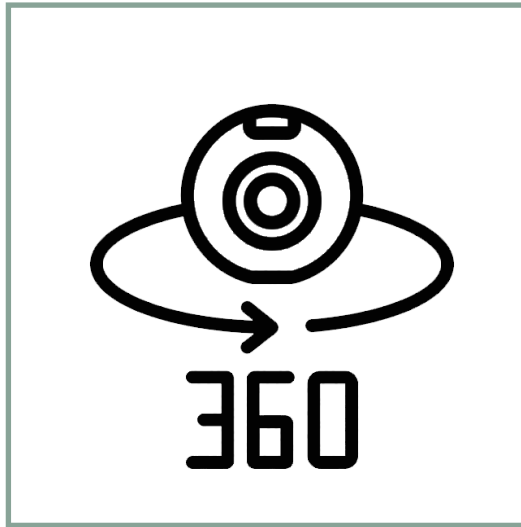
Amsterdam UMC, 2020)

Visualisation tools

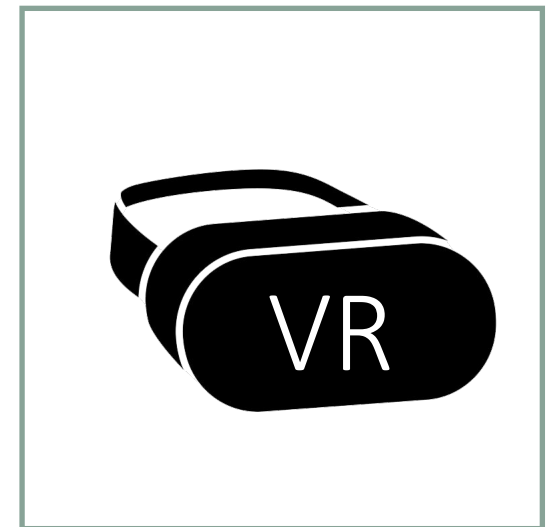
Virtual visualisation



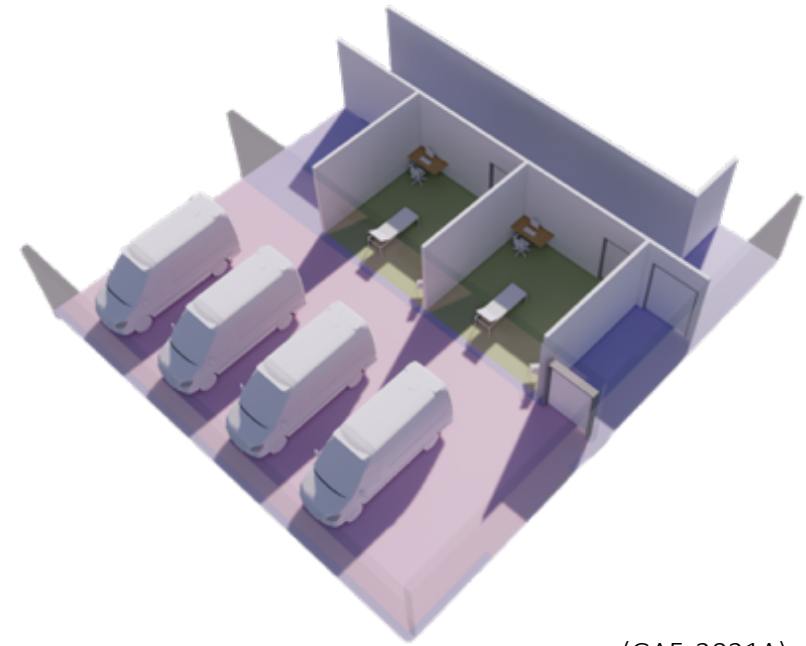
Non-immersive



Semi-immersive



Immersive



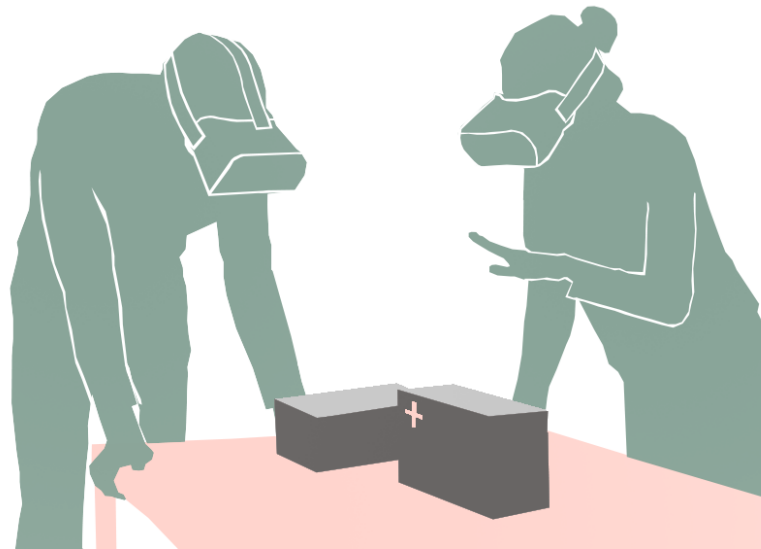
Problem statement

‘There is little known on how visualisation tools are used best to involve stakeholders within hospital (re)construction projects.’

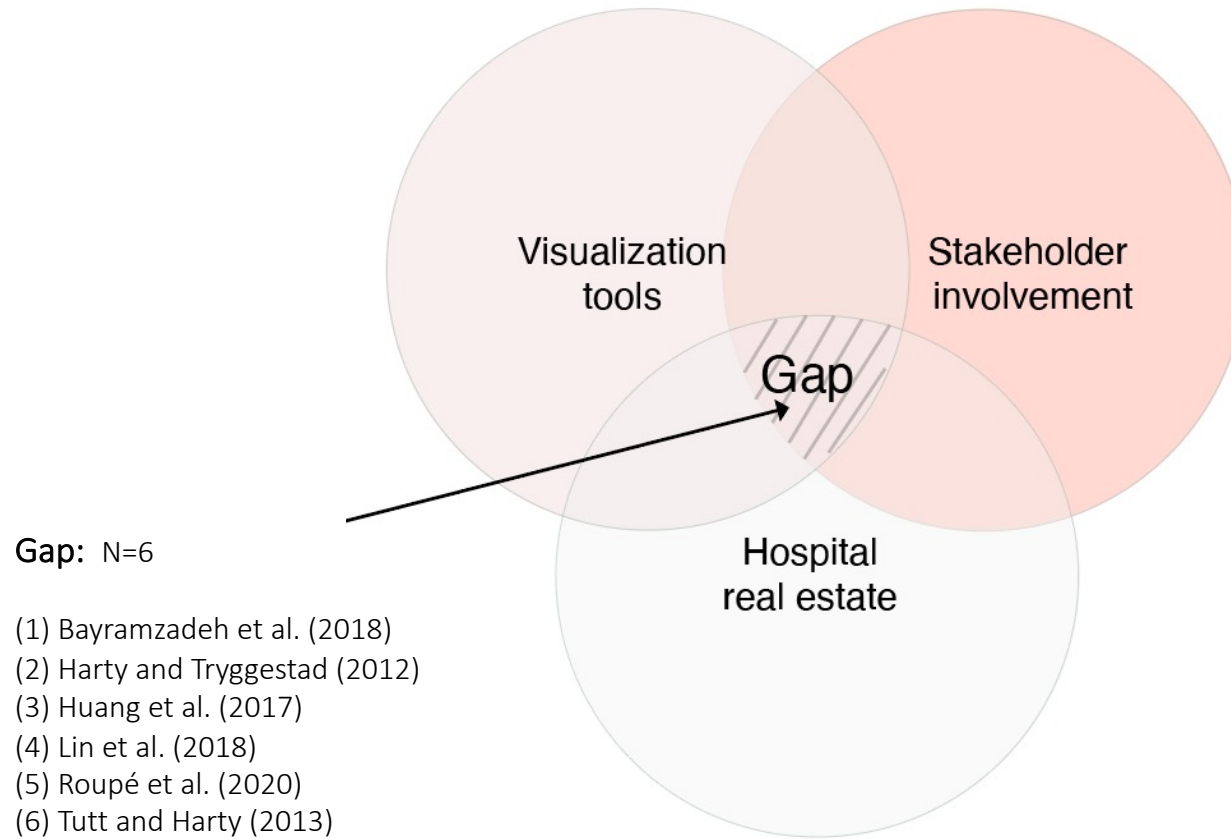


Goal

'Give hospital (re)construction projects and managers insights into how visualisation tools can be used to involve hospital stakeholders and provide them with advice to make this complex task more manageable.'



Knowledge gap



Introduction

Methodology

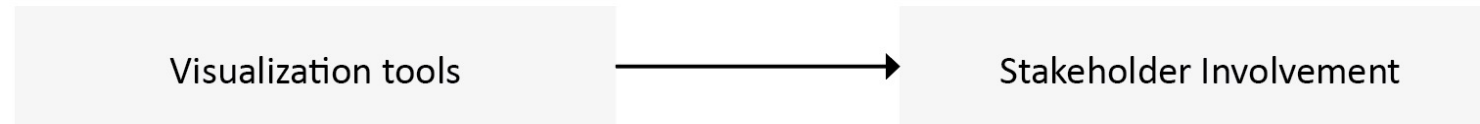
Findings

Conclusion

Recommendations

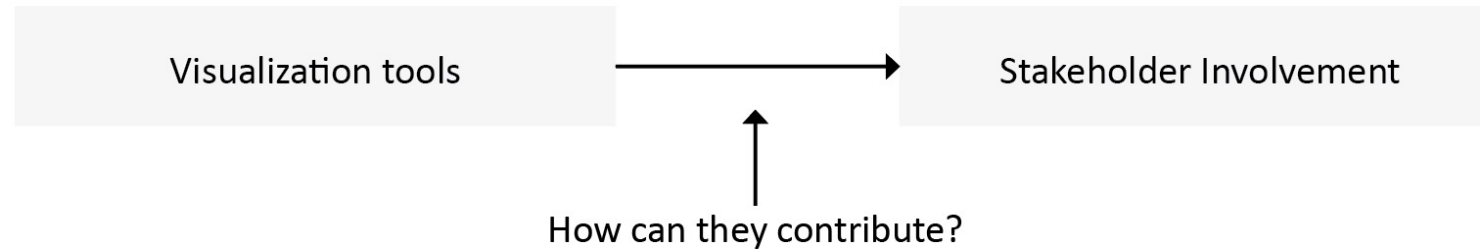
Research question

RQ= How can visualisation tools contribute to the involvement of stakeholders in hospital (re)construction projects?



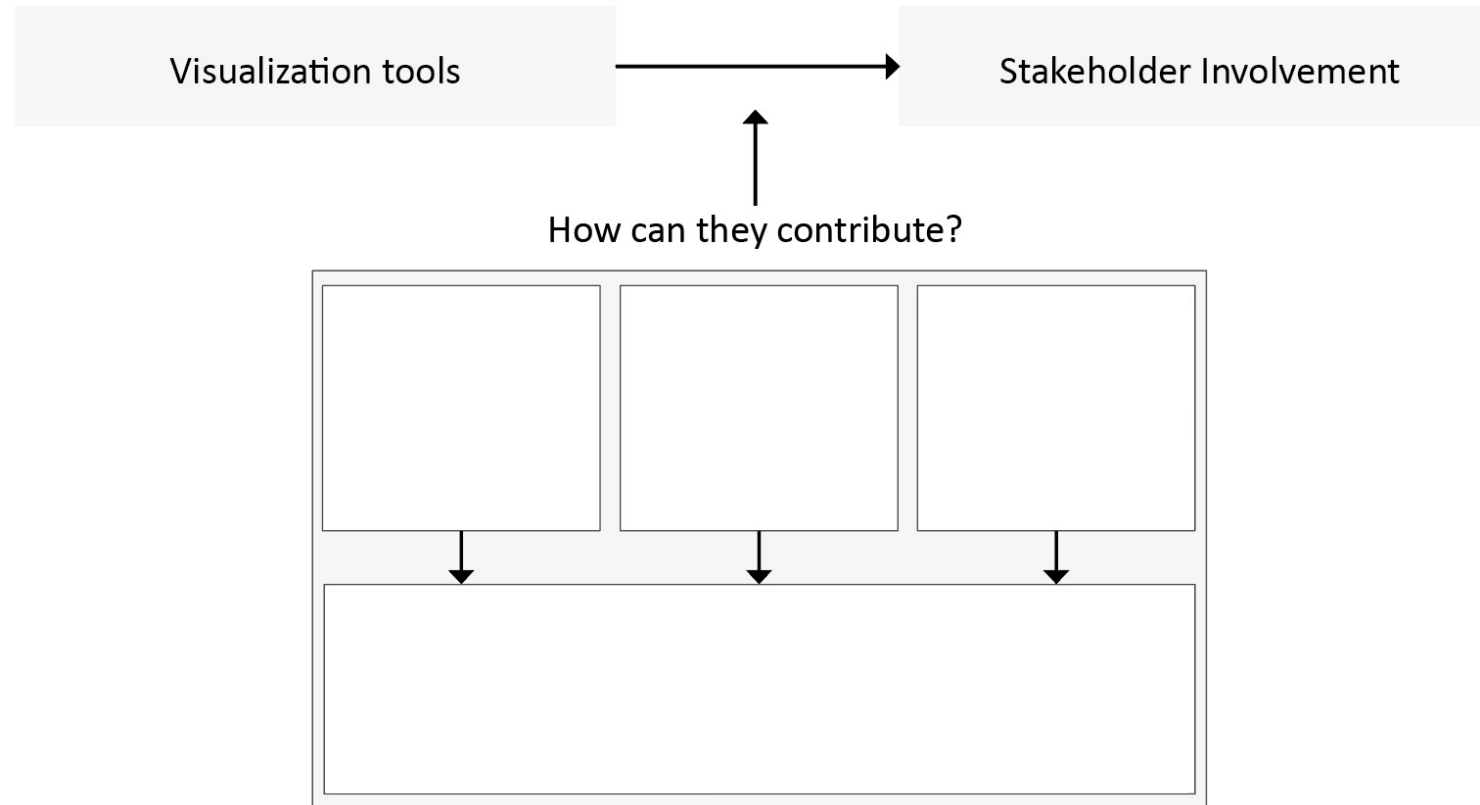
Research question

How can visualisation tools contribute to the involvement of stakeholders in hospital (re)construction project?



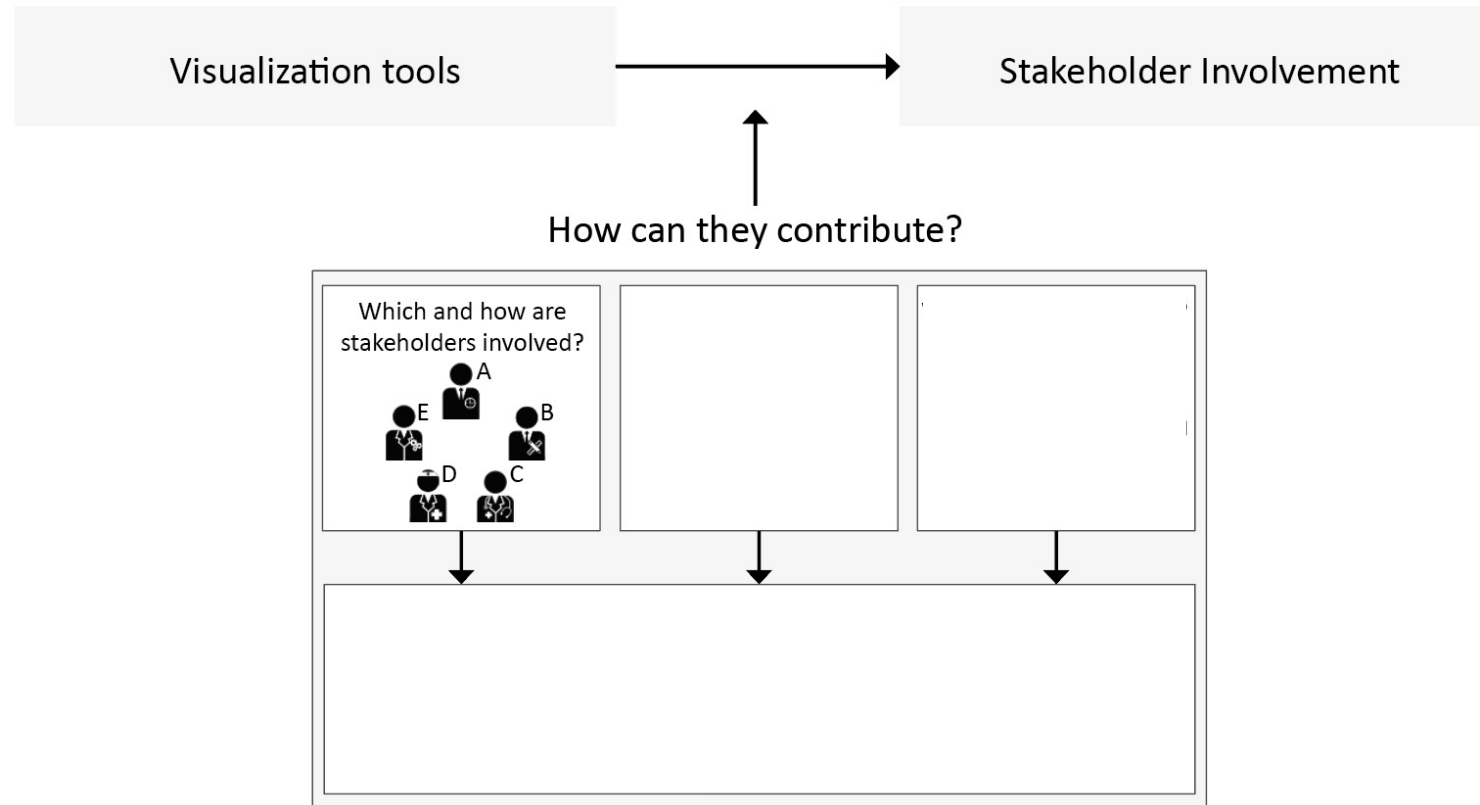
Research question

How can visualisation tools contribute to the involvement of stakeholders in hospital (re)construction project?



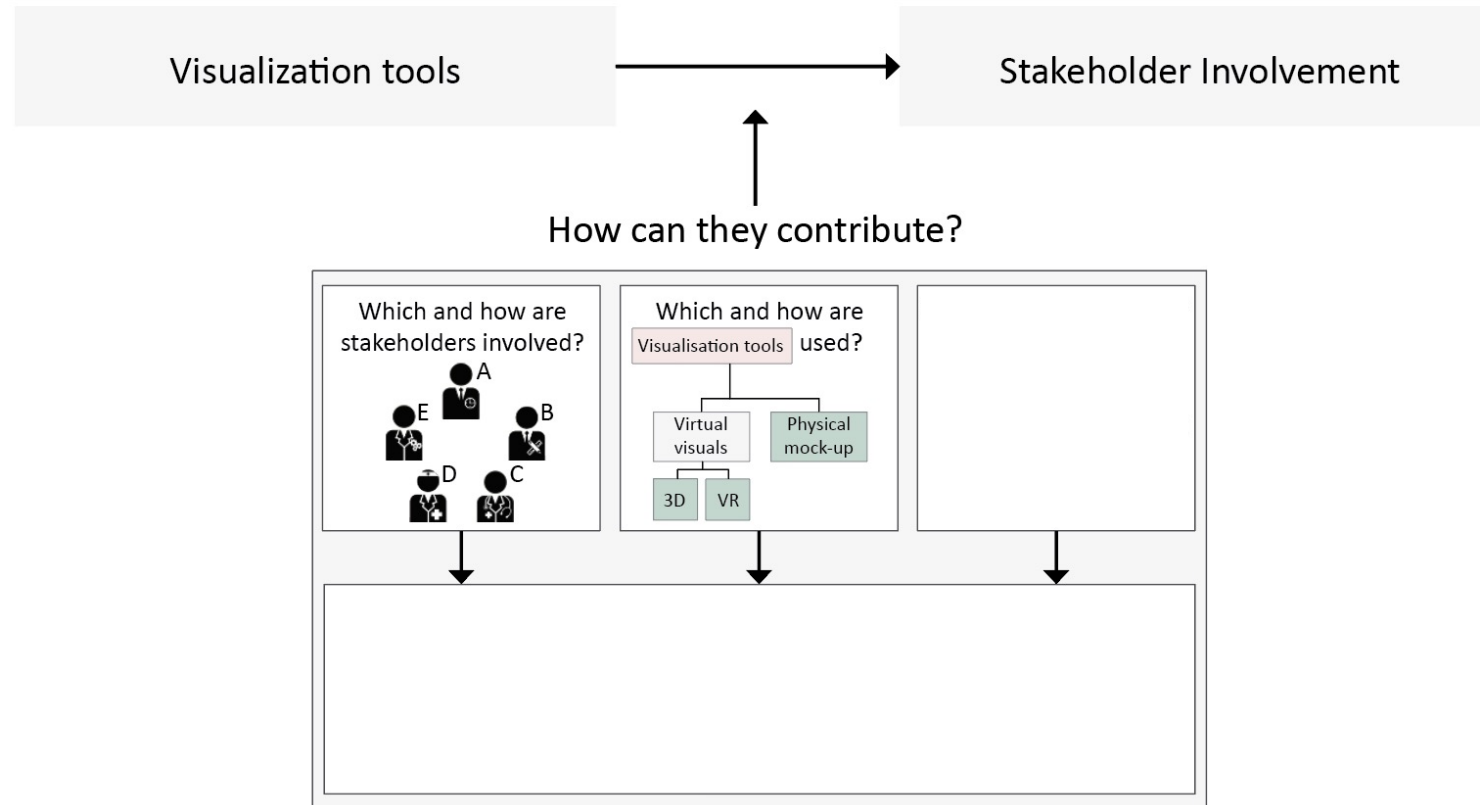
Research question

Question 1: Which stakeholders are involved in hospital (re)construction projects, and how?



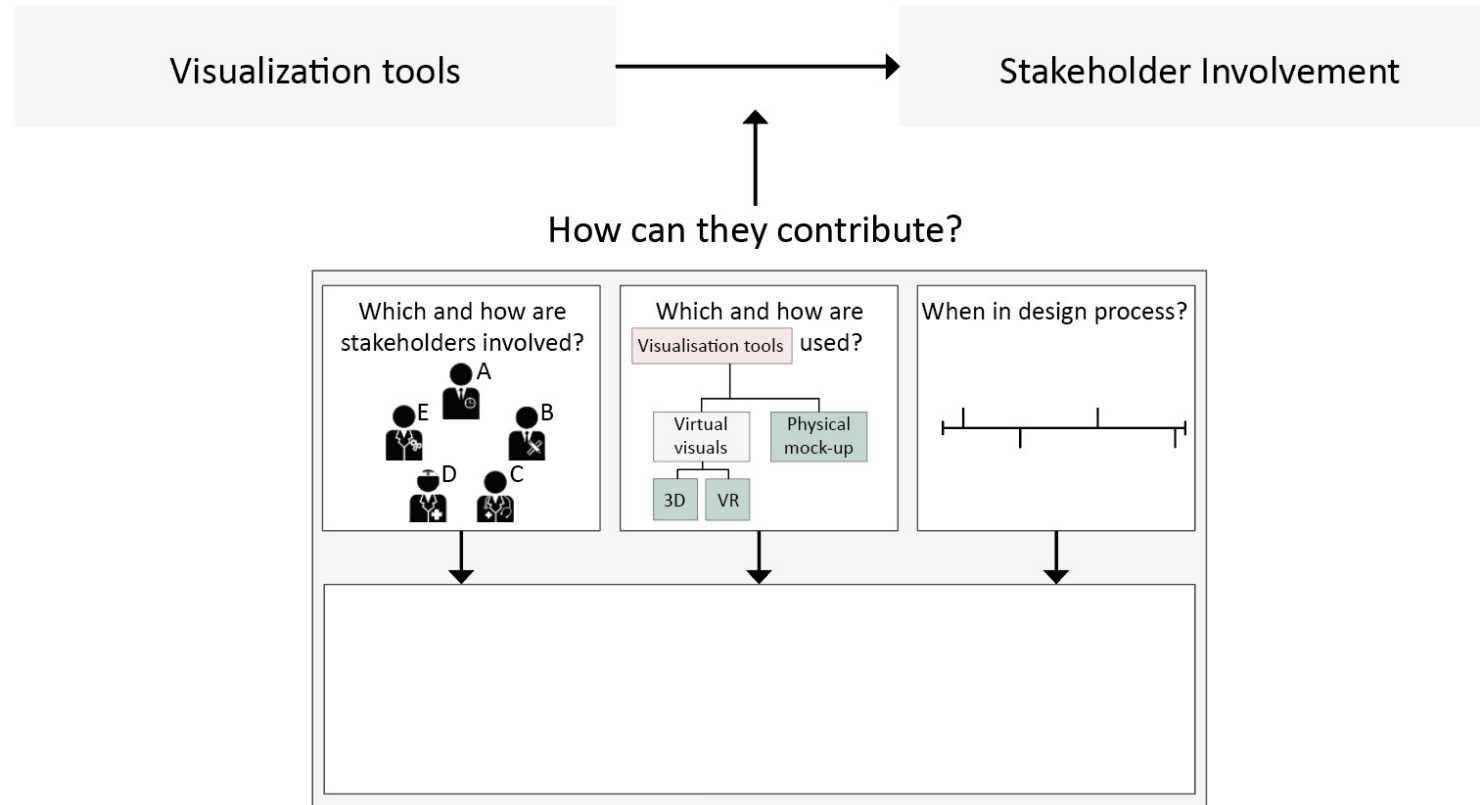
Research question

Question 2: Which visualisation tools are used in hospital (re)construction projects, and how?



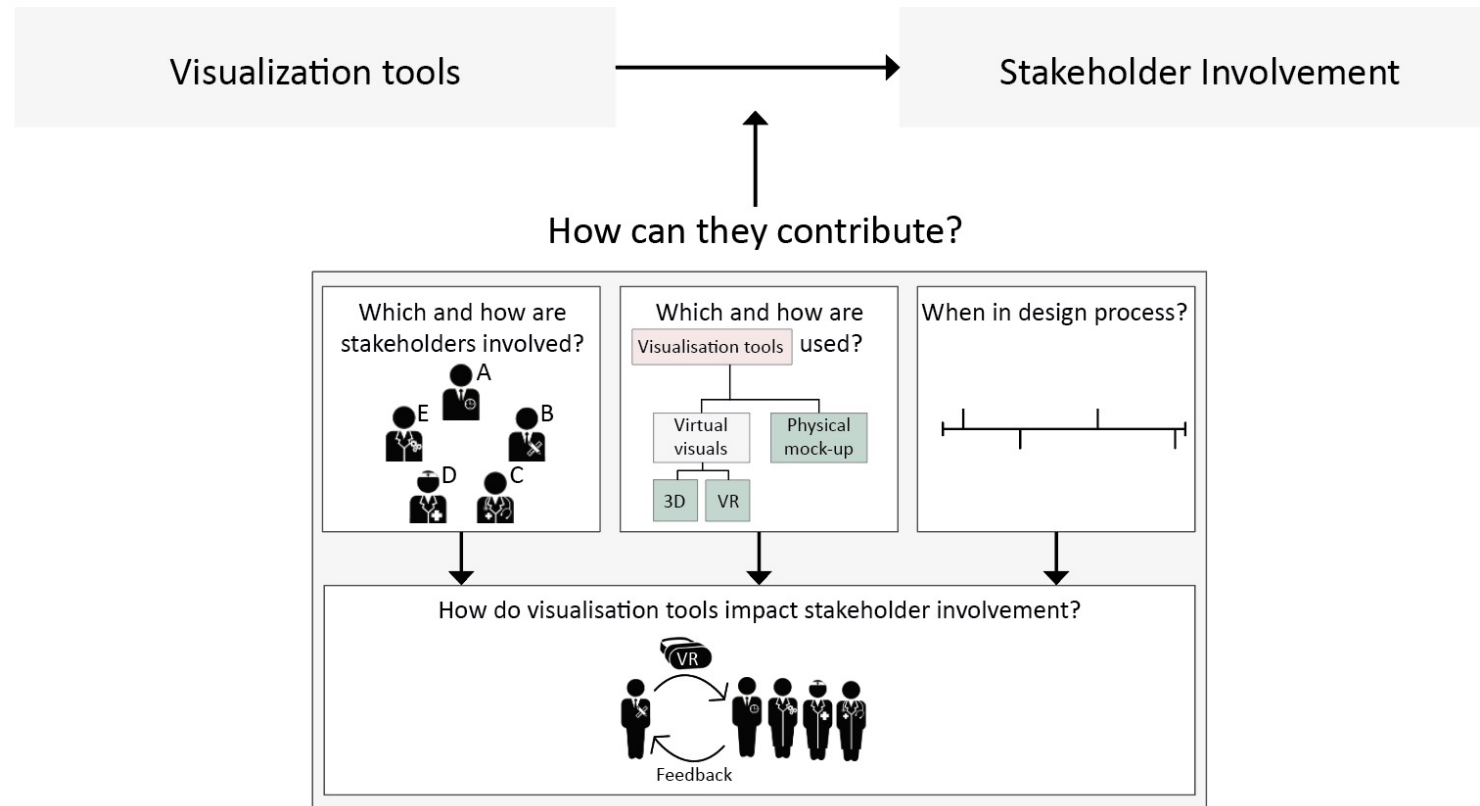
Research question

Question 3: When in the design process of hospital (re)construction projects are the visualisation tools used?

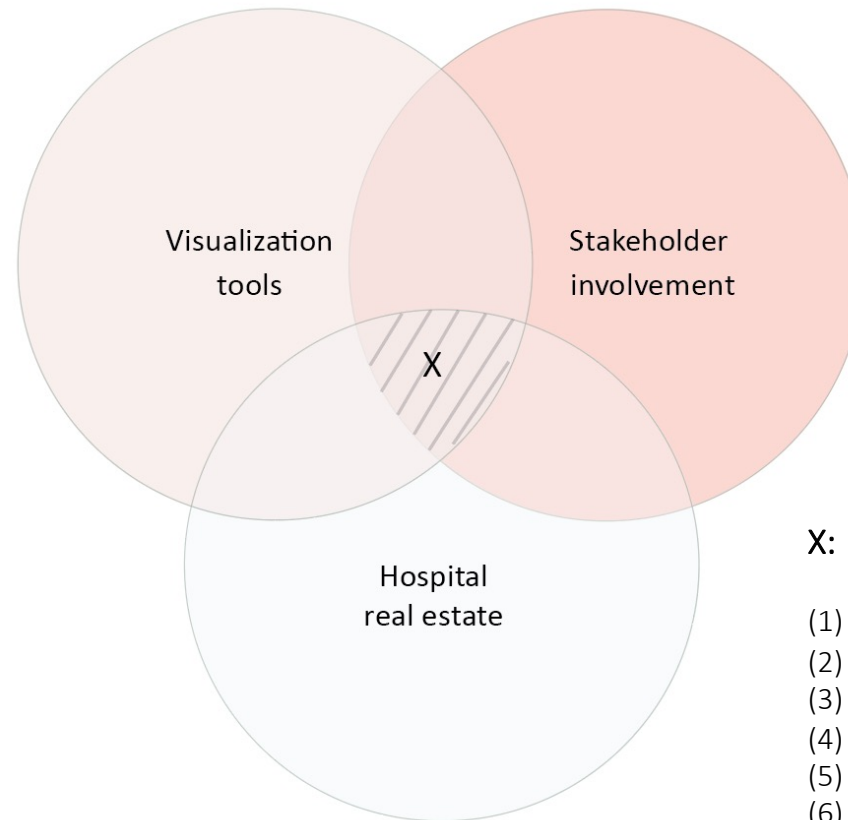


Research question

Question 4: How do visualisation tools impact stakeholder involvement in hospital (re)construction projects?



Literature study



X: N=6

- (1) Bayramzadeh et al. (2018)
- (2) Harty and Tryggestad (2012)
- (3) Huang et al. (2017)
- (4) Lin et al. (2018)
- (5) Roupé et al. (2020)
- (6) Tutt and Harty (2013)

Case study

Case 1.



Case 2.



Case 3.



Interviews

Case 1.



Project manager



Architect



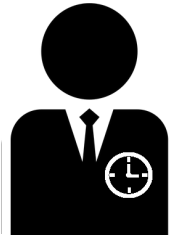
Doctor



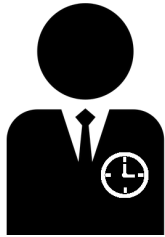
Nurse



Accommodation manager



Case 2.



Project manager



Architect



Doctor

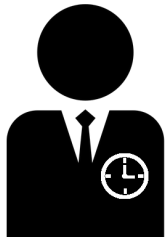


Nurse



Accommodation manager

Case 3.



Project manager



Architect



Doctor



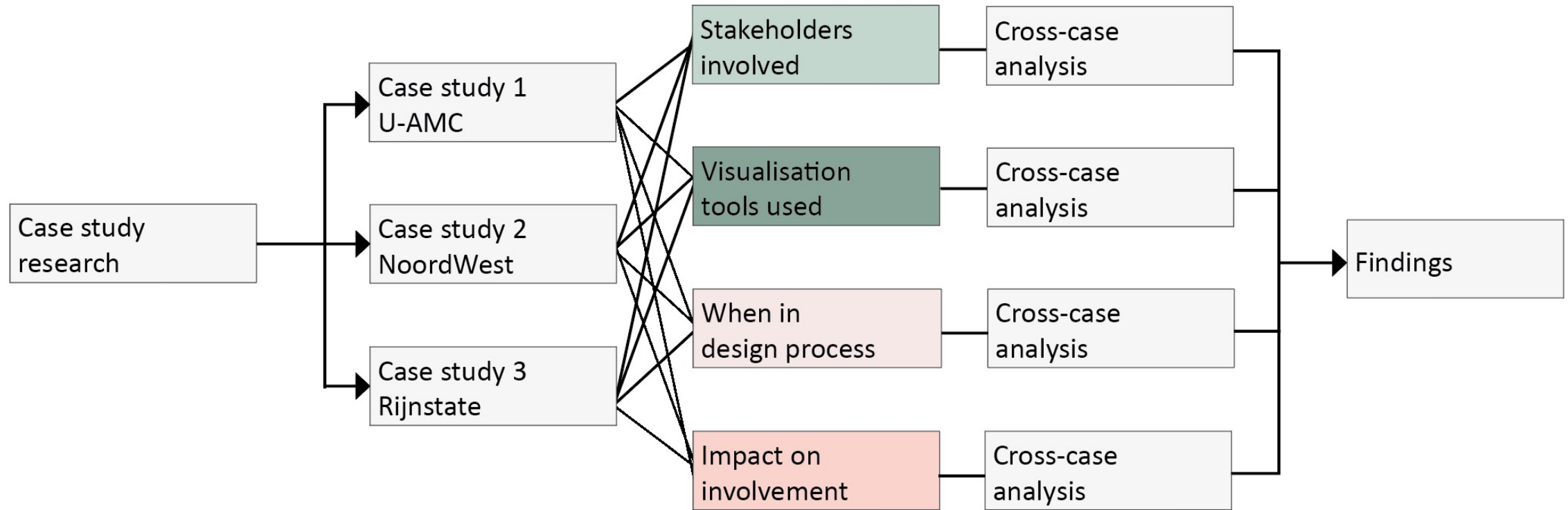
Nurse



Accommodation manager



Case study



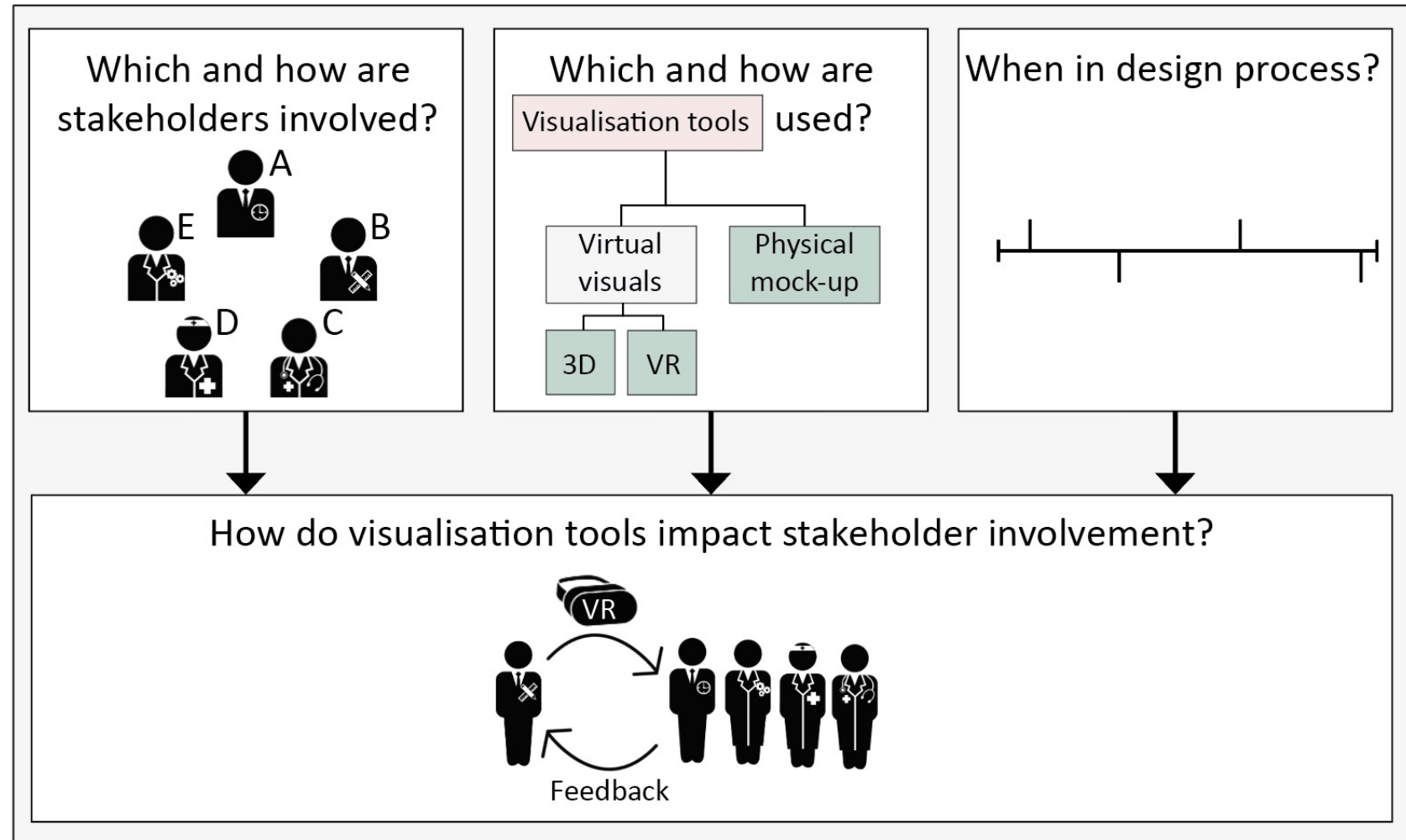
Validation

Expert panel

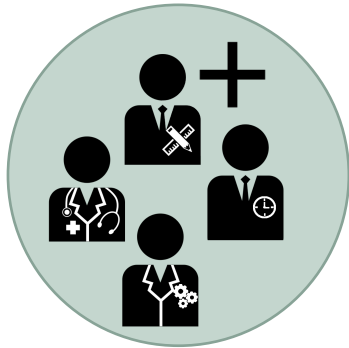
Expert	Company	Role
1.	AT Osborne	Senior Consultant Accommodation & Real Estate (Education and Research)
2.	AT Osborne	Consultant Accommodation & Real Estate (Healthcare)
3.	GAF	Architect (Healthcare)



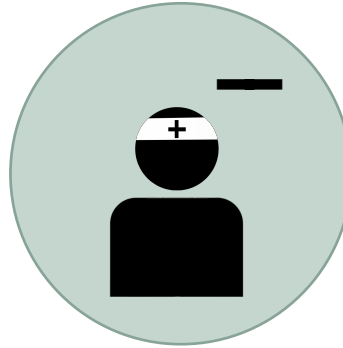
Findings



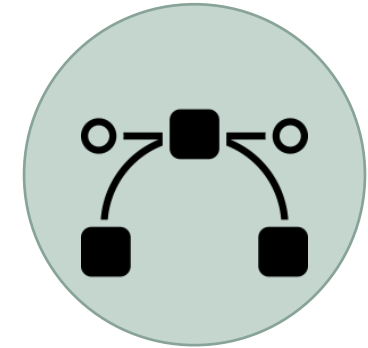
Q1. Which stakeholders are involved in hospital (re)construction projects, and how?



Many different hospital stakeholders



Patients are little involved



Ones involved represent their department

'Multidisciplinary groups work very well because the different stakeholders start discussing with each other and come to a solution together.' (B1, 2021)

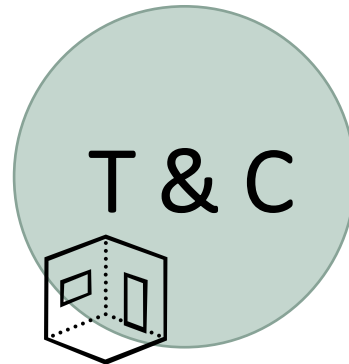


Project manager

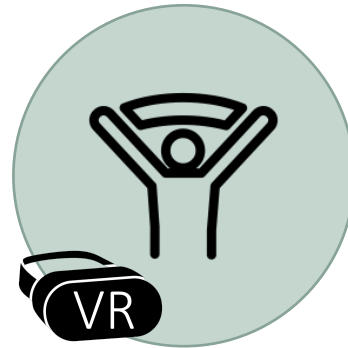
Q2. Which visualisation tools are used in hospital (re)construction projects, and how?



Mock-ups enable effective testing of a room



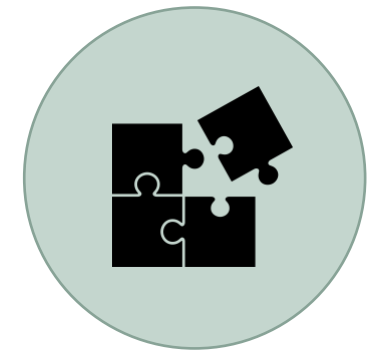
Mock-ups for 'typicals' and 'criticals'



Virtual visualisations create design support and enthusiasm



Virtual visualisations can not test physical user processes



Both tools complement each other: best used together

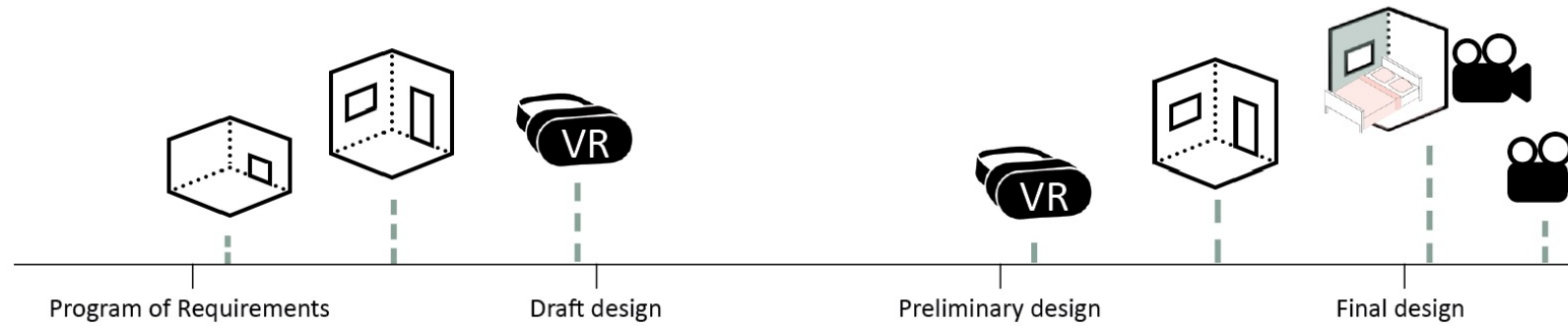
'A mock-up shows; this is the way you are standing in it, does it fit, can I resuscitate a patient in that room? Can I stand here with a nurse and another doctor?' (B3, 2021)



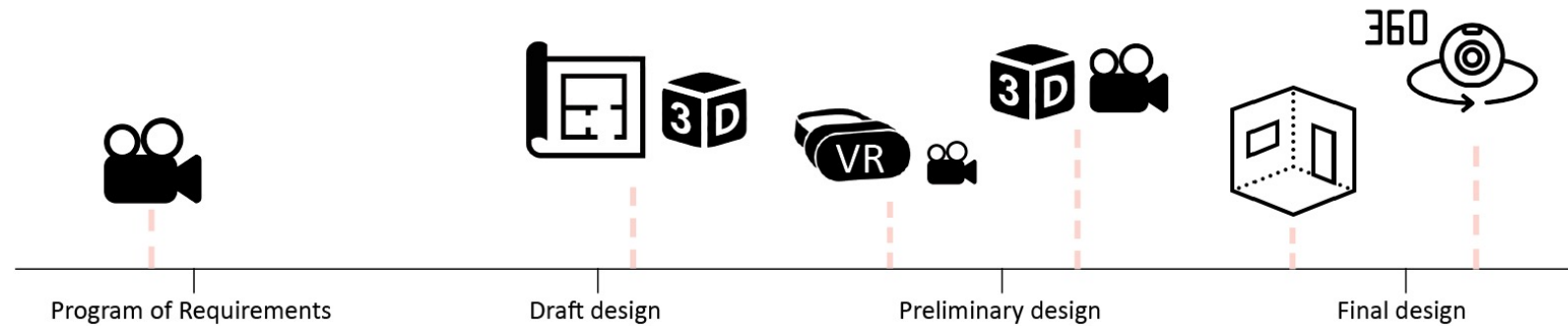
Doctor

Q3. When in the design process of hospital (re)construction projects are the visualisation tools used?

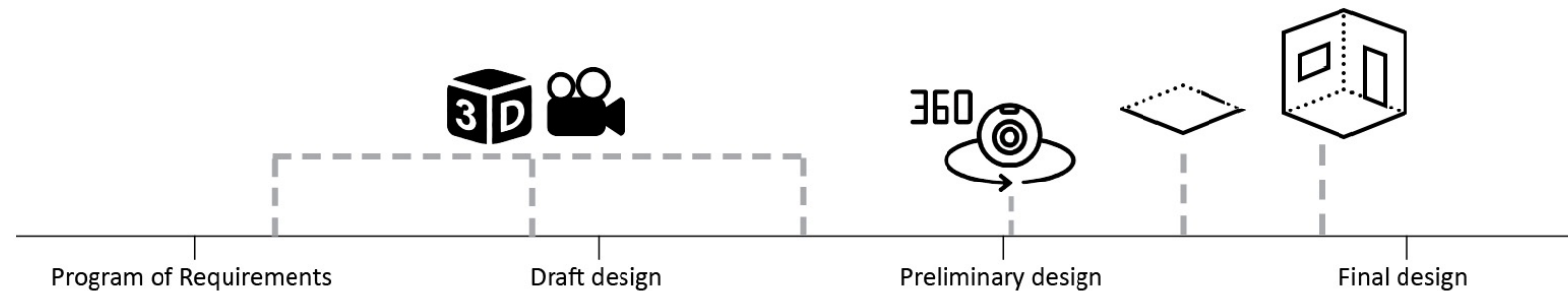
Case 1.



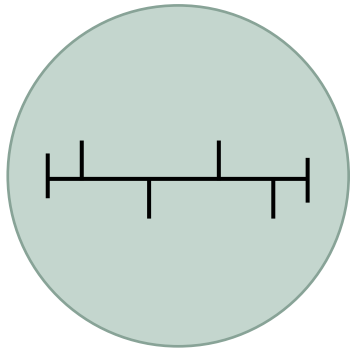
Case 2.



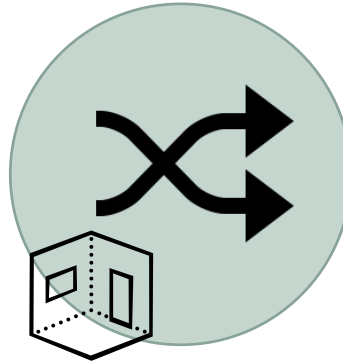
Case 3.



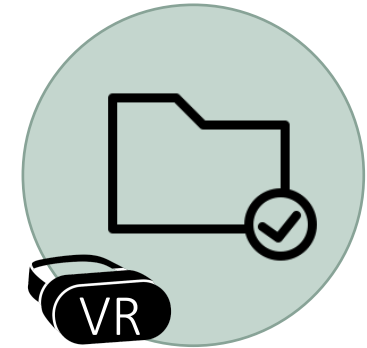
Q3. When in the design process of hospital (re)construction projects are the visualisation tools used?



Several visualisation tools
throughout the design process



Physical mock-ups can be used best in
an early design stage when design
changes can still easily be made



Virtual visualisations can be used best at
a later design stage to show a more
elaborated version of the design

'When the mock-up was finished, we realised that if you went into the bathroom and left the door open, you couldn't enter the main room if someone became unwell. Well, that was important to note, otherwise, you'd have to adjust that in all the rooms afterwards' (A3, 2021)

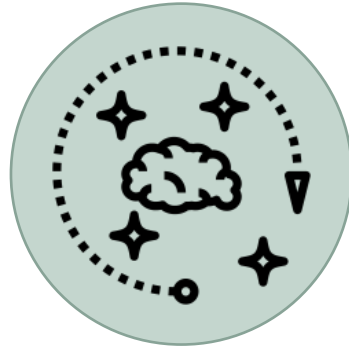


Nurse

Q4. How do visualisation tools impact stakeholder involvement in hospital (re)construction projects?



Improve
communication



Improve
Understanding



Virtual visualisations
can be misleading



Physical mock-ups
Improve collection
of feedback



Facilitate discussions
and compromises

'The saying 'a picture says more than a thousand words' is sometimes really true [...] what you cannot imagine, you cannot ask questions about' (C6, 2021)



Architect



Conclusion

How can visualisation tools contribute to the involvement of stakeholders in hospital (re)construction projects?



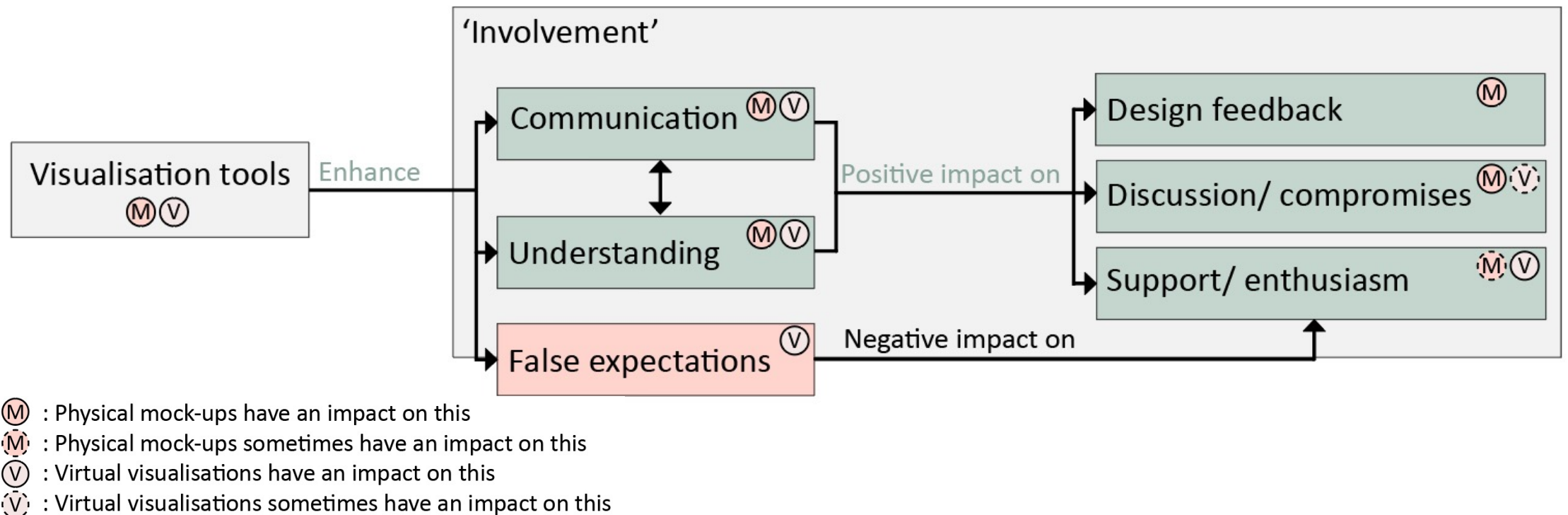
Physical mock-ups



Virtual visualisations

Conclusion

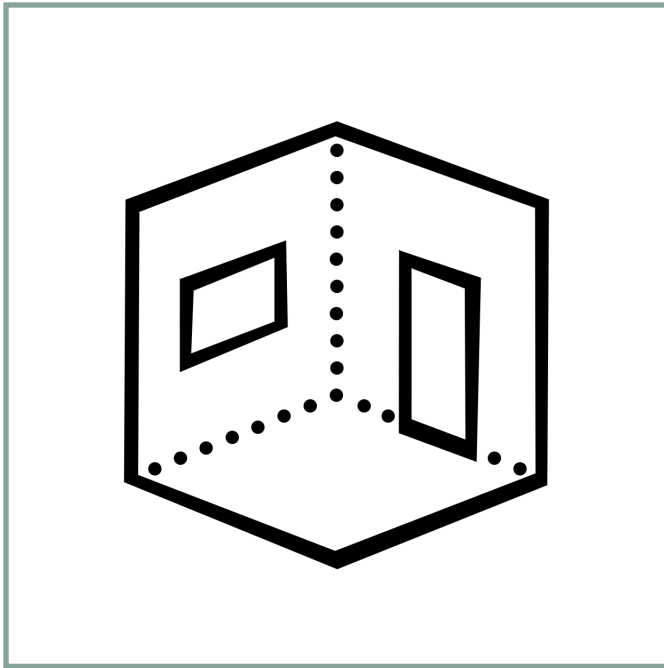
How can visualisation tools contribute to the involvement of stakeholders in hospital (re)construction projects?



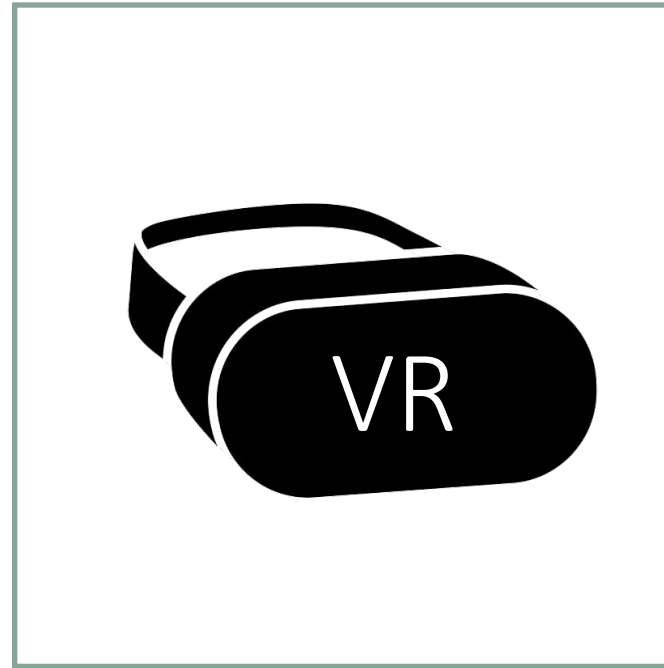
Conclusion

How can visualisation tools contribute to the involvement of stakeholders in hospital (re)construction projects?

Physical mock-up

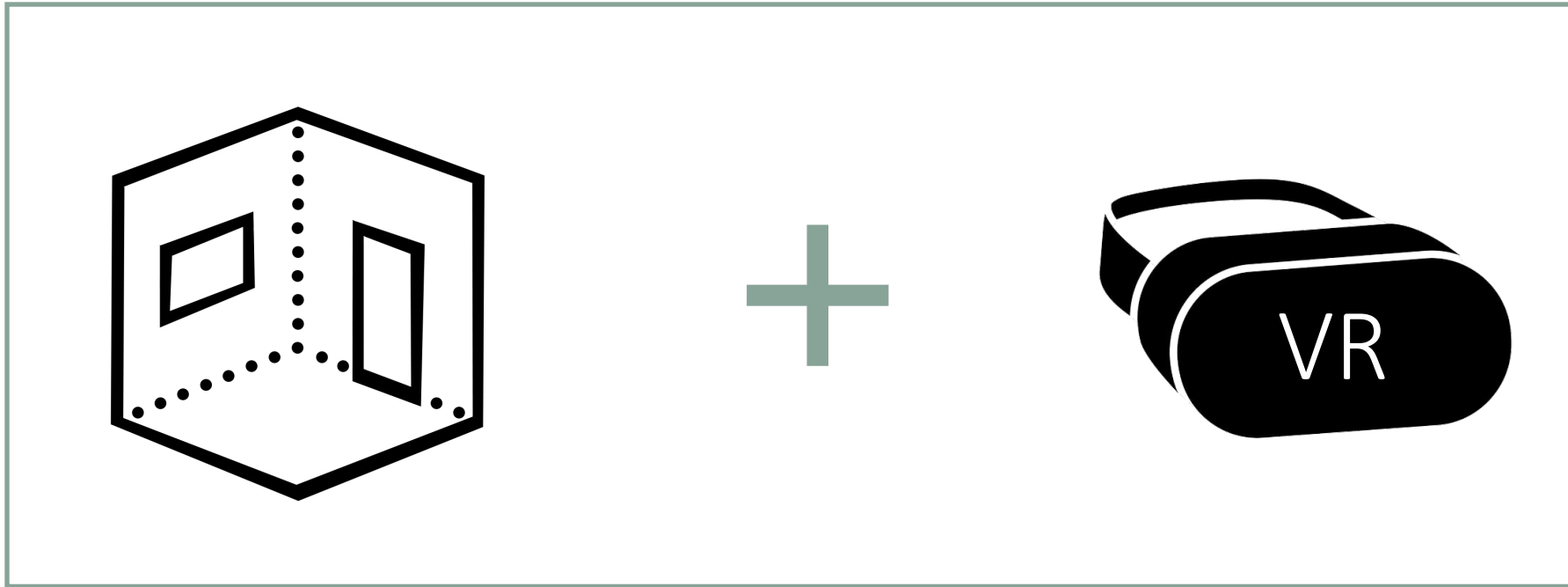


Virtual visualisation



Conclusion

How can visualisation tools contribute to the involvement of stakeholders in hospital (re)construction projects?



Introduction

Methodology

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Conclusion

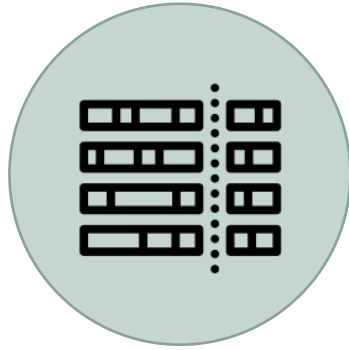
Recommendations

Recommendations

For future research



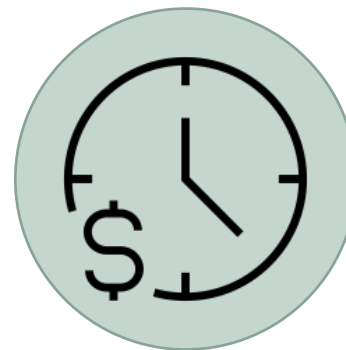
Other (real estate)
sectors



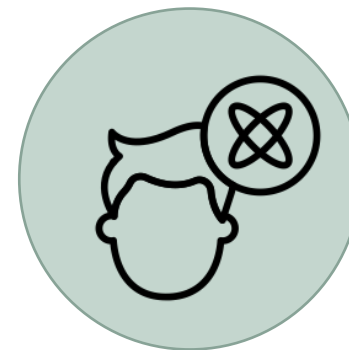
Other project
phases



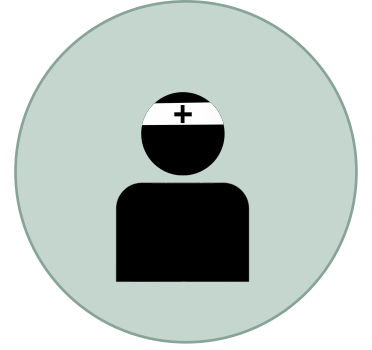
More in depth
research



Influence on
cost and time



The psychological
effect



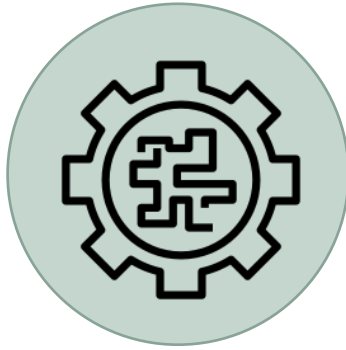
Possibilities to
involve patients

Recommendations

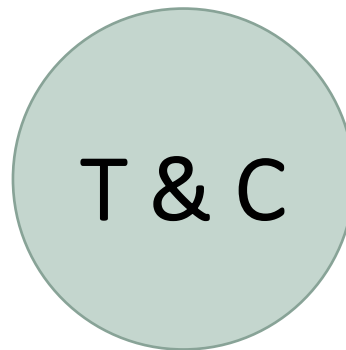
For practice



Use tools, work
from sketch to detail



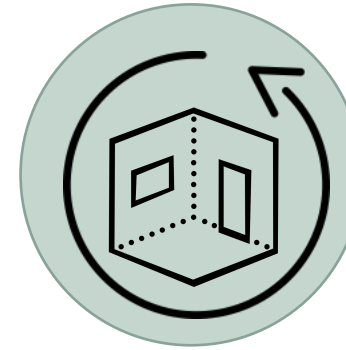
Face complexity
be explicit



Mock-ups for
typicals and criticals



Keep
developing

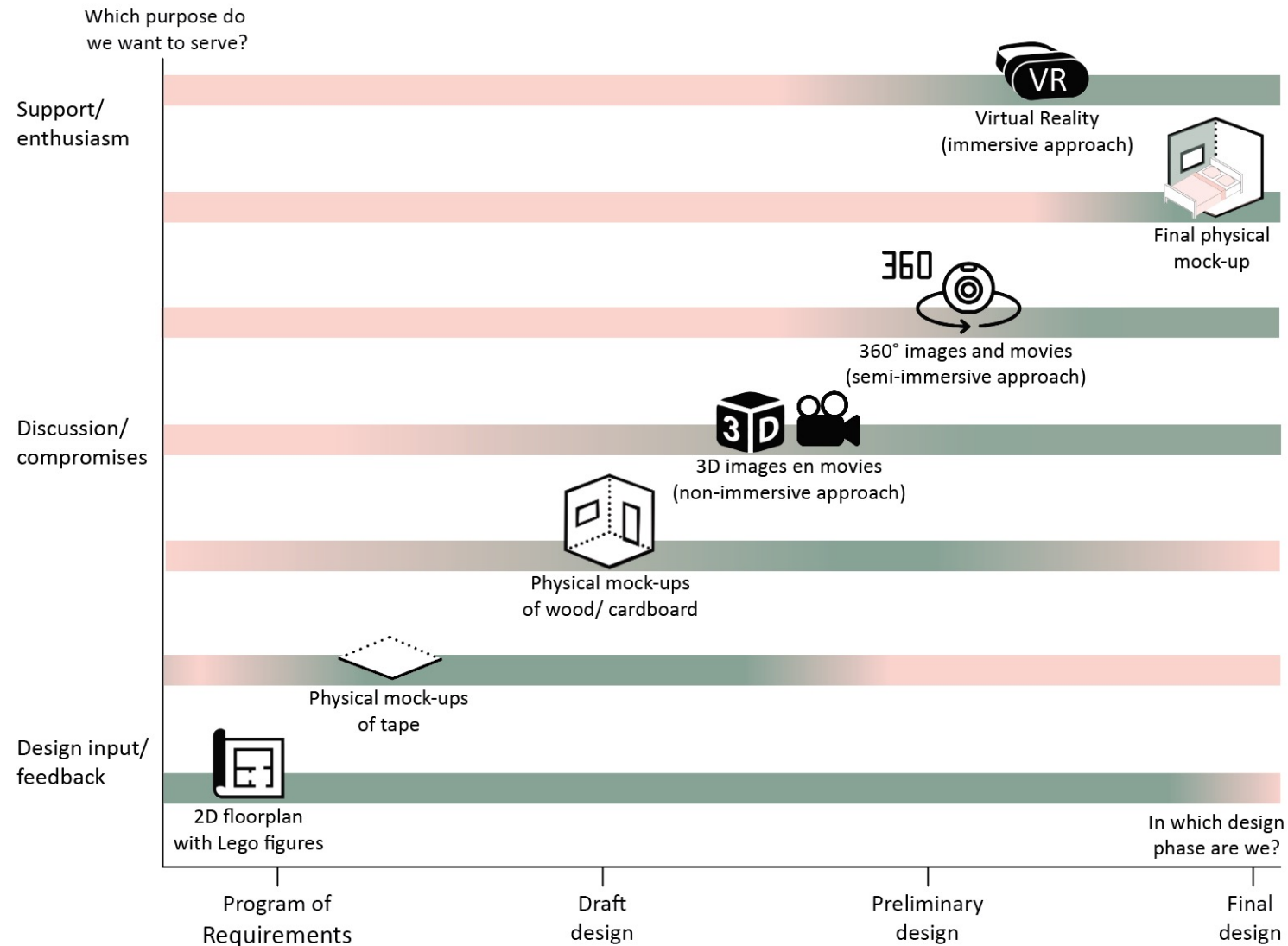


Keep using the tools
after completion

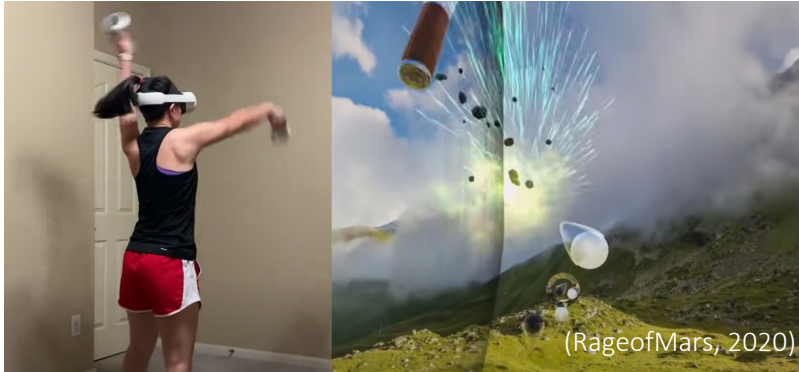


Use the rule
of thumb

Rule of thumb



The future of virtual visualisation tools



The future of virtual visualisation tools



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MSc thesis - June 21st 2021



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Fieke Noordam

MSc thesis - June 21st 2021



<https://api2.enscape3d.com/v3/view/8fb6e77d-46a5-46ba-b853-6e8b283a84fc>

<https://api2.enscape3d.com/v3/view/638d81f5-5a61-4bf8-8295-b172827adf08>

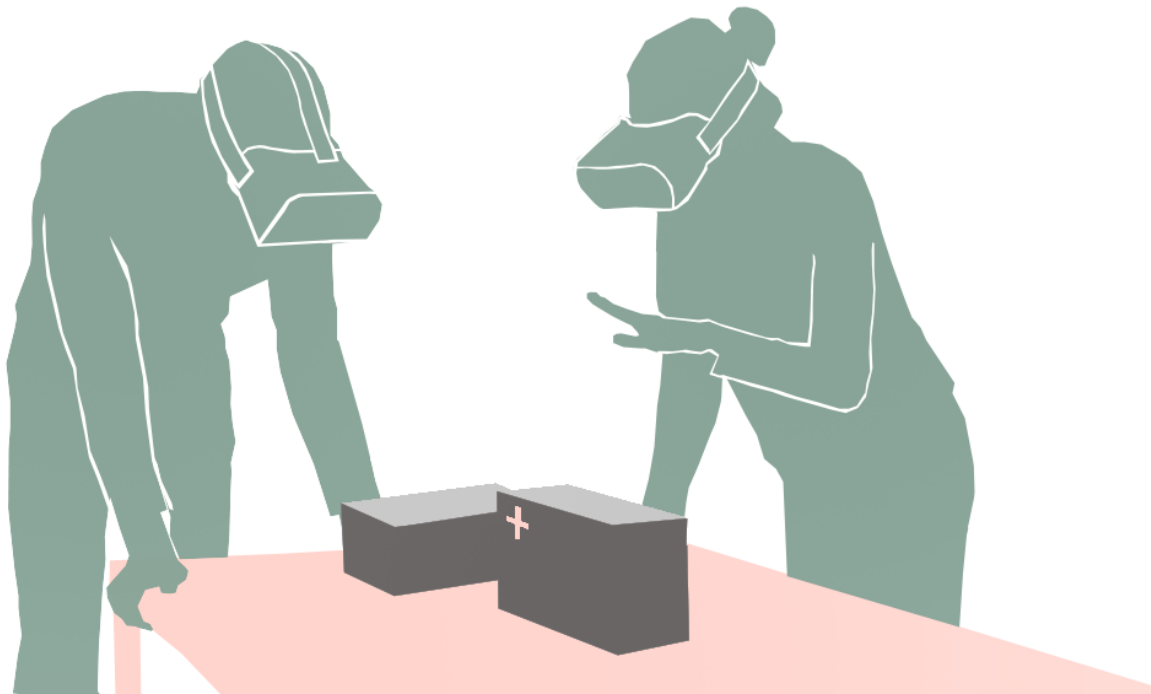
<https://api2.enscape3d.com/v3/view/fe7993cf-1d52-402c-9fc4-e9636462e106>

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Images

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Extra slides



Discussion

Opportunities of stakeholder involvement	Risks of stakeholder involvement	
A I. Create shared understanding ^(1,2)	F I. False expectations ^(6,7)	(1) (Arias et al., 2000)
B II. Enable collaboration ^(1,2)	II. Late involvement ⁽⁸⁾	(2) (Fischer et al., 2005)
C III. Use of local/ expert knowledge ⁽³⁾	III. Emergence of conflicts ^(9,10)	(3) (Van Bueren, 2020)
D IV. Create support for design ^(4,5)	B IV. Lack of mutual language/context ^(6,7,11)	(4) (Van Bueren & ten Heuvelhof, 2005)
E V. Stakeholders feel appreciated ⁽⁴⁾	V. Abuse of power ⁽¹²⁾	(5) (Keys et al., 2017)
VI. Prevents cost increase ⁽⁵⁾	G VI. Unsatisfactory compromise ⁽¹³⁾	(6) (Bakker et al., 2017)
VII. Reduce project delays ⁽⁵⁾	VII. Undesired exclusion of stakeholders ^(14,15)	(7) (Roupé et al., 2020)
		(8) (Bosch-Rekvelde et al., 2011)
		(9) (Bakker et al., 2017)
		(10) (McManus, 2002)
		(11) (Sutter et al., 2009)
		(12) (Hordijk et al., 2015)
		(13) (De Bruijn & Ten Heuvelhof, 2008)
		(14) (Hartman, 2000)
		(15) (Märker & Pipek, 2000)

Advantages of visualisation tools during involvement

3D representation of a design contributes to obtaining more informed design feedback ⁽¹⁾

Enables to better understand a design compared to 2D drawings, pictures or videos ^(1,2)

Enhances the ability to examine the design ^(3,4,5)

Reinforces communication, cogitation and integration ^(3,4,5)

Contributes to aligning design with the stakeholder's expectations ⁽¹⁾

Allows design evaluation during the earliest phases when modifications to the design are still possible at low cost ⁽⁶⁾

(1) (Delgado et al., 2020) (2) (Grudzewski et al., 2018)
 (5) (Soemardi Biemo, 2012) (6) (Preiser & Schramm, 2012)

Disadvantages of visualisation tools during involvement

I. Ample time, and cost commitment for implementation ^(1,7,8)

II. Need for technical awareness ^(1,7,8)

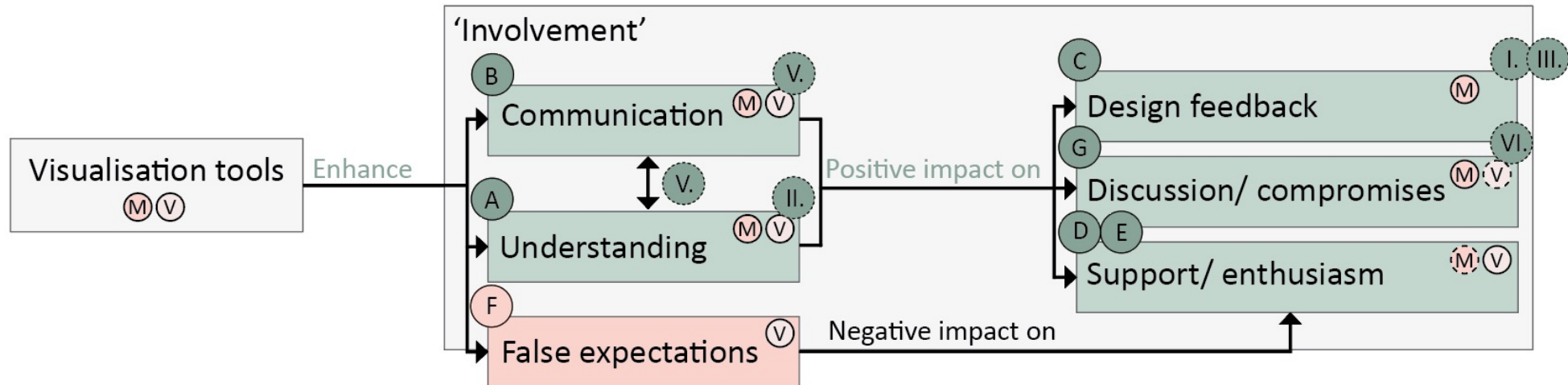
III. Poor usability for inexperienced users ^(1,7,8) *

IV. Cause sense of isolation ^(1,7,8) **

V. Experiences are not easily shared ^(1,7,8)

Unwillingness to accept a virtual environment ^(1,7,8)

(3) (Ibrahim & Pour Rahimian, 2010) (4) (Lin et al., 2018)
 (7) (Wang et al., 2014) (8) (Yung & Khoo-Lattimore, 2019)



Limitations

- Limited number of cases
- Case selection
- Language interviews
- Certain personal backgrounds are unexplored
- Comprehensive summaries instead of all-encompassing transcripts
- Validation within AT Osborne and GAF

(Dis)advantages of visualisation tools

	Advantages of visualisation tools	Disadvantages of visualisation tools
2D floorplan	-It gives an overview of the building as a whole (A4, B1, B2, B5, C6, C8).	-It is hard for hospital stakeholders to understand and to give feedback on (A1, A2, A3, A5, A7, A8, B1, B2, B3, B4, B5, C1, C3, C4, C6, C8).
Physical mock-up	<ul style="list-style-type: none"> -It allows stakeholders to physically test user processes (A1, A2, A3, A4, A5, A6, A7, A8, B1, B2, B3, B4, B5, C1, C2, C3, C4, C6, C7, C8). -It allows for a good and fast collection of feedback from involved stakeholders (A1, A2, A3, A4, A6, A7, B1, B2, B3, B4, B5, C1, C3, C4, C7, C8). -It makes it possible for stakeholder to adjust the design on the spot by moving things around (B1, B4, B5). -It enables all involved stakeholders to experience and discuss the design simultaneously (B2, B4, C1, C6, C8). -It is handy to test typical and critical spaces (A1, A3, A5, B4, B5, C1, C2, C3, C8). -It can convince stakeholders the design is sufficient (A7, A8, B3, B4, B5, C1, C4, C8). 	<ul style="list-style-type: none"> -It does not look beautiful, not inspiring because there are no colours nor actual materials (A4, A6, B3, B4). -It requires ample space (A1, A7, B4, B5, C1, C6).
Virtual visualisation tool	<ul style="list-style-type: none"> -It enthuses the user and creates design support (A1, A2, A4, A5, A6, A7, B1, B2, B3, B4, B5, C1, C2, C3, C4, C5, C6, C8). -It gives the user an idea of routing and the spatial relation of rooms (A1, A3, A6, A7, B1, B2, B3, B4, C1, C2, C3, C4, C5, C6). -It is relatively easy for the architect to make design changes (A1, B2, C2, C6). -It can convince stakeholders the design is sufficient (B3, C2, C3, C6). 	<ul style="list-style-type: none"> -It can not assess physical processes (A1, A3, A6, A7, B1, B2, B3, B4, B5, C6, C7, C8). -It does not easily collect feedback from involved stakeholders (A2, A3, A6, A7, A8, B1, B2, C6). -It shows specific details which can be misleading (A1, A4, A6, A7, A8, B3, B5, C2, C5, C6, C7, C8). -VR can only be used by one stakeholder at a time (A1, A4, B2, B4, C1, C2). -VR can create digital motion sickness for users (A1, A4, A6, B3, C1, C2).

Context of the 3 hospital projects



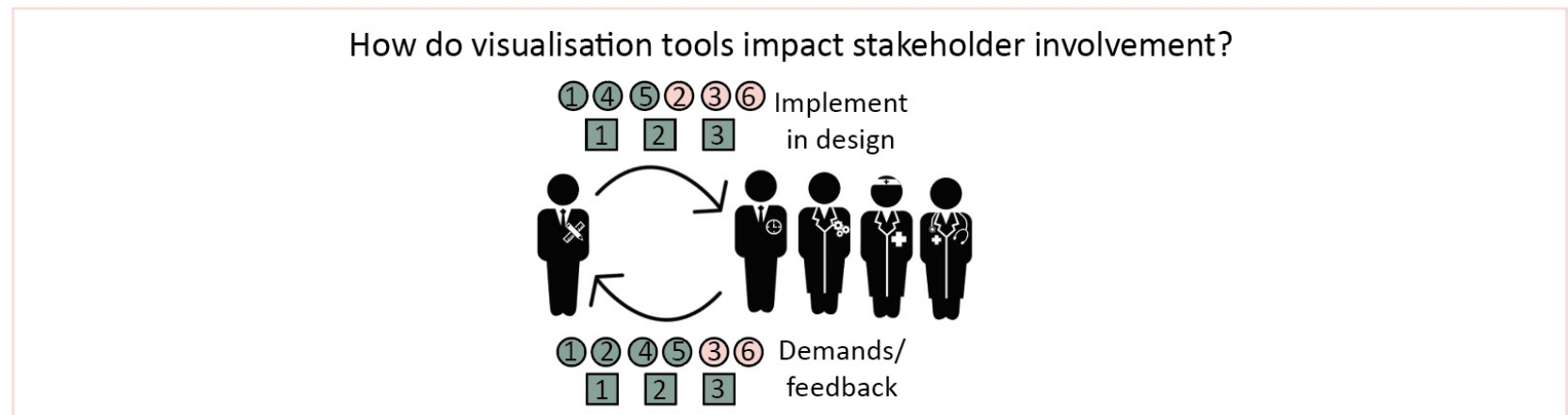
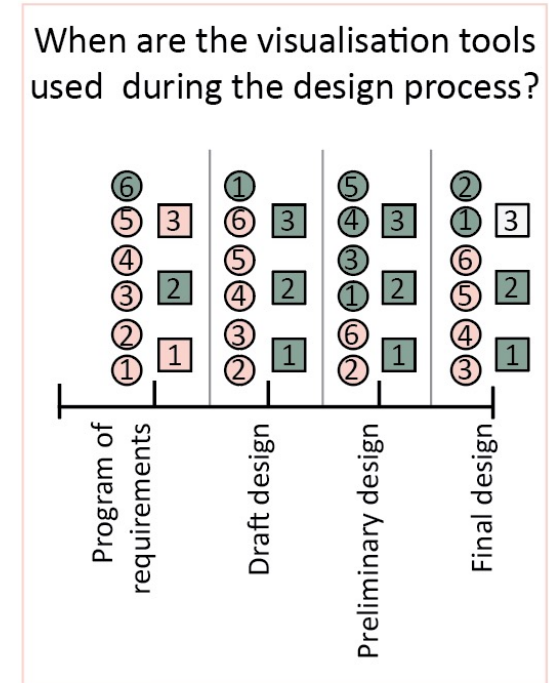
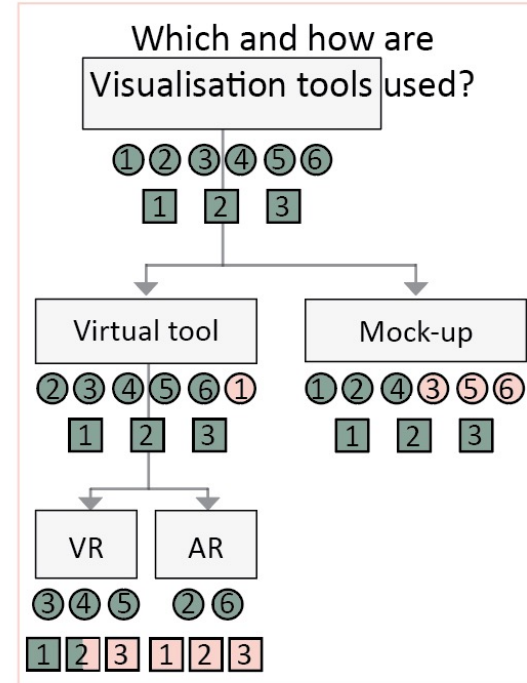
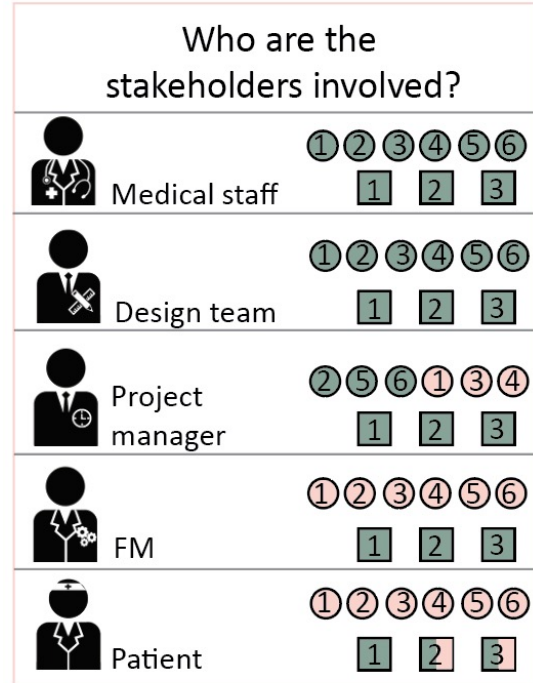
	Location	Project Timing	New construction or reconstruction	New location or current location
Case 1: UMC-A	Amsterdam	2015 -> ongoing (now constructing)	Reconstruction	Current location
Case 2: NoordWest	Alkmaar	2016 -> ongoing (now constructing)	New construction	Current location
Case 3: Rijnstate	Elst	2020 -> ongoing (now finalising design)	New construction	New location

Findings

- ① Bayramzadeh et al. (2018)
- ② Harty and Tryggstad (2012)
- ③ Huang et al. (2017)
- ④ Lin et al. (2018)
- ⑤ Roupé et al. (2020)
- ⑥ Tutt and Harty (2013)

- 1 Case 1
Amsterdam UMC
- 2 Case 2
NoordWest ziekenhuisgroep
- 3 Case 3
Ziekenhuis Rijnstate

- : Case shows this
- : Case does not shows this
- : Paper shows this
- : Paper does not shows this
- : Case partly shows this
- : No final design established yet

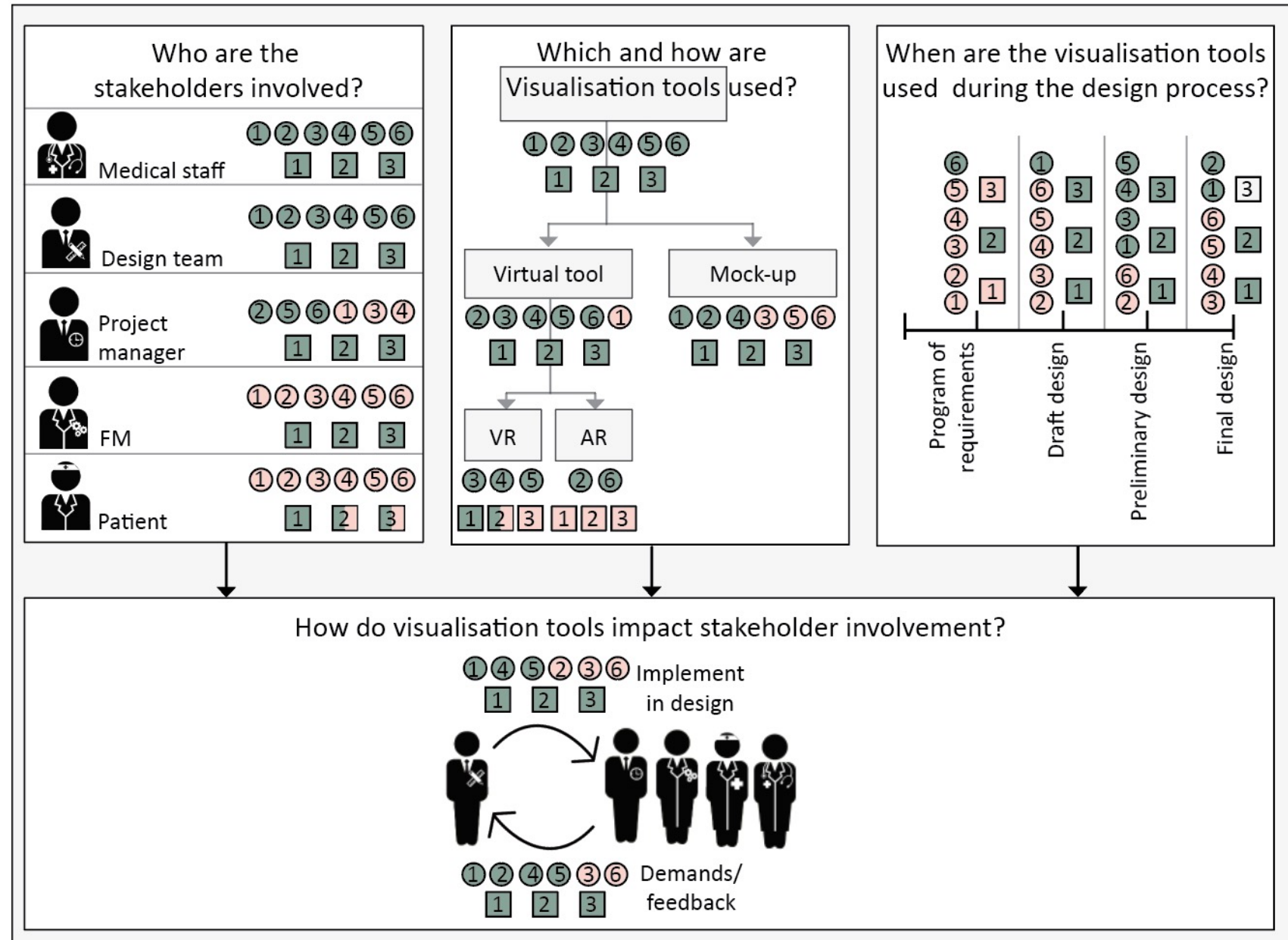


Findings

- ① Bayramzadeh et al. (2018)
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Ziekenhuis Rijnstate

- : Case shows this
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Interview protocol

Open question:

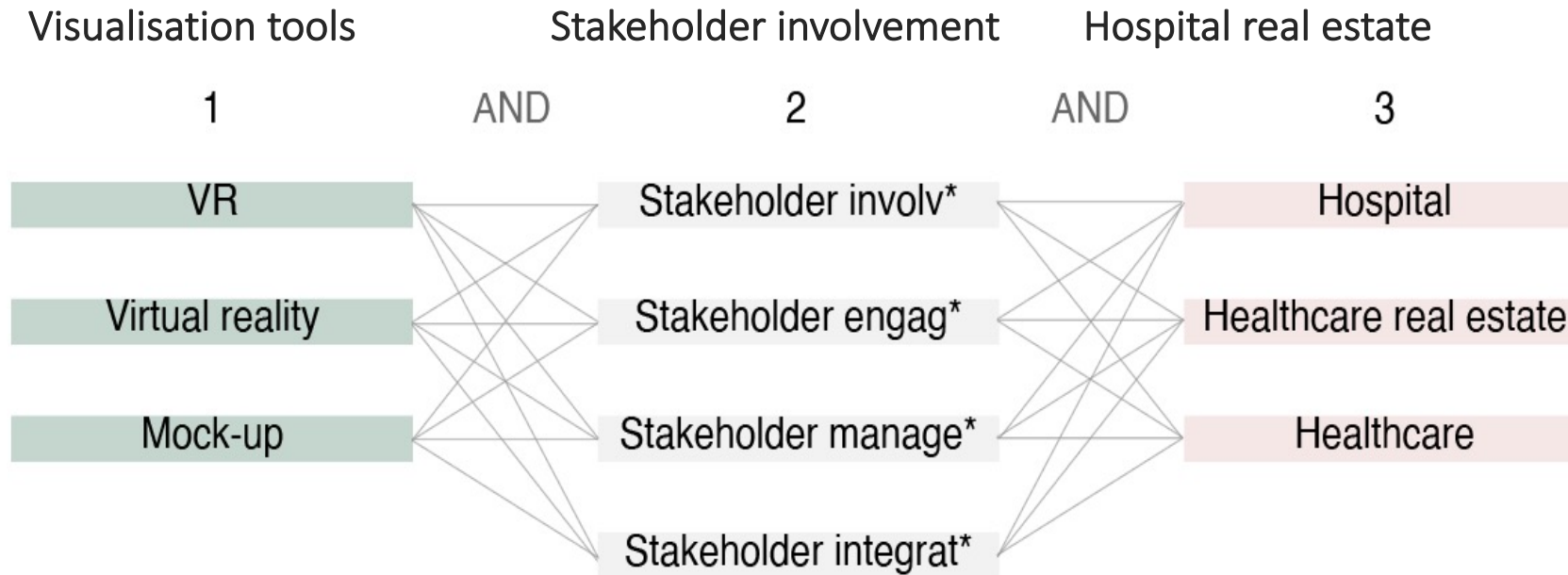
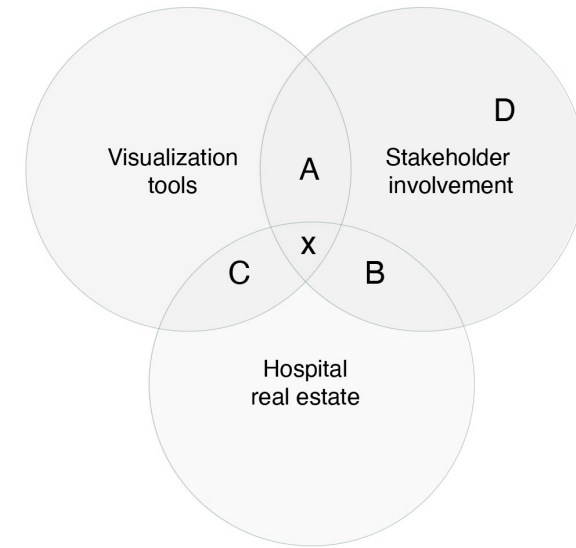
- A. Kun u uzelf introduceren en uw rol in het ziekenhuis verbouwing toelichten?
- B. Kunt u mij vertellen wie er nog meer betrokken waren bij de bouw van Rijnstate ziekenhuis? (De ziekenhuis gebruikers, contextuele belanghebbenden; patiënten, zorgverzekeraar, gemeente, etc.)
- C. Kunt u mij vertellen hoe de communicatie van dit bouwproject is verlopen? (flyers, afbeeldingen, vergaderingen, website)
- D. Wat vond u van de communicatie?
- E. Kunt u mij vertellen wat voor visualisatie tools (VR/ Mock-up) er zijn gebruikt?
- F. Kunt u mij iets vertellen over op wiens initiatief de visualisatie tools zijn gebruikt? Was diegene ook verantwoordelijk voor de visualisatie tools?
- G. Wat zijn uw ervaringen met het gebruik van de VR/Mock-up tijdens het verbouwingsproject?
- H. Wat is het verschil in ervaring bij de VR ten opzichte van de Mock-up ten opzichte van een 2D tekening?
- I. Kunt u mij vertellen wat het effect van de visualisatietools (mock-up/VR) was op de projectcommunicatie was?
- J. Kunt u mij vertellen wat de visualisatietools (mock-up/VR) hebben gedaan voor de betrokkenheid van de ziekenhuis stakeholders?
- K. Hoe denkt u dat de betrokkenheid van een ziekenhuisstakeholder bij het ontwerpproces nog meer vergroot kan worden?

Specific questions on the risks of stakeholder engagement:

- L. Kunt u mij vertellen of de VR/Mock-up de ziekenhuis stakeholders hebben ondersteund om juiste verwachtingen te vormen van het voorgestelde ontwerp?
- M. Kunt u mij vertellen wanneer in het ontwerpproces de stakeholders van het ziekenhuis betrokken waren?
- N. Is hun feedback vervolgens meegenomen in het ontwerp?
- O. Kunt u mij vertellen of de belanghebbenden in het ziekenhuis voldoende achtergrondkennis hadden om de visualisatie tool te begrijpen en te gebruiken?
- P. Kunt u mij vertellen of er conflicten/discussies zijn ontstaan terwijl de stakeholders de tool gebruikten?
- Q. Kunt u mij vertellen of er een verschil in macht was tussen de betrokken belanghebbenden in dit besluitvormingsproces? Wat was de invloed van de visualisatietool hierop?
- R. Zijn er in dit besluitvormingsproces onbevredigende compromissen gemaakt? Wat was de invloed van de visualisatietool hierop?
- S. Welke ziekenhuis stakeholders heeft u betrokken bij het gebruik van de visualisatietool? Denkt u dat andere belanghebbenden zich hiervan buitengesloten voelden?
- T. Sprak u namens een groep, en zo ja, hoe betrok u uw jouw achterban daarbij? / Spraken de betrokken stakeholders uit het ziekenhuis namens een groep, en zo ja, hoe betrokken zij hun achterban daarbij?

Literature study method

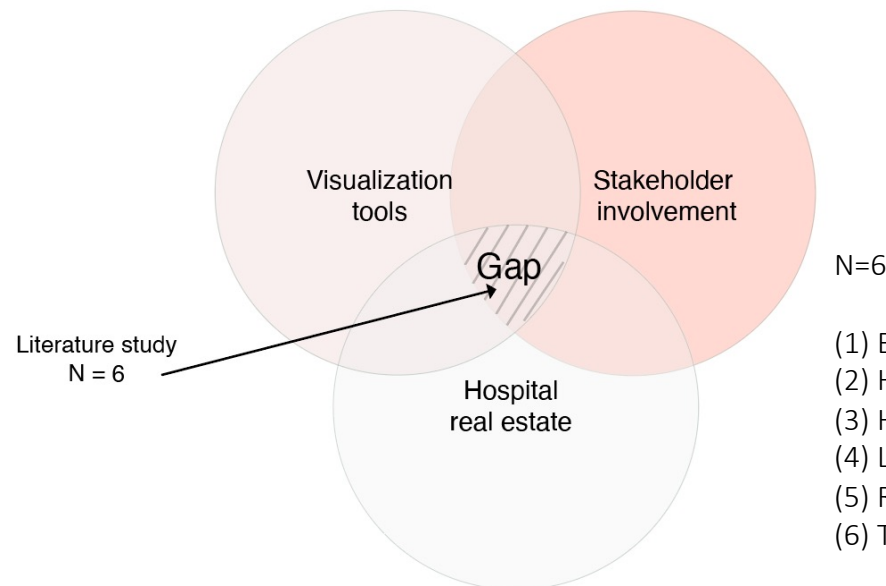
- Stakeholder involvement and visualisation tools in hospital real estate



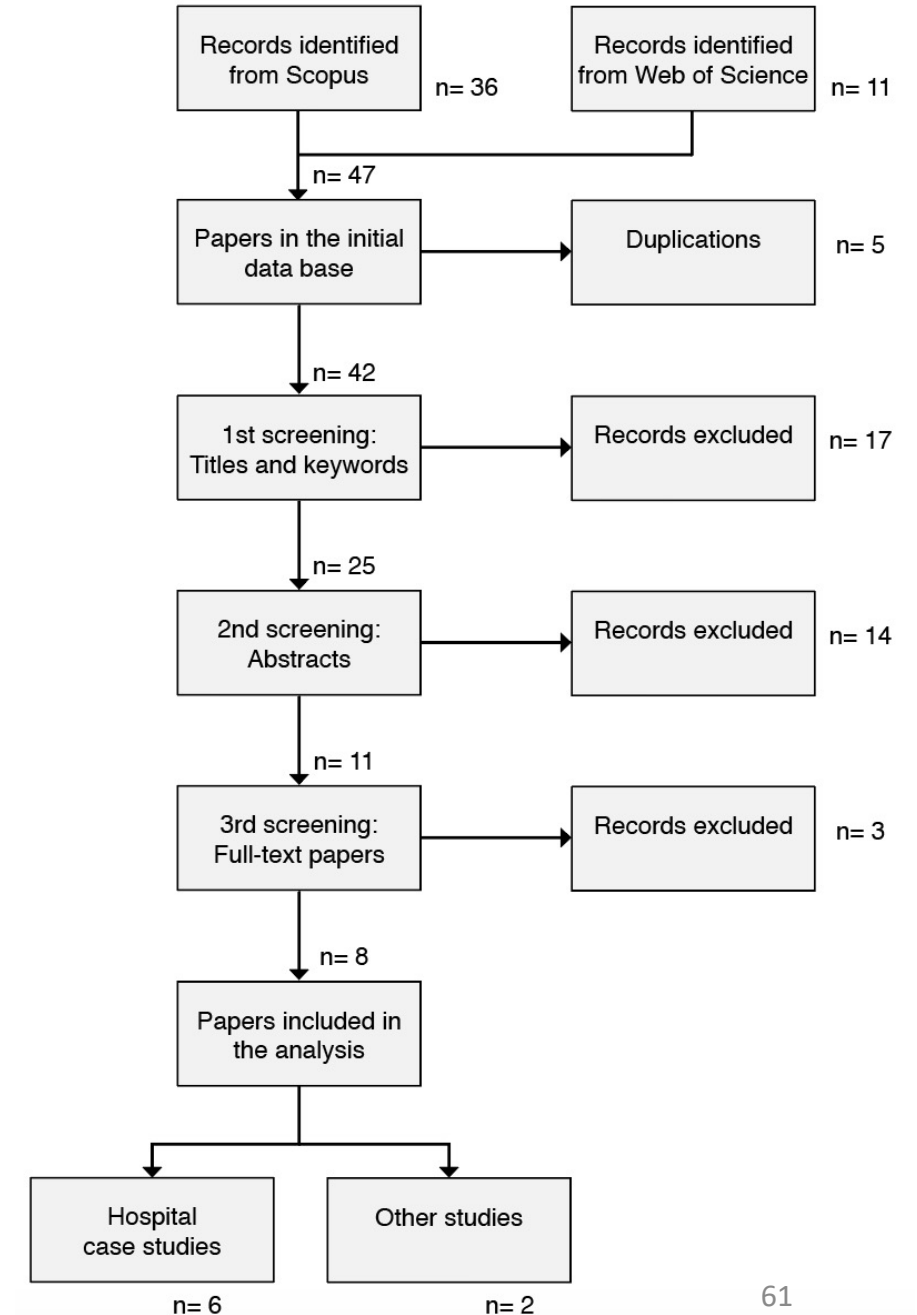
Literature study method

- Inclusion and exclusion criteria were used

Inclusion criteria	Exclusion criteria
Setting: Hospital real estate	Setting: other (healthcare) real estate such as small care practices
Study focusses on the involvement of stakeholders	Study does not mention the involvement of stakeholders
Study makes use of mock-up of a virtual visualisation tool	Study makes use of other communication tools, such as discussion groups
Purpose of the study is related to the real estate usage	Purpose of the study is related to other areas, such as educational practice
Method of the study is hospital case studies	The study uses theoretical papers, systematic reviews, position papers, statistical studies, etc.
Clear description of methods and results	Data-collection process is unclear

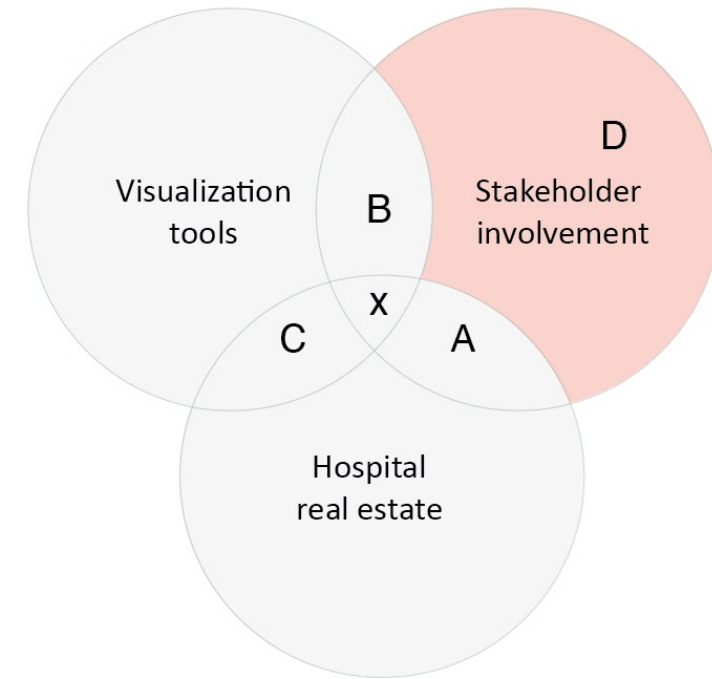
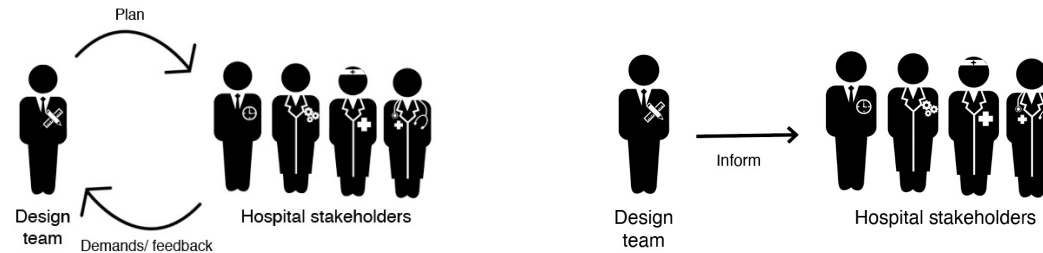


- (1) Bayramzadeh et al. (2018)
- (2) Harty and Tryggestad (2012)
- (3) Huang et al. (2017)
- (4) Lin et al. (2018)
- (5) Roupé et al. (2020)
- (6) Tutt and Harty (2013)



Literature study findings

Stakeholder involvement (D)



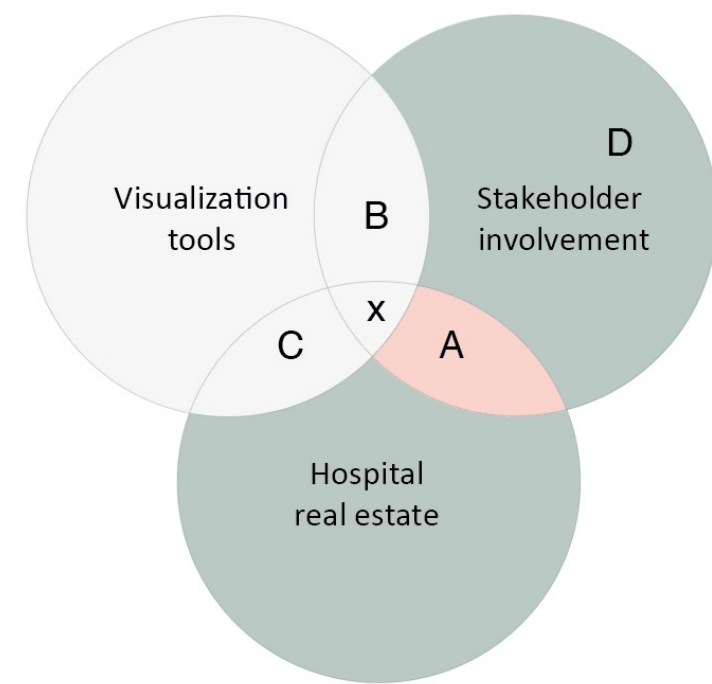
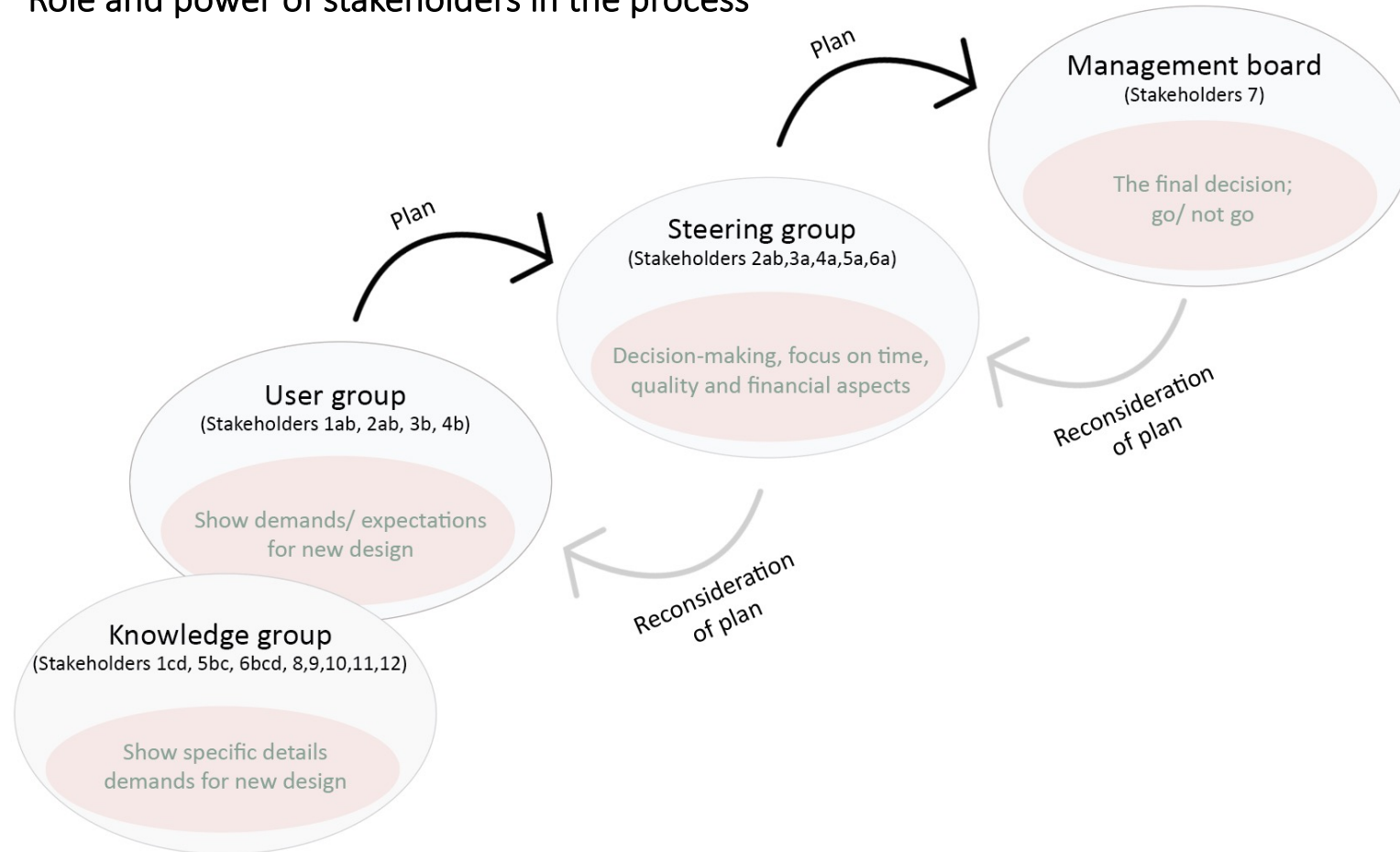
Opportunities and risks of stakeholder involvement

Opportunities of stakeholder involvement	Risks of stakeholder involvement	
I. Create shared understanding ^(1,2)	I. False expectations ^(6,7)	(1) (Arias et al., 2000)
II. Enable collaboration ^(1,2)	II. Late involvement ⁽⁸⁾	(2) (Fischer et al., 2005)
III. Use of local/ expert knowledge ⁽³⁾	III. Emergence of conflicts ^(9,10)	(3) (Van Bueren, 2020)
IV. Create support for design ^(4,5)	IV. Lack of mutual language/context ^(6,7,11)	(4) (Van Bueren & ten Heuvelhof, 2005)
V. Stakeholders feel appreciated ⁽⁴⁾	V. Abuse of power ⁽¹²⁾	(5) (Keys et al., 2017)
VI. Prevents cost increase ⁽⁵⁾	VI. Unsatisfactory compromise ⁽¹³⁾	(6) (Bakker et al., 2017)
VII. Reduce project delays ⁽⁵⁾	VII. Undesired exclusion of stakeholders ^(14,15)	(7) (Roupé et al., 2020)
		(8) (Bosch-Rekvelde et al., 2011)
		(9) (Bakker et al., 2017)
		(10) (McManus, 2002)
		(11) (Sutter et al., 2009)
		(12) (Hordijk et al., 2015)
		(13) (De Bruijn & Ten Heuvelhof, 2008)
		(14) (Hartman, 2000)
		(15) (Märker & Pipek, 2000)

Literature study findings

Stakeholder involvement in hospitals (A)

Role and power of stakeholders in the process



Literature study findings

Stakeholder involvement in hospitals (A)

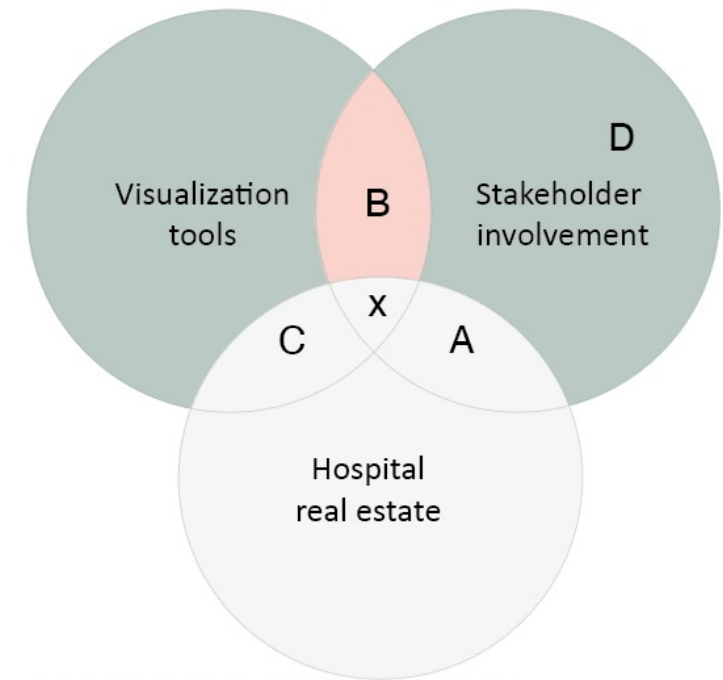
		Organisation unit																		
	Task	1A Architect	1B Industrial designer	1C Installation consultant	1D Constructor	2A Extern project manager	2B Intern project manager	3A Managing doctor	3B Executive doctor	4A Managing nurse	4B Executive nurse	4B Executive nurse	5A Head of FM	5B+C Cleaning & Logistics	6A Head of maintenance	6B+C+D Maintenance specialists	7 Management Board	2AB,3A,4A,5A,6A Steering group		
Initiation	Initiating the construction project					C	C	(I)		(I)								A	R	C
	Determine scope					C	C	(I)		(I)								A	R	C
	Calculate capacity					C	C	C*		C*								A	R	C
Definition	Define vision and ambition					C	C	C	(C)	C	(C)	C	C	C				A	R	C
	Consider different concepts (room types)					C	C	C	(C)	C	(C)	C	C	C				A	R ^O	C
	Discuss new work processes					C	C	C	C	C	C	C	C	C				A	R ^O	C
	Adopt programme of requirements					C	C	C	C	C	C	C	C	C				A	R	C
Design	Proposal of a first draft (SO)	R	A	R	A	R	A			R	R							A	R	C
						C	C	C ^A	I	C ^A	I	C ^A	I	C ^A	I	C ^A	I	C ^A	I	C
Elaboration	Developing the design (VO)	R	A	R	A	R	A			R	R							A	R	C
						C	C ^A	C ^A	I	C ^A	I	C ^A	I	C ^A	I	C ^A	I	C ^A	I	C
	Decision-making on the final design (DO)	R	A	R	A	R	A			R	R							A	R	C
						C	C		I		I		I		I		I			C
Realisation	Realisation of the design (UO)	(C)	(C)	(C)	R	A	(R)	(R)										A	R	A
									I		I		I		I		I	(C)	I	

R (Responsibility)	A (Accountable)
C (Consulted)	I (Informed)

Literature study findings

Visualisation tools for stakeholder involvement (B)

- Visualisation tools facilitate involvement

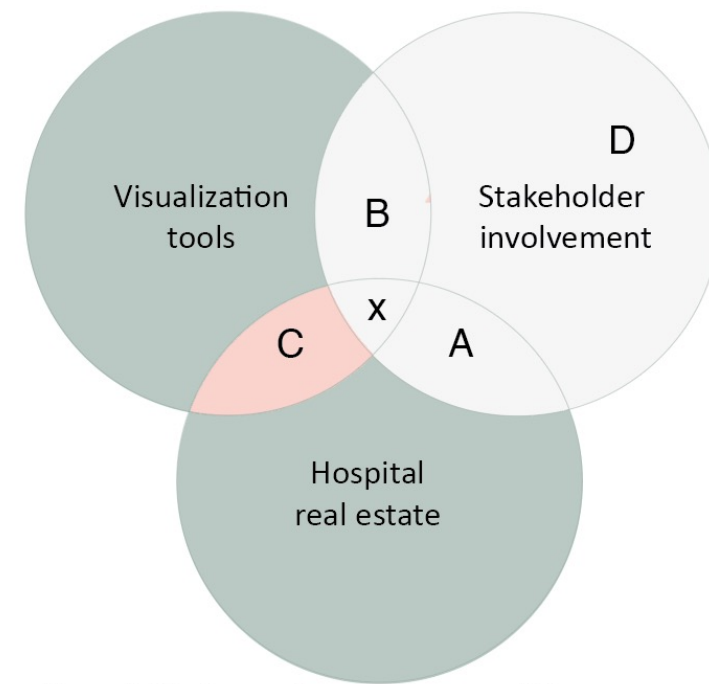


Literature study findings

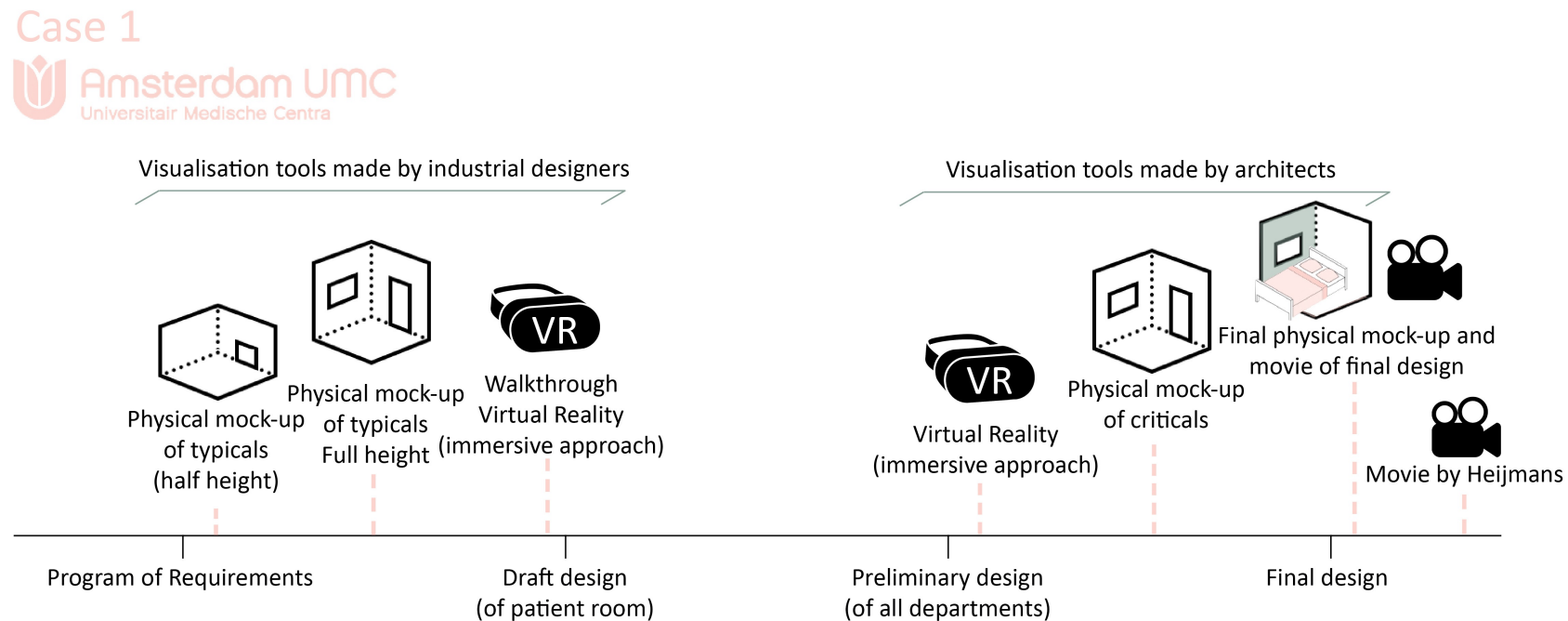
Visualisation tools in hospitals (C)

- Visualisation tools facilitate involvement

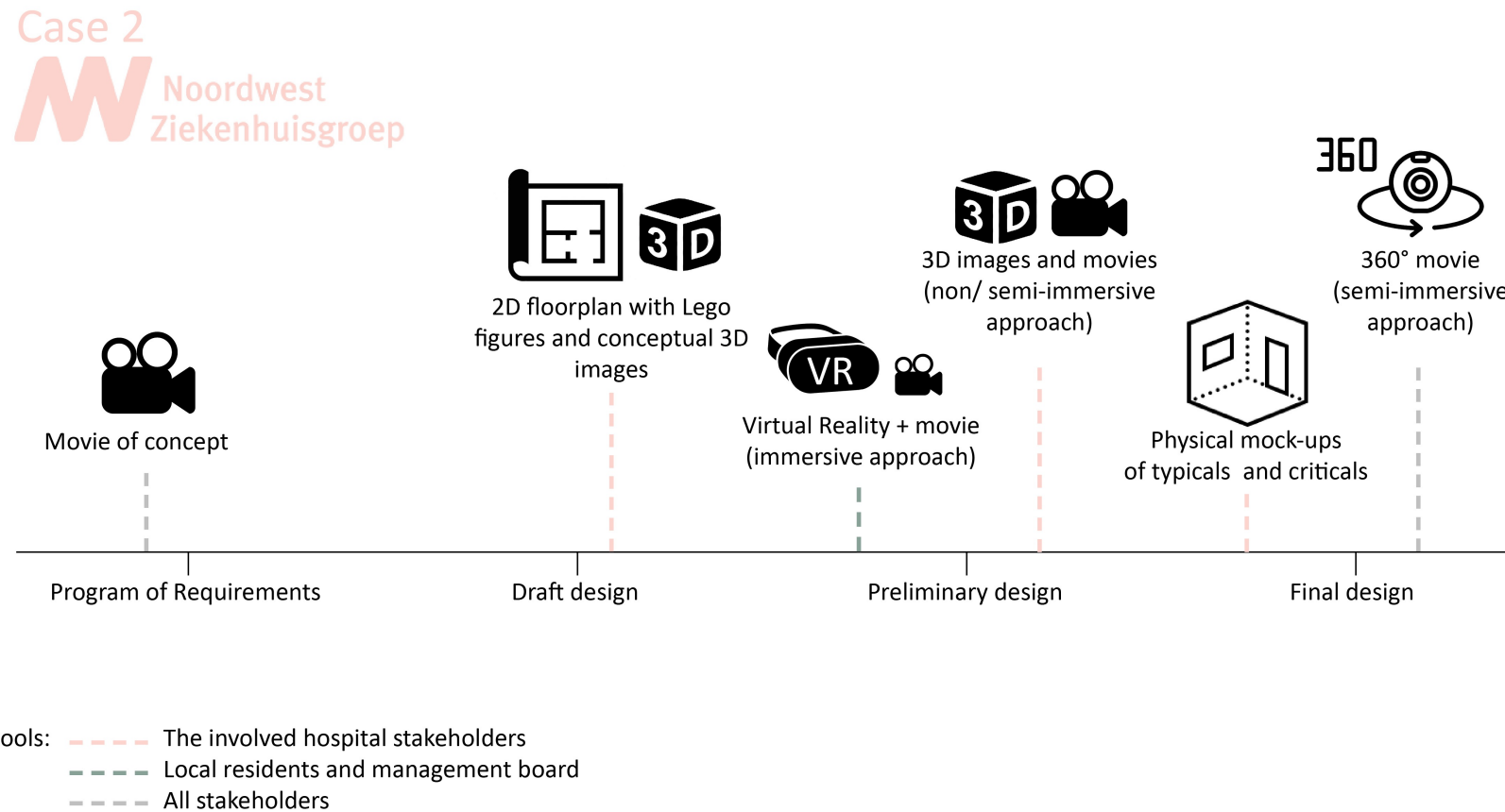
	Advantages	Disadvantages
Tools	Mock-up	- (Full)scale model enables stakeholders to experience the proposed design jointly
	VR	- Excludes misrepresentations since it leaves no room for self-interpretation
	AR	- Functions well for renovation projects since it can overlay a current situation with a filter
Approaches	Immersive approach	- The HMD disables face-to-face communication, which makes it less suitable for a collaborative design process - Users can experience digital motion sickness by using a HMD
	Semi-immersive approach	- Large investments costs of the hyperboloid screen - 360 degrees movie requires specific skills of architects
	Non-immersive approach	- Does not allow the stakeholder to visualise a complete 3D environment



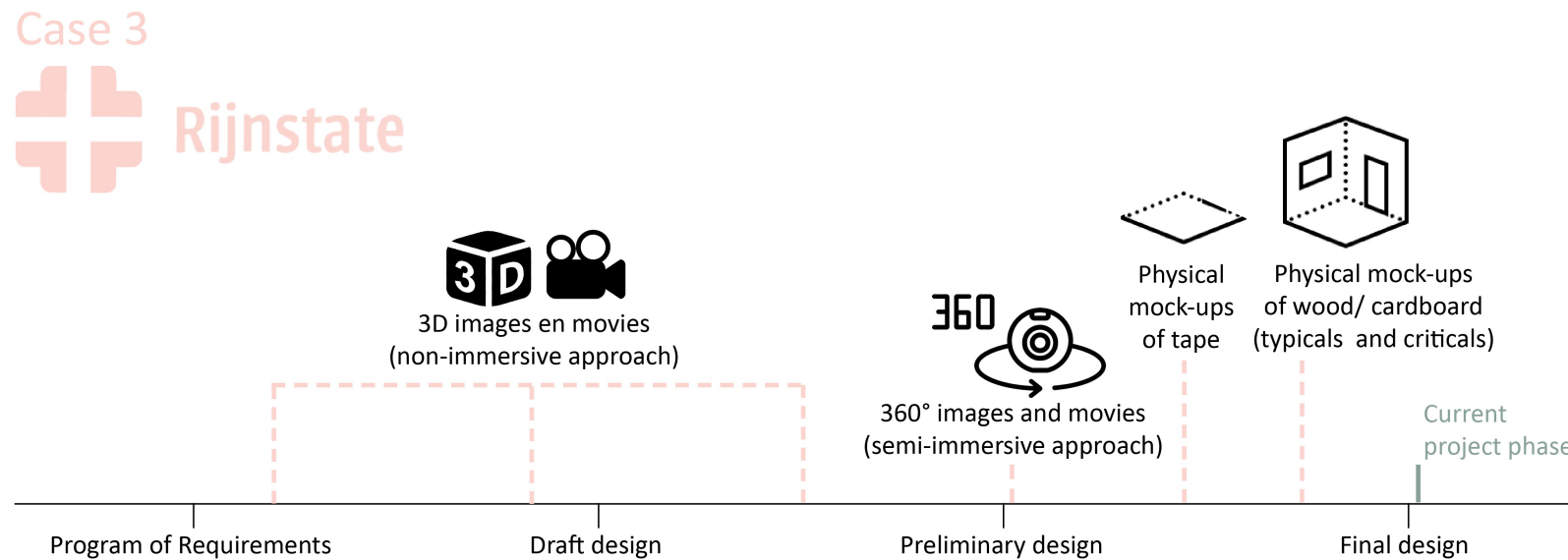
Q3. When in the design process of hospital (re)construction projects are the visualisation tools used?



Q3. When in the design process of hospital (re)construction projects are the visualisation tools used?



Q3. When in the design process of hospital (re)construction projects are the visualisation tools used?



Who made use of the tools: - - - - The involved hospital stakeholders