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Acceptance and B2C Market Potential of Smart Home-Based AAL Solutions for Elderly Care from an Energy Provider's Perspective

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Agenda

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1 Motivation & research questions

2 Data & methodology

3 Results

4 Implications & conclusion

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Problem

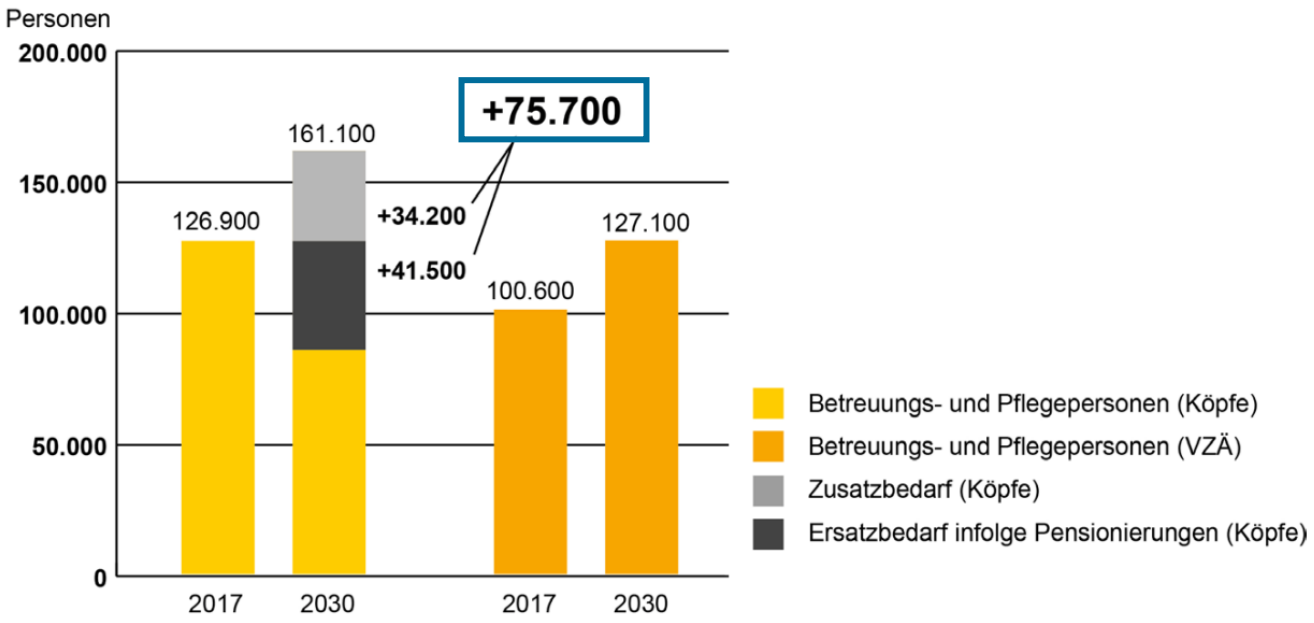
The aging population keeps increasing, and with that the frequency of chronic diseases, while at the same time, a lack of healthcare personnel exists.

WACHSENDER PERSONAL-BEDARF: PLUS 75.700 BIS 2030

41.500 Betreuungs- und Pflegepersonen als Ersatz für Pensionierungen

34.200 zusätzlich aufgrund des demographischen Wandels

Anzahl Betreuungs- bzw. Pflegepersonen in VZÄ/Köpfen in den Jahren 2017 und 2030



Quelle: GÖG, Pflegepersonal-Bedarfsprognose für Österreich, BMASGK, S. 42, 2019

Sources: Schwarzmair (2019), Chand & Tung (2014), Hilfswerk (2020), Jaschinski et al. (2021), Kroisleitner (2019), Böhmer (2021), Weichhart (2022), WHO (2021a)

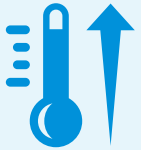
Solutions

1. Increase in healthcare personnel by providing more incentives such as higher salaries or better working conditions → not sufficient

2. Technologies suitable for elderly care such as smart home-based Ambient Assisted Living (AAL) solutions

Activity detection using a smart meter

Fall detection sensors



Environmental monitoring sensors
(add-on)

<5% of people aged 65-74 used smart home solutions in 2019
(Statistik Austria, 2019)

Despite the potential that lies within smart home-based AAL solutions, they have been scarcely adopted so far – **WHY?**

Objective and research questions

The objective is to **analyze the demand side of the smart home-based elderly care market**. The aim is to assess the acceptance and market potential of such technologies in the B2C market. Attention will be paid to the three technologies presented before.

Research question 1

Which factors impact the adoption of smart home-based AAL solutions from the perspective of the (potential) end-users?

Research question 2

What influences the willingness to pay for smart home-based AAL solutions from the perspective of the (potential) end-users?

Research question 3

What (potential) end-user segments can be identified that share similar preferences for smart-home based AAL solutions?

Methodology

Literature review

- Evolution of technology acceptance & adoption theories and their application in recent research
- Collection and evaluation of most common factors impacting the acceptance & adoption

Survey

- Web-based **survey** including a choice-based conjoint experiment
- Survey was pretested with a sample of N = 15
- Survey was conducted in **May 2022** via a market institute (market research company)
- **n = 316** respondents above the age of 59 living in the Greater Vienna Area filled in the survey

1. Questionnaire to assess socio-demographics (age, gender, care provision/reception etc.)
2. Short video on AAL solutions
3. Assessment of opinion on AAL technologies using Likert scales (adapted from Jaschinski et al. (2021) and Offermann-van Heek & Ziefle (2019))
4. Choice-based conjoint analysis tasks

Conjoint analysis: attributes and levels

Attributes	Levels
Product	▪ 3 fall detection sensors for three rooms ▪ Activity detection using smart meter ▪ 3 fall detection sensors for three rooms in combination with a sensor for environmental monitoring ▪ Activity detection using smart meter in combination with a sensor for environmental monitoring
Monthly service fee	▪ 10 € ▪ 20 € ▪ 30 € ▪ 40 €
Purchase price	▪ 0 € ▪ 100 € ▪ 200 € ▪ 300 €
Provider	▪ Private technology company ▪ Public energy supplier ▪ Private energy supplier ▪ Public care organization ▪ Private care organization
Data sharing	▪ With person(s) of choice ▪ With nursing staff ▪ With both person(s) of choice and nursing staff ▪ With nobody
Data storage	▪ 1 week ▪ 1 month ▪ 1 year ▪ None

With regards to prices and fees, dependencies were included so that the two cheapest or the two most expensive options would not be offered jointly

Conjoint analysis: illustrative example

Product	3 fall detection sensors for three rooms	Activity detection using smart meter	3 fall detection sensors for three rooms + a sensor for environmental monitoring
Monthly service fee	20 €	10 €	40 €
Purchase price	200 €	300 €	0 €
Provider	Private care organization	Public energy supplier	Private technology company
Data sharing	With nobody	With nursing staff	With person(s) of choice
Data storage	1 week	1 year	None
I would not choose any of these options			

Each respondent answered 12 of these choice tasks with 3 options and a none-option

Final sample descriptives

n=316		
Gender = female	47.5	%
Age mean	69.5	y.o.
Wi-Fi connection at home	92.1	%
Average household size	1.7	ppl.
Living in Vienna	78.2	%
Providing long-term care either to relatives, friends, or neighbors	20.3	%
Receiving long-term care from either relatives, friends and/or nursing staff	9.5	%
Experience with AAL	3.8	%
Informed oneself about AAL	9.5	%

Results: RQ1: Factors explaining the intention to adopt AAL solutions

1. **Descriptives:**
   - Although **general perception (3.65)** and **benefits (4.24)** received relatively high values, the **intention to use AAL technologies was rather low (2.89),** indicating that the respondents neither completely agreed nor completely disagreed

2. **Multiple linear regression:** explaining *intention to use AAL* through 17 independent variables
   - Adjusted R Square = 0.547
   - Significance: <.001
   - Significant variables:
     - **Personal norm (+),**
     - **General perception (+),**
     - **Social norm (+),**
     - **Perceived behavioral control (+)**

Latent variables	Mean	SD	Minimum	Maximum
Intention to use AAL	2.89	0.89	1	5
General perception	3.65	0.80	1	5
Social norm	2.84	1.08	1	5
Personal norm	3.37	0.99	1	5
Perceived behavioral control	3.30	0.80	1	5
Benefits	4.24	0.67	1	5
Barriers	3.40	0.98	1	5

Table 4: Mean, standard deviation and range of the latent variables (1=Disagree, 2=Rather disagree, 3=Neither nor, 4=Rather agree, 5=Agree)

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
1 (Constant)	.181	0.567		.319	.750
Age	-0.007	.006	-.047	-1.175	.241
Household size	.048	.058	.034	.822	.412
Physical health status	.033	.045	.037	.744	.458
Mental health status	0.36	.045	.039	.808	.420
Experience with AAL / informed (binary)	0.081	.107	.031	.760	.448
Care reception (binary)	-.027	.134	-.009	-.200	.842
Care provision (binary)	.014	.095	.006	.144	.885
Residence in Vienna (binary)	.040	.085	.019	.473	.636
Gender	.011	.074	.006	.154	.878
Academic (binary)	.067	.081	.033	.820	.413
Internet (binary)	-.379	.307	-.048	-1.237	.217
Personal norm	.153	.038	.172	3.997	<.001
Benefits	-.006	.069	-.005	-.093	.926
Barriers	-.007	.041	-.008	-.169	.866
General perception	.412	.064	.373	6.406	<.001
Social norm	.251	.036	.307	6.912	<.001
Perceived behavioral control	.176	.054	.160	3.265	.001

Table 7: Multiple linear regression table of coefficients

Results: RQ1: Factors explaining the intention to adopt AAL solutions

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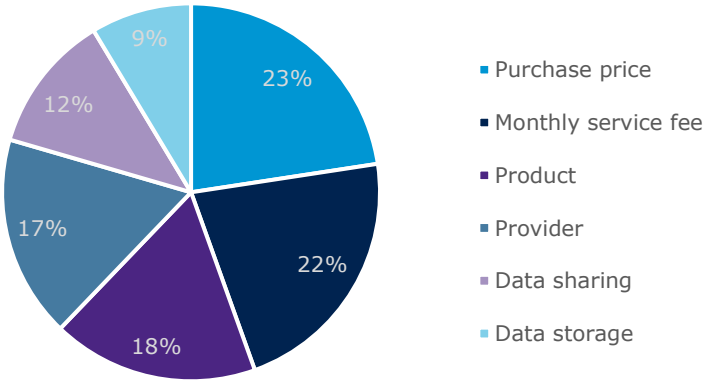
3. Hierarchical Bayes estimations to identify importance of attributes



- **Fall detection sensors** were most preferred
- As a provider, **public energy supplier ranked third** with a utility close to zero
- With regards to data-sharing, **person(s) of choice** was most preferred
- No data storage was most preferred

Attributes and levels	Average utilities	SD
Product (relative importance = 17.66)		**9.93**
Three fall detection sensors for three rooms	20.33	48.97
Three fall detection sensors for three rooms in combination with a sensor for environmental monitoring	28.50	44.58
Activity detection using a smart meter	-30.72	43.21
Activity detection using a smart meter in combination with a sensor for environmental monitoring	-18.11	46.34
Monthly service fee (relative importance = 21.93)		**7.68**
10 €	58.42	30.09
20 €	42.39	27.92
30 €	-37.76	30.34
40 €	-63.05	29.68
Purchase price (relative importance = 22.59)		**9.29**
0 €	77.36	43.51
100 €	1.34	22.38
200 €	-33.76	18.05
300 €	-44.94	29.94
Provider (relative importance = 17.33)		**7.03**
Private technology company	-38.00	34.51
Public energy supplier	-0.95	32.42
Private energy supplier	-9.95	33.62
Private care organization	13.71	30.75
Public care organization	35.19	35.62
Data sharing (relative importance = 11.87)		**5.90**
With nursing staff	-6.21	24.91
With person(s) of your choice	26.30	20.52
With nursing staff and person(s) of your choice	7.98	25.98
With nobody	-28.07	26.67
Data storage (relative importance = 8.63)		**3.47**
None	16.49	21.38
One week	1.75	15.11
One month	-10.52	20.22
One year	-7.71	18.40
None	**243.57**	**279.72**

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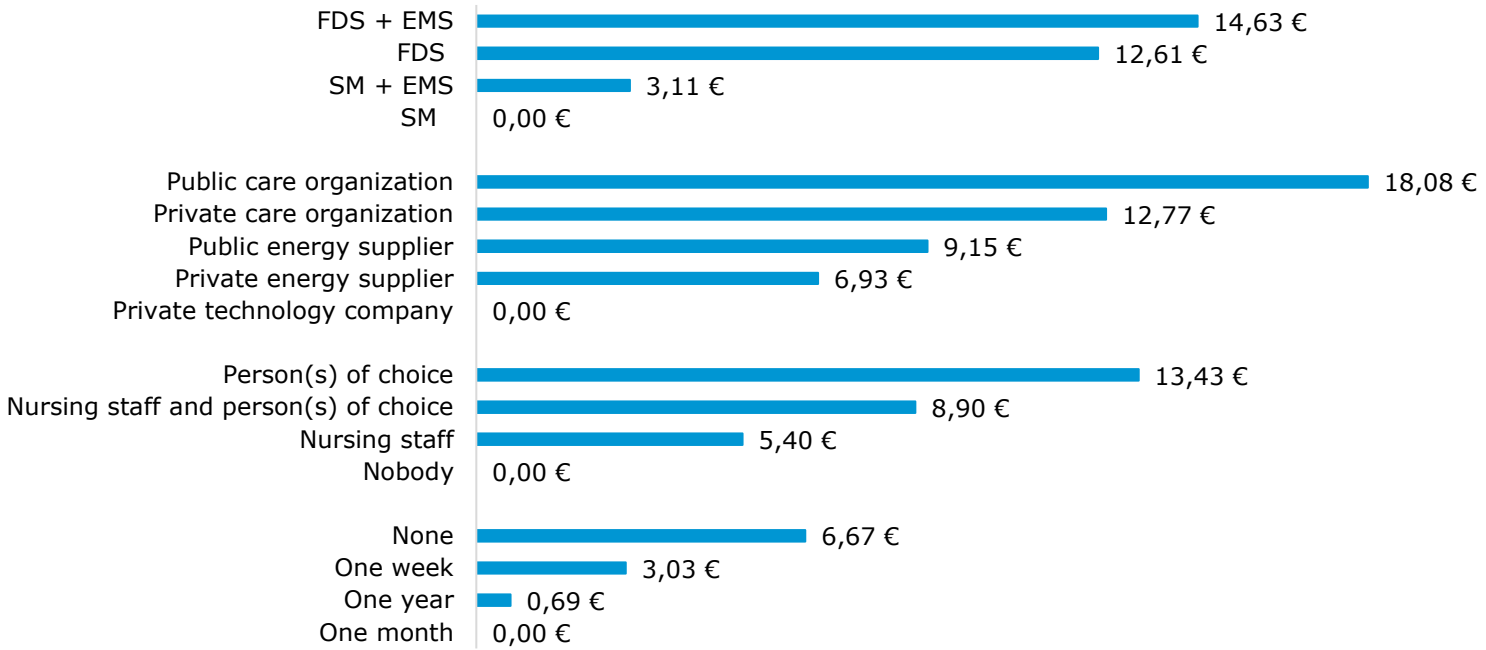
Results: RQ2: Willingness to pay for AAL solutions

The indirect willingness to pay was assessed using this formula*: $WTP\left(u_{ij}\right) = \left(u_{ij} - u_{ij\,Default}\right) * \frac{p_{max} - p_{min}}{u_{pj\,max} - u_{pj\,min}}$



Respondents were **willing to pay > 4x for fall detection sensors (FDS) as opposed to activity detection using a smart meter (SM)**. Further, they would have paid twice the amount for public care organization as provider as opposed to public energy supplier.

*Source: Orme, 2010; Salm et al., 2016
u = part-worth utility, i = attribute, j = level, p = price

Results: RQ3: Customer segments sharing similar preferences

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1. Description and preferences of segments:

	Non-adopters	Price-sensitives	Early adopters
Segment size	n=130 41.1%	n=91 29%	n=95 29.9%
Product	22.19	15.38	16.44
Monthly service fee	19.85	**23.07**	28.98
Purchase price	18.66	**26.20**	17.16
Provider	21.60	15.78	15.36
Data sharing	7.84	15.17	16.65
Data storage	9.86	4.41	5.42
None	**534.42**	118.73	**-341.78**

- The **non-adopters** chose in the majority of cases the none-option
- The **price-sensitives** indicated that especially (a low) purchase price was important to them, followed by (a cheap) monthly service fee
- The **early adopters** most often chose one of three presented technologies

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Results: RQ3: Customer segments sharing similar preferences

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2. Differences among the three segments:

Variable	Sample	Non-adopters	Price-sensitives	Early adopters	Sig.
	n=316	n=130	n=91	n=95	
Demographic variables					
Age	69.52	68.82	70.29	69.76	-
Gender (female)	47.5%	44.6%	46.15%	52.63%	-
Academic	26.27%	23.08%	26.37%	30.53%	-
Long-term care provision	20.25%	23.08%	17.58%	18.95%	-
Long-term care reception	9.50%	9.23%	10.99%	8.42%	-
Household size	1.7	1.65	1.65	1.81	-
Experience with AAL	13.3%	11.54%	14.29%	14.74%	-
Residence (Vienna)	78.2%	78.46%	81.32%	74.74%	-
Physical health status	2.40	2.40	2.44	2.35	-
Mental health status	1.96	2.11	1.90	1.80	0.05
Physical health status of care-receiving person	3.19 (n=64)	3.37 (n=30)	3.00 (n=16)	3.06 (n=18)	-
Mental health status of care-receiving person	3.69 (n=64)	3.73 (n=30)	3.56 (n=16)	3.72 (n=18)	-
Socio-psychological variables					
Intention to use AAL	2.89	2.51	3.08	3.22	<0.001
General perception	3.65	3.39	3.77	3.88	<0.001
Social norm	2.84	2.51	2.95	3.20	<0.001
Personal norm	3.37	3.17	3.51	3.51	0.009
Perc. behavioral control	3.30	3.05	3.37	3.56	<0.001
Benefits	4.24	4.01	4.38	4.41	<0.001
Barriers	3.40	3.54	3.57	3.05	<0.001

Table 11: Descriptives of the sample and the segments and significance level of difference between the three groups; the health status variables range from 1-5, with 1 indicating a very good and 5 a bad health status

The three segments showed significant differences regarding some variables.

The early adopters had significantly higher values for:

- intention to use AAL,
- general perception,
- social norm,
- personal norm,
- perceived behavioral control, and
- benefits.

They had significantly lower values for:

- mental health status, and
- barriers.

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Summary key findings and implications

Key findings

- Rather low acceptance of smart home-based AAL technologies
- The likelihood of adoption was explained through the opinion on AAL technologies of people of importance, the perception of oneself as a user of technologies for well-being and health, the confidence in learning to use AAL, and the general attitude toward these technologies
- Fall detection sensors were most preferred
- Public care organizations were most preferred as provider
- With regards to data sharing, person(s) of choice was the most popular option

Key implications

- Challenge when entering the market; it might make sense to test new AAL products/services in more controlled environments such as nursing homes (B2B2C)
- Elderly people might be more likely to adopt AAL solutions when people of importance and/or trust promote the usage of AAL solutions and assist them in the adoption process, which might lead to elders establishing more confidence in using AAL technologies; therefore, marketing should also address people of importance/trust
- As new entrants on the market, companies are well-advised offering fall detection sensors in a first step
- It might make sense to cooperate with one such organization. Further, they have the most experience with the needs of this customer group
- Providers should let people choose who can access their data/who is a contact person in case of emergencies and generally tailor their products to the elders' preferences

Thank you!

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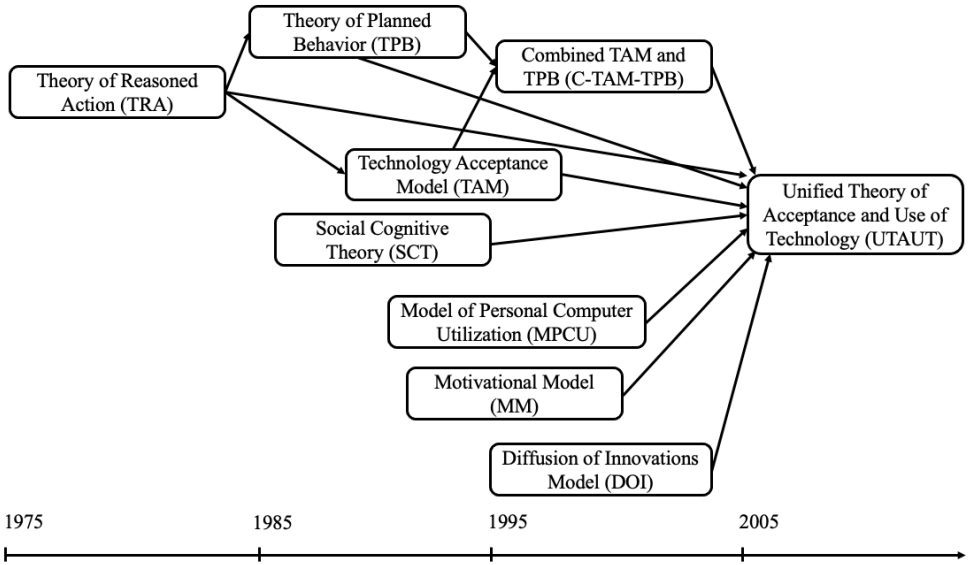
Abstract

The constantly growing aging population and the rising frequency of chronic diseases indicate an **increasing need for healthcare services** in the near future. Since a lack of personnel in the healthcare sector already exists, other solutions such as **smart home-based Ambient Assisted Living (AAL) technologies** for elderly care purposes are promising. However, AAL has been scarcely adopted so far. Thus, the aim is to assess the **acceptance and B2C market potential** of selected smart home-based AAL solutions for elderly care purposes from the perspective of **an energy provider**. A survey (n=316) was conducted in May 2022, assessing socio-psychological factors as well as preferences for two different AAL solutions through a choice-based conjoint analysis. The results suggest that **fall detection sensors** enjoyed a higher acceptance among the participants compared to activity detection using a smart meter. The likelihood of adoption was explained through the opinion on AAL technologies of people of importance, the perception of oneself as a user of technologies for well-being and health, the confidence in learning to use AAL, as well as the general attitude toward these technologies. Overall, though, the respondents were **rather reluctant to adopt AAL technologies**, representing a challenge to (potential) providers, which could be met through cooperating with organizations who are familiar with this market, i.e. care organizations and technology companies, and by adjusting the product and its related service to the elders' preferences and needs.

Theoretical background

Common theories

- Research fields: information systems, psychology, and sociology
- Explaining behavioral intention and/or usage behavior
- Most accurate: UTAUT & TAM
- Focus mainly on pre-implementation phase



Theories in literature in the context of smart home-based technologies for elderly care purposes

- 5 review papers and 4 papers published in 2021 were compared
- Majority of (reviewed) papers did not build upon a theoretical framework
- Focus mostly on pre-implementation
- 6 overarching factor categories were found to influence the adoption:

Environmental factors	**Individual factors**	**Psychological factors**
Intervention factors	**Technology factors**	**Support & training factors**

Sources: Alkhwaldi & Kamala (2017), Venkatesh et al. (2003, Jaschinski et al. (2021), Samaradiwakara & Gunawardena (2014), Peek et al. (2014), Vichitvanichphong et al. (2018), Kavandi & Jaana (2020), Li et al. (2021), Choukou et al. (2021), Ghorayeb et al. (2021), Jo et al. (2021), Wilkowska et al. (2021)

Latent variables - items

Variables	Items	Example item	Cronbach's Alpha	Adapted from
Intention to use AAL technology	4	In the future, I intend to use AAL technologies.	α = 0.894	Jaschinski et al. (2021)
General perception	4	I find AAL technologies valuable.	α = 0.871	Offermann-van Heek & Ziefle (2019)
Social norm	3	Most people who influence me would approve of me using AAL technologies.	α = 0.971	Jaschinski et al. (2021)
Personal norm	3	I view myself as a user of technologies for my health and well-being.	α = 0.695	Jaschinski et al. (2021)
Perceived behavioral control	4	I would be able to use AAL technologies.	α = 0.718	Jaschinski et al. (2021)
Benefits	6	AAL enables an increased independency.	α = 0.938	Offermann-van Heek & Ziefle (2019)
Barriers	6	One disadvantage of AAL technologies is the invasion in privacy.	α = 0.917	Offermann-van Heek & Ziefle (2019)

Attribute importance scores and attribute level utilities per segment

Attributes and levels	Non-adopters	Price-sensitive	Early adopters
Segment size	n=130 41.4%	n=91 29%	n=95 29.9%
Product	**22.19**	**15.38**	**16.44**
Three fall detection sensors	-84.34	41.52	-1.76
Three fall detection sensors + a sensor for environmental monitoring	48.83	34.42	51.52
Activity detection using smart meter	47.70	-50.76	-47.10
Activity detection using smart meter + a sensor for environmental monitoring	12.19	-25.19	-2.66
Monthly service fee	**19.85**	**23.07**	**28.98**
10 €	54.80	71.27	77.70
20 €	-8.76	31.23	26.90
30 €	-64.28	-35.37	-8.42
40 €	18.24	-67.12	-96.18
Purchase price	**18.66**	**26.20**	**17.16**
0 €	19.36	96.97	55.50
100 €	-78.56	11.96	26.66
200 €	25.78	-48.71	-34.70
300 €	33.42	-60.22	-47.45
Provider	**21.60**	**15.78**	**15.36**
Private technology company	-68.44	-39.26	-23.30
Public energy supplier	40.42	-3.98	25.35
Private energy supplier	61.16	-20.33	-46.46
Private care organization	-59.84	8.16	-1.30
Public care organization	26.70	55.41	45.71
Data sharing	**7.84**	**15.17**	**16.65**
With nursing staff	-19.89	-9.56	0.74
With person(s) of your choice	23.45	40.50	35.06
With nursing staff and person(s) of your choice	-23.57	19.59	29.02
With nobody	20.02	-50.53	-64.82
Data storage	**9.86**	**4.41**	**5.42**
None	36.08	17.08	14.85
One week	-13.02	1.34	0.58
One month	0.01	-9.36	-17.64
One year	-23.07	-9.07	2.21
None	**534.42**	**118.73**	**-341.78**

Results: RQ2: Willingness to pay for AAL solutions

The indirect willingness to pay was assessed using this formula: $$WTP\,(u_{ij}) = (u_{ij} - u_{ij\,Default}) * \frac{p_{max} - p_{min}}{u_{pj\,max} - u_{pj\,min}}$$

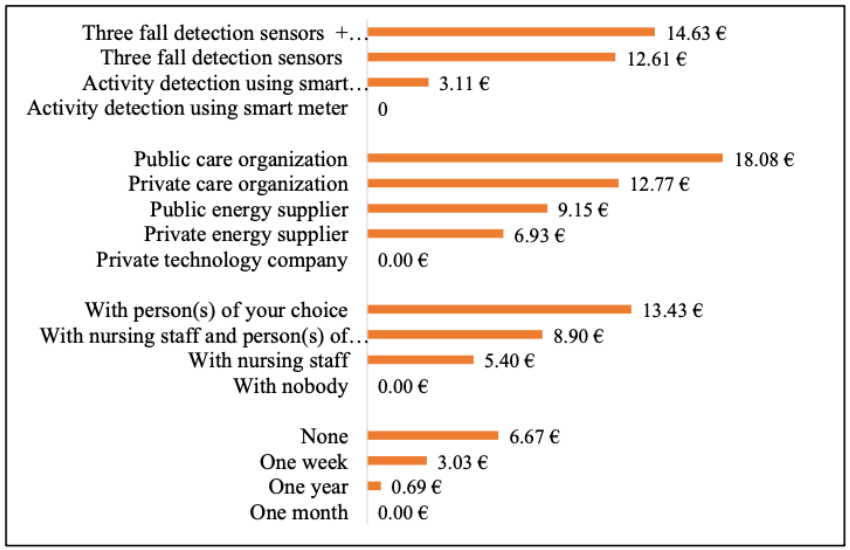


Figure 8: Indirect willingness to pay based on monthly service fee for individual attribute levels (relative to default)

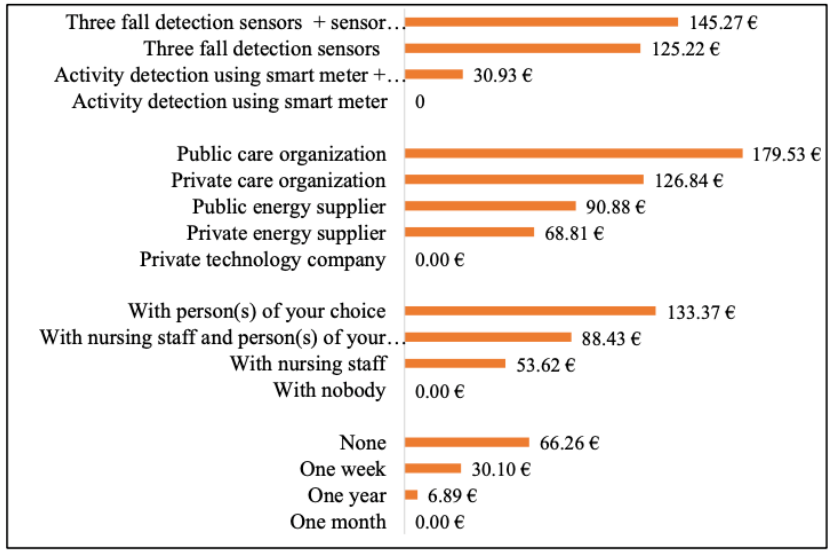


Figure 9: Indirect willingness to pay based on purchase price for individual attribute levels (relative to default)

Respondents were **willing to pay four times as much for fall detection sensors as opposed to activity detection using a smart meter**. Further, they would have paid twice the amount for public care organization as provider as opposed to public energy supplier.

Results: RQ3: Customer segments sharing similar preferences

Sensitivity analysis at segment level: fall detection sensors

- **Assumption: no competitive products** on the market
- **45.1%** of the respondents would have chosen the base case product consisting of:
  - Three fall detections sensors + a sensor for environmental monitoring
  - 30€ monthly service fee
  - No purchase price
  - Data sharing with person(s) of choice
  - No data storage

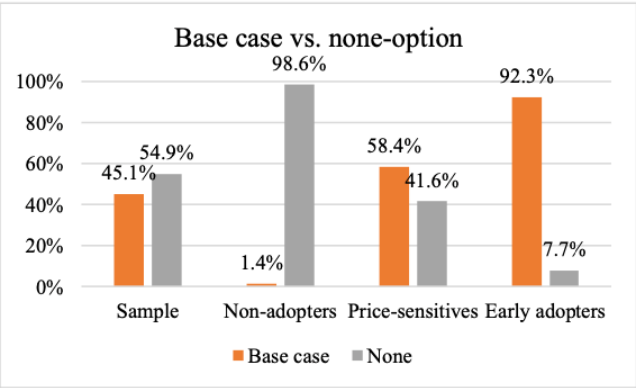


Figure 10: Market simulation with no competition (FDS + EMS)

Altering the attribute levels one at a time to see how the share of preferences change:

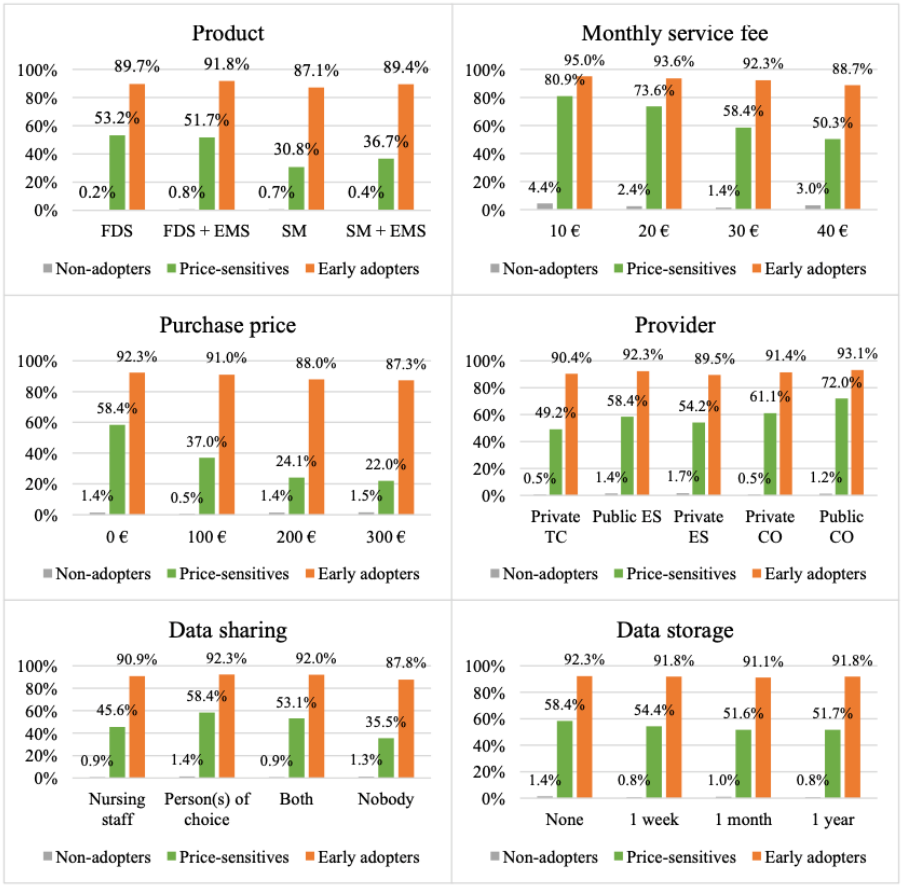
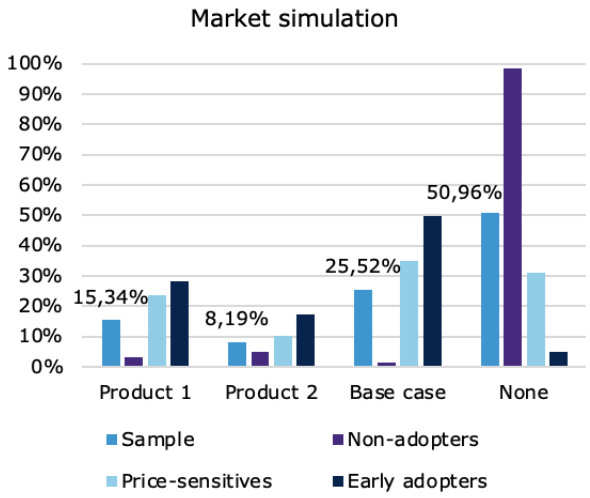


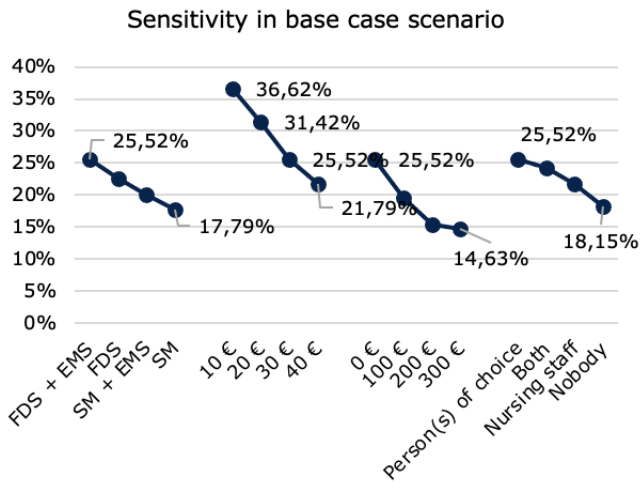
Figure 11: Summary of sensitivity analyses on a segment level using fall detection sensors as base case product (share of preference); FDS = fall detection sensors, EMS = sensor for environmental monitoring, SM = smart meter, TC = technology company, ES = energy supplier, CO = care organization

Results: RQ3: Customer segments sharing similar preferences

Sensitivity analysis at segment level: fall detection sensors

- **Assumption: two competitive products** on the market charging a **monthly service fee**
- **25.5%** of the respondents would have chosen the base case product consisting of:
  - Three fall detections sensors + a sensor for environmental monitoring
  - 30€ monthly service fee
  - No purchase price
  - Data sharing with person(s) of choice



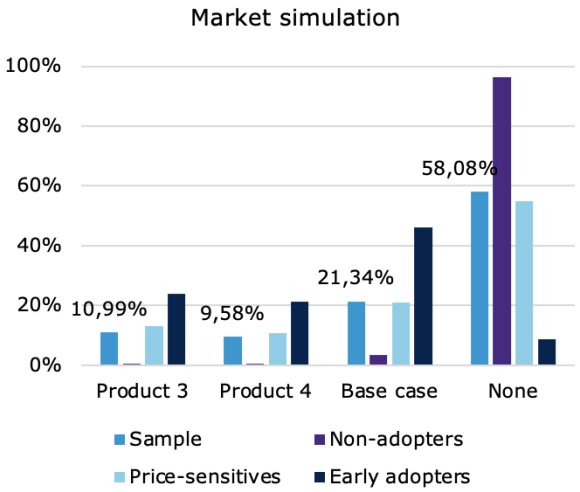


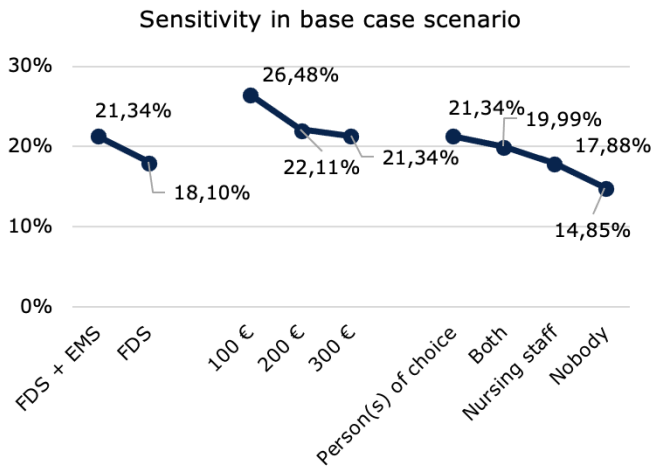
Market simulation with competitors charging a monthly service fee (randomized first choice)
Product 1: 3 FDS, 30€ monthly service fee, no purchase price, private technology company, person(s) of choice
Product 2: 3 FDS, 40€ monthly service fee, no purchase price, private technology company, nursing staff
Base case: 3 FDS + EMS, 30€ monthly service fee, no purchase price, public energy provider, person(s) of choice

Results: RQ3: Customer segments sharing similar preferences

Sensitivity analysis at segment level: fall detection sensors

- **Two competitive products** on the market charging a **purchase price**
- **21.3%** of the respondents would have chosen the base case product consisting of:
  - Three fall detections sensors + a sensor for environmental monitoring
  - No monthly service fee
  - 300€ purchase price
  - Data sharing with person(s) of choice





Market simulation for providers with a purchase price (randomized first choice)
Product 3: 1 FDS, no monthly service fee, 200€ purchase price, private technology company, person(s) of choice
Product 4: 1 FDS, no monthly service fee, 300€ purchase price, private technology company, person(s) of choice
Base case: 1 FDS + EMS, no monthly service fee, 300€ purchase price, public energy provider, person(s) of choice

Results: RQ3: Customer segments sharing similar preferences

Sensitivity analysis at segment level: activity detection using a smart meter

- **No competitive products** on the market
- **37.6%** of the respondents would have chosen the base case product consisting of:
  - Activity detection via a smart meter + a sensor for environmental monitoring
  - 30€ monthly service fee
  - No purchase price
  - Data sharing with person(s) of choice
  - Data storage of one year

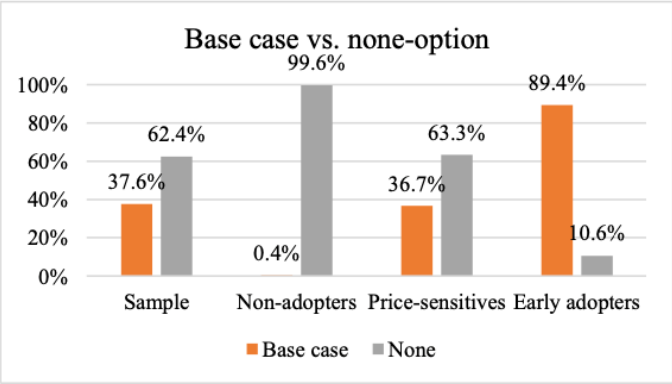


Figure 14: Market simulation with no competition (SM + EMS)

Altering the attribute levels one at a time to see how the share of preferences change:

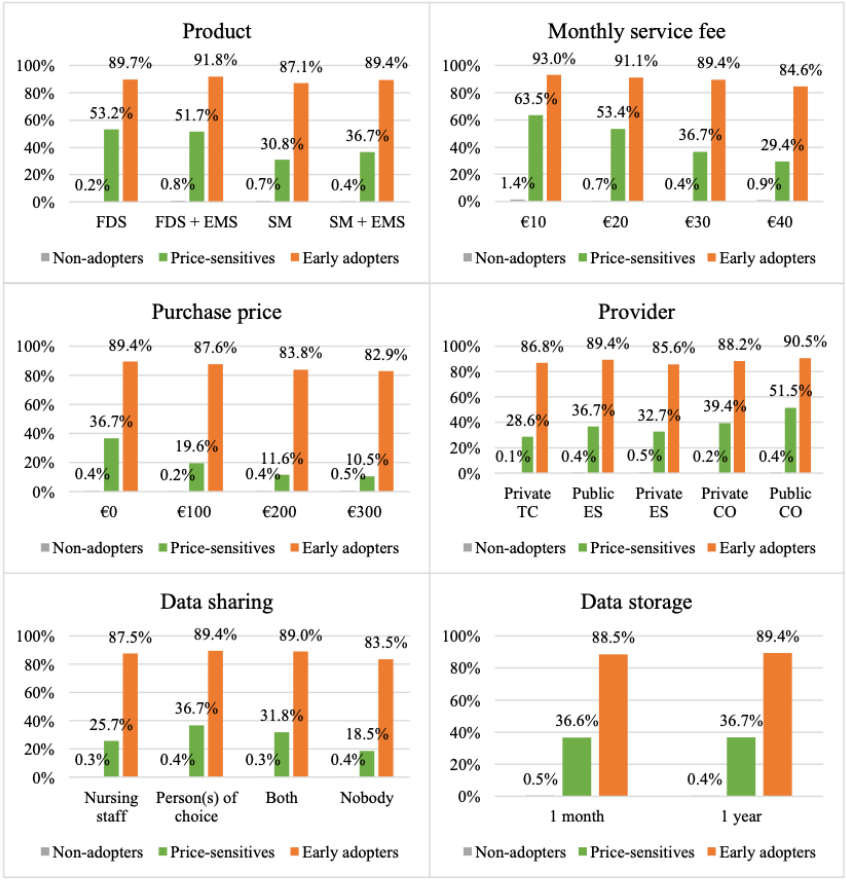


Figure 15: Summary of sensitivity analyses on a segment level using activity detection via a smart meter as base case product (share of preference); FDS = fall detection sensors, EMS = sensor for environmental monitoring, SM = smart meter, TC = technology company, ES = energy supplier

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