

APPENDIX to “Robots and Labor in Nursing Homes”

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Appendix A. Illustrations of nursing care robot types in Japan



Prof. Sankai, University of Tsukuba / CYBERDYNE Inc.

Figure 1A. Transfer aid robot, wearable (Cyberdyne).

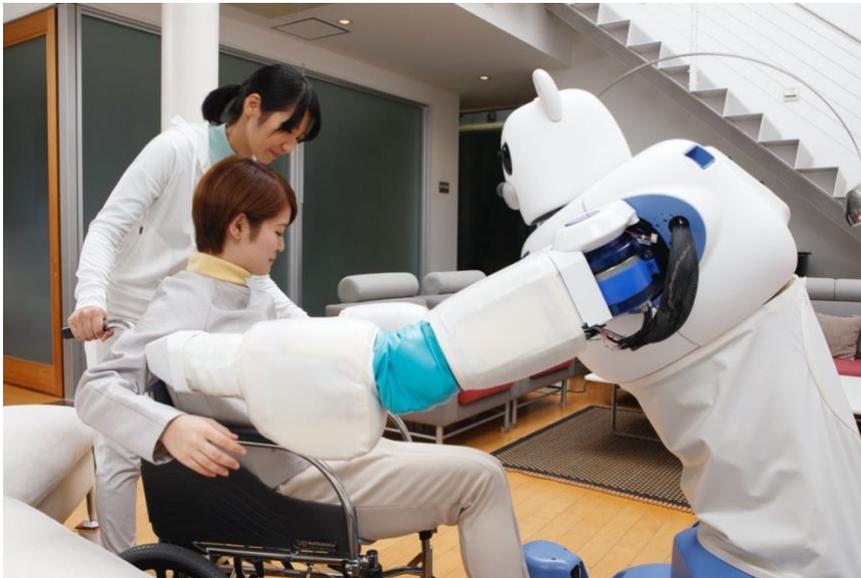


Figure 1B. Transfer aid robot, not wearable. Photo credit to © RIKEN.



Figure 2A. Monitoring robot (silhouette monitoring sensor). Photo credit to KINGSECURITY.

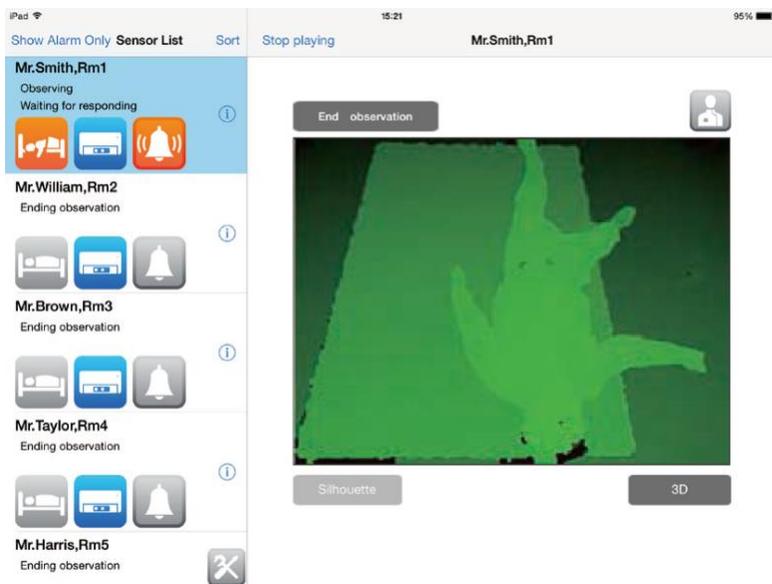


Figure 2B. Monitoring robot (silhouette monitoring sensor). Photo credit to KINGSECURITY.



Figure 3. Communication robot. Photo credit to FUJI SOFT INCORPORATED.

Appendix Table 1. Occupation mix (nurse to care worker ratio)

	(2)	(3)	(4)	(5)
	Nurses/Care workers			
	Total	Non-regular	Regular	Full-time equivalent
<i>Panel A: Robot adoption</i>				
Adopt robots	0.00774 (0.00663)	0.00804 (0.0573)	0.00108 (0.00728)	0.0382 (0.0340)
Nursing home and year FEs	Yes	Yes	Yes	Yes
Control variables	No	No	No	No
Observations	517	472	517	517
R-squared	0.005	0.000	0.000	0.025
Mean of dep. var.	0.159	0.331	0.138	0.146
<i>Panel B: Robot adoption</i>				
Adopt robots	0.00736 (0.00726)	0.0371 (0.0636)	-0.00247 (0.00809)	0.0415 (0.0304)
Nursing home and year FEs	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes
Observations	468	427	468	468
R-squared	0.122	0.111	0.105	0.199
Mean of dep. var.	0.159	0.335	0.137	0.146
<i>Panel C: Number of robots</i>				
Log(number of robots)	0.00283 (0.00235)	-0.00625 (0.0206)	0.000833 (0.00247)	0.00123 (0.00225)
Nursing home and year FEs	Yes	Yes	Yes	Yes
Control variables	No	No	No	No
Observations	489	445	489	489
R-squared	0.006	0.001	0.001	0.002
Mean of dep. var.	0.160	0.333	0.138	0.142
<i>Panel D: Number of robots</i>				
Log(number of robots)	0.00339 (0.00254)	0.00119 (0.0242)	-0.00138 (0.00264)	0.00260 (0.00168)
Nursing home and year FEs	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes
Observations	447	407	447	447
R-squared	262	248	262	262
Mean of dep. var.	0.159	0.336	0.137	0.142

Notes: All regressions include nursing home and year fixed effects, and control variables. Control variables include resident case-mix controls for the log number of residents with care levels 1-3, 4, and 5; technology adoption controls for each non-robot technology used in the nursing homes; management practices control for human resource management practices; and Covid-19 prevalence controls including cases and deaths. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 2. Pooled OLS results for total employment and care staffing

	(1)	(2)	(3)	(4)	(5)
	Log(total employees)	Log(caregivers)			Full-time equivalent
		Total	Non-regular	Regular	
<i>Panel A: Robot adoption</i>					
Adopt robots	0.0518** (0.0211)	0.0655*** (0.0214)	0.0567 (0.0774)	0.0490** (0.0234)	0.0317 (0.0229)
Observations	468	468	468	468	468
R-squared	0.624	0.669	0.281	0.605	0.664
<i>Panel B: Robot adoption by type</i>					
Adopt monitoring robots	0.0445** (0.0213)	0.0560** (0.0225)	0.0859 (0.0794)	0.0465** (0.0233)	0.0522** (0.0241)
Adopt mobility robots	0.0272 (0.0257)	0.0454* (0.0272)	0.135 (0.102)	0.00864 (0.0284)	0.0208 (0.0291)
Adopt transfer robots	-0.0202 (0.0277)	-0.0107 (0.0299)	-0.0911 (0.111)	-0.0245 (0.0306)	-0.0247 (0.0312)
Observations	468	468	468	468	468
R-squared	0.625	0.672	0.287	0.606	0.668
<i>Panel C: Number of robots</i>					
Log(number of robots)	0.0149** (0.00684)	0.0234*** (0.00683)	0.0198 (0.0273)	0.0160** (0.00723)	0.0131* (0.00721)
Observations	447	447	447	447	447
R-squared	0.626	0.675	0.287	0.609	0.675
<i>Panel D: Number of robots by type</i>					
Log(number of monitoring robots)	0.0119 (0.00743)	0.0186** (0.00797)	0.00582 (0.0298)	0.0201** (0.00801)	0.0144* (0.00827)
Log(number of mobility robots)	0.0206 (0.0145)	0.0315* (0.0164)	0.108* (0.0613)	-0.00115 (0.0172)	0.0136 (0.0169)
Log(number of transfer robots)	-0.00642 (0.0168)	-3.70e-05 (0.0194)	0.00707 (0.0713)	-0.0284 (0.0185)	-0.0191 (0.0173)
Observations	447	447	447	447	447
R-squared	0.628	0.678	0.293	0.612	0.677

Notes: All regressions include control variables and a year dummy variable. Control variables include facility characteristics including years of operation, facility type, and location; resident case-mix controls for the log number of residents with care levels 1-3, 4, and 5; technology adoption controls for each non-robot technology used in the nursing homes; management practices control for human resource management practices; Covid-19 prevalence controls including cases and deaths; and prefecture economic and demographic characteristics. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 3. Robustness tests for total employment and care staffing

	(1)	(2)	(3)	(4)	(5)
	Log(total employees)	Log(caregivers)			Full-time equivalent
		Total	Non-regular	Regular	
<i>Panel A: Balanced panel sample with non-missing information on the number of robots in use</i>					
Adopt robots	0.0587*** (0.0214)	0.0757*** (0.0252)	0.151** (0.0697)	0.0232 (0.0307)	0.0341 (0.0221)
Observations	410	410	410	410	410
R-squared	0.229	0.216	0.203	0.158	0.205
Mean of dep. var.	4.019	3.636	1.960	3.426	3.516
Log(number of robots in use)	0.0240*** (0.00790)	0.0296*** (0.00944)	0.0510* (0.0262)	0.0136 (0.0113)	0.0194*** (0.00705)
Observations	410	410	410	410	410
R-squared	0.242	0.226	0.200	0.166	0.225
Mean of dep. var.	4.019	3.636	1.960	3.426	3.516
<i>Panel B: Balanced panel sample with non-decreasing number of robots in use</i>					
Adopt robots	0.0760*** (0.0243)	0.0884*** (0.0296)	0.172** (0.0821)	0.0377 (0.0360)	-0.0226 (0.0480)
Observations	375	375	375	375	375
R-squared	0.278	0.261	0.197	0.185	0.268
Mean of dep. var.	4.017	3.641	1.953	3.435	3.514
Log(number of robots in use)	0.0400*** (0.0110)	0.0461*** (0.0135)	0.0896** (0.0376)	0.0227 (0.0162)	0.0243*** (0.00908)
Observations	354	354	354	354	354
R-squared	0.330	0.301	0.216	0.238	0.302
Mean of dep. var.	4.020	3.644	1.961	3.435	3.521
<i>Panel C: Sample of nursing homes with resident capacity below the median (60 people)</i>					
Adopt robots	0.0618 (0.0385)	0.0812 (0.0492)	0.0246 (0.0729)	0.0739 (0.0587)	-0.0602 (0.0698)
Observations	217	217	217	217	217
R-squared	0.353	0.337	0.410	0.289	0.306
Mean of dep. var.	3.799	3.362	1.688	3.172	3.211
Log(number of robots in use)	0.0220 (0.0186)	0.0296 (0.0245)	-0.0280 (0.0327)	0.0370 (0.0289)	0.00873 (0.0134)
Observations	207	207	207	207	207
R-squared	0.363	0.323	0.410	0.311	0.309
Mean of dep. var.	3.800	3.364	1.680	3.175	3.221
<i>Panel D: Sample of nursing homes with resident capacity above the median (60 people)</i>					
Adopt robots	0.0376** (0.0177)	0.0558*** (0.0171)	0.275*** (0.0828)	-0.0345* (0.0190)	0.0314* (0.0170)
Observations	251	251	251	251	251
R-squared	0.219	0.175	0.291	0.269	0.166
Mean of dep. var.	4.201	3.870	2.181	3.649	3.768
Log(number of robots in use)	0.0270*** (0.00758)	0.0352*** (0.00748)	0.126*** (0.0342)	-0.00327 (0.00804)	0.0246*** (0.00714)
Observations	240	240	240	240	240
R-squared	0.277	0.262	0.329	0.314	0.244
Mean of dep. var.	4.203	3.870	2.198	3.646	3.768

Notes: All regressions include nursing home and year fixed effects, and control variables. Control variables include resident case-mix controls for the log number of residents with care levels 1-3, 4, and 5; technology adoption controls for each non-robot technology used in the nursing homes; management practices control for human resource management practices; and Covid-19 prevalence controls including cases and deaths. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix Table 4. Full results and falsification test excluding robot adoption

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Log(total employees)	Log(caregivers)			Log(total employees)	Log(caregivers)				
		Total	Non-regular	Regular	Full-time equivalent	Total	Non-regular	Regular	Full-time equivalent	
Adopt robot	0.0514*** (0.0189)	0.0650*** (0.0226)	0.137** (0.0623)	0.0199 (0.0270)	-0.00387 (0.0336)					
Log(capacity)	0.206 (0.126)	0.198 (0.133)	0.266 (0.297)	0.163 (0.167)	0.237 (0.147)	0.193 (0.122)	0.182 (0.132)	0.231 (0.285)	0.158 (0.167)	0.238* (0.144)
Lift(standing assistance)	-0.0276 (0.0196)	-0.0354* (0.0207)	-0.116 (0.0889)	-0.00636 (0.0214)	-0.0174 (0.0256)	-0.0230 (0.0194)	-0.0296 (0.0210)	-0.104 (0.0889)	-0.00458 (0.0210)	-0.0178 (0.0264)
Wheelchair lift for cars	0.0262** (0.0120)	0.00647 (0.0144)	0.0900* (0.0474)	-0.00128 (0.0136)	-0.00805 (0.0163)	0.0249** (0.0123)	0.00485 (0.0148)	0.0866* (0.0492)	-0.00178 (0.0134)	-0.00796 (0.0161)
Adjustable bed	0.0241 (0.0297)	0.0426 (0.0268)	-0.122 (0.102)	0.0843** (0.0404)	0.0477 (0.0339)	0.0176 (0.0308)	0.0344 (0.0280)	-0.140 (0.103)	0.0818** (0.0407)	0.0482 (0.0346)
Wheelchair with built-in seat lift	-0.000396 (0.0212)	0.0124 (0.0236)	0.0820 (0.0803)	-0.00570 (0.0361)	-0.0209 (0.0357)	-0.00540 (0.0218)	0.00602 (0.0243)	0.0686 (0.0792)	-0.00763 (0.0364)	-0.0206 (0.0359)
Special bathtub (with side door)	-0.0417** (0.0194)	-0.0274 (0.0210)	-0.0675 (0.0623)	-0.0140 (0.0221)	-0.0160 (0.0247)	-0.0383** (0.0189)	-0.0232 (0.0201)	-0.0585 (0.0608)	-0.0127 (0.0216)	-0.0162 (0.0246)
Stretcher	0.00131 (0.0206)	0.00135 (0.0250)	-0.146* (0.0819)	0.0317 (0.0373)	-0.00828 (0.0310)	0.00699 (0.0201)	0.00854 (0.0241)	-0.131 (0.0815)	0.0339 (0.0368)	-0.00871 (0.0320)
Shower carry	-0.000310 (0.0203)	0.0164 (0.0252)	0.0284 (0.0716)	0.00601 (0.0290)	-0.0351 (0.0290)	0.00214 (0.0214)	0.0195 (0.0270)	0.0350 (0.0722)	0.00696 (0.0298)	-0.0353 (0.0298)
Lifting device (only for lifting)	0.00896 (0.0183)	-0.0132 (0.0209)	0.105 (0.0777)	-0.0458* (0.0261)	-0.0619 (0.0425)	0.0130 (0.0197)	-0.00812 (0.0222)	0.116 (0.0814)	-0.0443* (0.0260)	-0.0622 (0.0443)
Wheelchair scales	0.0209 (0.0218)	0.00288 (0.0269)	0.275*** (0.0915)	-0.0618** (0.0306)	0.136 (0.0959)	0.0103 (0.0200)	-0.0105 (0.0253)	0.247*** (0.0915)	-0.0659** (0.0291)	0.137 (0.101)
Standardized protocols for care	-0.00479 (0.0103)	0.0108 (0.0129)	0.000724 (0.0563)	0.0189 (0.0151)	0.0164 (0.0145)	0.00137 (0.0108)	0.0186 (0.0139)	0.0171 (0.0544)	0.0213 (0.0157)	0.0159 (0.0129)
Adjustable staffing	0.00825 (0.00951)	0.0112 (0.0107)	0.0446 (0.0410)	-0.000658 (0.0112)	0.0165 (0.0151)	0.00610 (0.00928)	0.00849 (0.0104)	0.0389 (0.0406)	-0.00149 (0.0110)	0.0166 (0.0158)
Problem resolution protocol	-0.00542 (0.00878)	7.82e-05 (0.00946)	-0.00859 (0.0342)	-0.00569 (0.0103)	0.00728 (0.0113)	-0.00801 (0.00868)	-0.00321 (0.00942)	-0.0155 (0.0344)	-0.00669 (0.0103)	0.00748 (0.0111)
Performance tracking	-0.0209** (0.00905)	-0.0251** (0.0107)	-0.0724* (0.0429)	-0.0166 (0.0115)	-0.0260* (0.0149)	-0.0231** (0.00932)	-0.0280** (0.0111)	-0.0785* (0.0429)	-0.0175 (0.0118)	-0.0259* (0.0142)
Communication and feedback	0.0307*** (0.00959)	0.0341*** (0.0111)	0.0587 (0.0437)	0.0246** (0.0122)	0.0104 (0.0174)	0.0318*** (0.0104)	0.0355*** (0.0120)	0.0617 (0.0445)	0.0250** (0.0125)	0.0103 (0.0178)
Performance based promotion	0.00543 (0.00873)	0.00687 (0.0105)	-0.00189 (0.0395)	0.00641 (0.0117)	0.00405 (0.0124)	0.00181 (0.00918)	0.00229 (0.0106)	-0.0115 (0.0405)	0.00500 (0.0117)	0.00432 (0.0126)
Log(care required level 1)	-0.0166 (0.0194)	-0.00547 (0.0203)	0.0109 (0.0647)	-0.00605 (0.0221)	0.00727 (0.0176)	-0.0117 (0.0196)	0.000639 (0.0200)	0.0238 (0.0668)	-0.00418 (0.0212)	0.00691 (0.0178)
Log(care required level 2)	0.00290 (0.0208)	0.0215 (0.0256)	0.0700 (0.0634)	0.00137 (0.0300)	0.00268 (0.0202)	-0.00380 (0.0209)	0.0130 (0.0253)	0.0522 (0.0658)	-0.00122 (0.0286)	0.00318 (0.0214)
Log(care required level 3)	0.0179 (0.0209)	0.0548** (0.0212)	0.0928 (0.0848)	0.0326 (0.0251)	0.0780** (0.0321)	0.0159 (0.0216)	0.0522** (0.0224)	0.0875 (0.0858)	0.0319 (0.0251)	0.0782** (0.0329)
Log(care required level 4)	0.0440 (0.0301)	0.0977** (0.0385)	0.136 (0.129)	0.0946** (0.0456)	0.101* (0.0599)	0.0375 (0.0296)	0.0895** (0.0378)	0.118 (0.126)	0.0921** (0.0447)	0.101 (0.0628)
Log(care required level 5)	0.0368 (0.0288)	0.0532 (0.0327)	-0.109 (0.101)	0.0694* (0.0372)	0.0540 (0.0347)	0.0340 (0.0293)	0.0497 (0.0335)	-0.117 (0.104)	0.0683* (0.0368)	0.0542 (0.0346)
Log(dementia)	-0.00571 (0.00647)	-0.00515 (0.00617)	-0.00299 (0.0347)	-0.0114 (0.00728)	-0.0101 (0.00779)	-0.00565 (0.00675)	-0.00507 (0.00641)	-0.00283 (0.0351)	-0.0114 (0.00715)	-0.0101 (0.00778)
Any Covid cases	-0.0287 (0.0282)	-0.0414 (0.0339)	-0.175 (0.135)	0.0124 (0.0422)	-0.0342 (0.0418)	-0.0219 (0.0289)	-0.0329 (0.0350)	-0.157 (0.136)	0.0150 (0.0426)	-0.0347 (0.0413)
Log(Covid cases)	0.0157 (0.0148)	0.0220 (0.0203)	-0.00688 (0.103)	0.0107 (0.0268)	-0.00349 (0.0259)	0.00582 (0.0142)	0.00945 (0.0198)	-0.0333 (0.0999)	0.00691 (0.0269)	-0.00275 (0.0240)
Log(local Covid cases)	0.00638 (0.00877)	0.00238 (0.0108)	-0.0308 (0.0325)	0.00625 (0.0129)	-0.00712 (0.0135)	0.00719 (0.00928)	0.00341 (0.0114)	-0.0286 (0.0334)	0.00657 (0.0129)	-0.00718 (0.0137)
Year(2022)	0.0106 (0.0113)	0.0116 (0.0134)	0.131*** (0.0379)	-0.0169 (0.0148)	0.0288 (0.0227)	0.0153 (0.0118)	0.0176 (0.0145)	0.144*** (0.0393)	-0.0151 (0.0157)	0.0284 (0.0206)
Observations	468	468	468	468	468	468	468	468	468	468
R-squared	0.219	0.209	0.195	0.152	0.205	0.178	0.163	0.176	0.148	0.205
Number of svy_ID	264	264	264	264	264	264	264	264	264	264
Mean	4.015	3.634	1.952	3.428	3.510	4.015	3.634	1.952	3.428	3.510

Notes: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 5. Piecewise correlation between robot adoption and other technologies

	Robot	Lift(standing assistance)	Wheelchair lift for cars	Adjustable bed	Wheelchair with built-in seat lift	Special bathtub (with side door)	Stretcher	Shower carry	Lifting device (only for lifting)	Wheelchair scales
Robot	1									
Lift(standing assistance)	0.097	1								
Wheelchair lift for cars	-0.0422	0.1136	1							
Adjustable bed	0.0321	0.0309	0.1386	1						
Wheelchair with built-in seat lift	-0.0162	-0.0295	0.0805	-0.0258	1					
Special bathtub (with side door)	-0.0073	0.0801	0.1551	0.0562	0.0116	1				
Stretcher	0.002	0.0702	0.0585	0.1307	0.0267	0.1762	1			
Shower carry	0.0386	0.1199	0.084	-0.0057	0.0253	0.2081	0.2048	1		
Lifting device (only for lifting)	-0.0083	0.0583	0.0985	-0.0306	-0.0204	0.1004	0.0594	0.0659	1	
Wheelchair scales	0.0185	0.0767	0.1037	0.1485	-0.0469	0.0815	0.1715	0.1167	-0.0411	1

Appendix Table 6. Labor share (Wave 2)

VARIABLES	(1)	(2)	(3)	(4)
	Labor share = wage bill/revenue			
Adopt robots	-0.0283 (0.0225)			
Log(number of robots)		-0.00389 (0.00657)		
Adopt monitoring robots			-0.0198 (0.0210)	
Adopt mobility robots			-0.0331 (0.0204)	
Adopt transfer robots			-0.00306 (0.0226)	
Log(number of monitoring robots)				0.000867 (0.00650)
Log(number of mobility robots)				-0.0125 (0.0101)
Log(number of transfer robots)				-0.0104 (0.0110)
Observations	199	191	199	191
R-squared	0.156	0.155	0.166	0.162
Mean of dep. var.	0.642	0.641	0.642	0.641

Notes: Control variables included in all regressions include resident case-mix controls for the log number of residents with care levels 1-3, 4, and 5; technology adoption controls for each non-robot technology used in the nursing homes; management practices control for human resource management practices; and Covid-19 prevalence controls including cases and deaths. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 7. Robustness tests – Quality of Care

	(1)	(2)	(3)	(4)
	Quality of care			
	Log(restraint use)	Log(ulcer cases)	Log(falls)	Log(falls at night)
<i>Panel A: Balanced panel sample with non-missing information on the number of robots in use</i>				
Adopt robots	-0.129*	-0.240**	0.0314	-0.0819
	(0.0667)	(0.114)	(0.152)	(0.0888)
Observations	407	402	401	397
R-squared	0.138	0.194	0.104	0.140
Mean of dep. var.	0.198	0.694	0.974	0.430
Log(number of robots in use)	-0.0272	-0.0462	0.0654	0.00527
	(0.0219)	(0.0390)	(0.0548)	(0.0314)
Observations	407	402	401	397
R-squared	0.120	0.179	0.113	0.136
Mean of dep. var.	0.198	0.694	0.974	0.430
<i>Panel B: Balanced panel sample with non-decreasing number of robots in use</i>				
Adopt robots	-0.119	-0.258*	0.0187	-0.141
	(0.0879)	(0.139)	(0.182)	(0.112)
Observations	373	367	368	363
R-squared	0.169	0.174	0.175	0.156
Mean of dep. var.	0.227	0.684	0.971	0.421
Log(number of robots in use)	-0.0335	-0.0213	0.0361	-0.0579
	(0.0337)	(0.0557)	(0.0732)	(0.0448)
Observations	352	348	347	342
R-squared	0.207	0.217	0.187	0.178
Mean of dep. var.	0.210	0.693	0.979	0.433
<i>Panel C: Sample of nursing homes with resident capacity below the median (60 people)</i>				
Adopt robots	0.0213	-0.107	0.121	-0.0251
	(0.0799)	(0.164)	(0.185)	(0.132)
Observations	214	209	210	209
R-squared	0.223	0.400	0.225	0.331
Mean of dep. var.	0.164	0.607	0.738	0.276
Log(number of robots in use)	-0.00752	-0.0289	0.0720	-0.0266
	(0.0161)	(0.0661)	(0.0907)	(0.0503)
Observations	204	200	200	199
R-squared	0.277	0.431	0.254	0.390
Mean of dep. var.	0.140	0.620	0.748	0.281
<i>Panel D: Sample of nursing homes with resident capacity above the median (60 people)</i>				
Adopt robots	-0.224**	-0.327*	-0.0599	-0.233**
	(0.0910)	(0.167)	(0.177)	(0.110)
Observations	252	248	248	244
R-squared	0.228	0.306	0.256	0.211
Mean of dep. var.	0.267	0.762	1.126	0.531
Log(number of robots in use)	-0.0479	-0.0513	0.0204	-0.0268
	(0.0346)	(0.0502)	(0.0642)	(0.0419)
Observations	241	238	237	233
R-squared	0.204	0.321	0.262	0.198
Mean of dep. var.	0.261	0.765	1.126	0.544

Notes: All regressions include nursing home and year fixed effects, and control variables. Control variables include resident case-mix controls for the log number of residents with care levels 1-3, 4, and 5; technology adoption controls for each non-robot technology used in the nursing homes; management practices control for human resource management practices; and Covid-19 prevalence controls including cases and deaths. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix Table 8. Robustness by type of robot

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Log(total employees)	Log(care workers)				Quality of care			
		Total	Non-regular	Regular	Full-time equivalent	Log(restraint use)	Log(ulcer cases)	Log(falls)	Log(falls at night)
<i>Panel A: Balanced panel sample with non-missing information on the number of robots in use</i>									
Adopt monitoring robots	0.0627*** (0.0205)	0.0708*** (0.0248)	0.0952 (0.0690)	0.0436 (0.0287)	0.0451** (0.0200)	-0.149*** (0.0517)	-0.196* (0.105)	-0.0283 (0.136)	-0.163* (0.0829)
Adopt mobility robots	0.0100 (0.0184)	0.00445 (0.0207)	-0.0661 (0.0758)	0.00638 (0.0257)	0.00476 (0.0236)	-0.0106 (0.0641)	0.114 (0.109)	0.597*** (0.179)	0.283** (0.109)
Adopt transfer robots	-0.0129 (0.0169)	-0.0118 (0.0221)	0.0498 (0.0766)	-0.00815 (0.0249)	-0.0186 (0.0206)	0.0235 (0.0466)	-0.113 (0.117)	-0.205* (0.124)	0.0952 (0.0831)
Observations	410	410	410	410	410	407	402	401	397
R-squared	0.244	0.215	0.193	0.172	0.220	0.153	0.194	0.180	0.187
Mean of dep. var.	4.019	3.636	1.960	3.426	3.516	0.198	0.694	0.974	0.430
Log(number of monitoring robots)	0.0249*** (0.00833)	0.0288*** (0.0100)	0.0485* (0.0265)	0.0190* (0.0114)	0.0199*** (0.00755)	-0.0264 (0.0205)	-0.0486 (0.0395)	0.0254 (0.0496)	-0.0372 (0.0317)
Log(number of mobility robots)	-0.000862 (0.0108)	-0.00225 (0.0130)	-0.0437 (0.0400)	-0.0102 (0.0149)	0.00189 (0.0120)	-0.0199 (0.0270)	0.0668 (0.0581)	0.292*** (0.0988)	0.154** (0.0777)
Log(number of transfer robots)	-0.00121 (0.0133)	0.00157 (0.0147)	0.0425 (0.0494)	-0.00251 (0.0208)	-0.00503 (0.0144)	0.0167 (0.0290)	-0.0511 (0.0633)	-0.120 (0.0777)	0.0587 (0.0583)
Observations	410	410	410	410	410	407	402	401	397
R-squared	0.246	0.222	0.202	0.176	0.228	0.124	0.184	0.162	0.174
Mean of dep. var.	4.019	3.636	1.960	3.426	3.516	0.198	0.694	0.974	0.430
<i>Panel B: Balanced panel sample with non-decreasing number of robots in use</i>									
Adopt monitoring robots	0.0844*** (0.0221)	0.0905*** (0.0286)	0.0894 (0.0809)	0.0710** (0.0320)	0.0469* (0.0270)	-0.198** (0.0847)	0.00953 (0.123)	-0.0395 (0.148)	-0.116 (0.0927)
Adopt mobility robots	-0.000366 (0.0192)	0.00982 (0.0243)	0.0547 (0.0867)	-0.0316 (0.0273)	-0.0108 (0.0308)	-0.0160 (0.0771)	0.211 (0.140)	0.512*** (0.189)	0.334*** (0.124)
Adopt transfer robots	-0.0462** (0.0199)	-0.0499* (0.0254)	0.110 (0.0930)	-0.0475 (0.0291)	-0.0720*** (0.0261)	0.00615 (0.0533)	-0.0941 (0.131)	-0.353*** (0.132)	-0.0355 (0.0920)
Observations	375	375	375	375	375	373	367	368	363
R-squared	0.321	0.289	0.195	0.231	0.295	0.204	0.169	0.237	0.193
Mean of dep. var.	4.017	3.641	1.953	3.435	3.514	0.227	0.684	0.971	0.421
Log(number of monitoring robots)	0.0423*** (0.0109)	0.0450*** (0.0140)	0.0658* (0.0370)	0.0334** (0.0159)	0.0288*** (0.00939)	-0.0356 (0.0309)	-0.0169 (0.0530)	0.0269 (0.0653)	-0.0716* (0.0418)
Log(number of mobility robots)	-0.00670 (0.0134)	-0.00193 (0.0183)	-0.00439 (0.0414)	-0.0264 (0.0180)	-0.00280 (0.0152)	-0.0180 (0.0385)	0.0680 (0.0677)	0.292*** (0.0995)	0.181* (0.102)
Log(number of transfer robots)	-0.0219 (0.0143)	-0.0197 (0.0204)	0.128* (0.0654)	-0.0345 (0.0223)	-0.0333* (0.0177)	0.0425 (0.0410)	-0.0717 (0.0947)	-0.264*** (0.0919)	-0.107 (0.0786)
Observations	354	354	354	354	354	352	348	347	342
R-squared	0.357	0.309	0.224	0.283	0.336	0.215	0.222	0.258	0.220
Mean of dep. var.	4.020	3.644	1.961	3.435	3.521	0.210	0.693	0.979	0.433
<i>Panel C: Sample of nursing homes with resident capacity below the median (60 people)</i>									
Adopt monitoring robots	0.0498 (0.0370)	0.0616 (0.0487)	-0.0889 (0.0661)	0.0863 (0.0557)	0.00763 (0.0421)	-0.114 (0.0694)	-0.0214 (0.138)	0.116 (0.192)	-0.116 (0.0932)
Adopt mobility robots	-0.0162 (0.0262)	-0.000392 (0.0360)	-0.198** (0.0818)	0.0171 (0.0375)	-0.00709 (0.0617)	0.0772 (0.106)	0.271 (0.185)	0.644** (0.254)	0.221 (0.134)
Adopt transfer robots	-0.0212 (0.0255)	-0.0182 (0.0343)	0.0709 (0.1000)	0.00168 (0.0362)	0.00707 (0.0500)	0.00393 (0.0634)	-0.111 (0.181)	-0.451** (0.203)	0.0405 (0.116)
Observations	217	217	217	217	217	214	209	210	209
R-squared	0.354	0.326	0.448	0.317	0.296	0.276	0.419	0.321	0.363
Mean of dep. var.	3.799	3.362	1.688	3.172	3.211	0.164	0.607	0.738	0.276
Log(number of monitoring robots)	0.0223 (0.0178)	0.0286 (0.0234)	-0.0285 (0.0312)	0.0359 (0.0268)	0.00930 (0.0130)	-0.0127 (0.0164)	-0.0245 (0.0644)	0.0442 (0.0853)	-0.0613 (0.0479)
Log(number of mobility robots)	-0.00697 (0.0160)	-0.00468 (0.0210)	-0.114** (0.0532)	0.00291 (0.0203)	-0.000353 (0.0219)	-0.00344 (0.0461)	0.158 (0.108)	0.425** (0.179)	0.0728 (0.0793)
Log(number of transfer robots)	-0.00537 (0.0187)	-0.0137 (0.0231)	0.0149 (0.0595)	0.0136 (0.0269)	-0.00528 (0.0208)	0.0252 (0.0248)	-0.0876 (0.102)	-0.204 (0.127)	0.150** (0.0640)
Observations	207	207	207	207	207	204	200	200	199
R-squared	0.367	0.326	0.439	0.314	0.310	0.284	0.453	0.331	0.432
Mean of dep. var.	3.800	3.364	1.680	3.175	3.221	0.140	0.620	0.748	0.281
<i>Panel D: Sample of nursing homes with resident capacity above the median (60 people)</i>									
Adopt monitoring robots	0.0594***	0.0662***	0.242***	0.00652	0.0409**	-0.205**	-0.111	-0.295**	-0.186*

	(0.0156)	(0.0160)	(0.0870)	(0.0215)	(0.0175)	(0.0824)	(0.138)	(0.133)	(0.109)
Adopt mobility robots	0.0211	0.0182	0.0516	-0.00365	0.0150	-0.0583	0.190	0.533**	0.313*
	(0.0217)	(0.0206)	(0.109)	(0.0275)	(0.0201)	(0.0794)	(0.166)	(0.257)	(0.178)
Adopt transfer robots	-0.0374	-0.0304	0.0939	-0.0591**	-0.0356	0.0545	-0.00718	-0.130	0.0915
	(0.0227)	(0.0266)	(0.105)	(0.0267)	(0.0246)	(0.0916)	(0.135)	(0.184)	(0.143)
Observations	251	251	251	251	251	252	248	248	244
R-squared	0.306	0.231	0.298	0.285	0.210	0.243	0.285	0.312	0.233
Mean of dep. var.	4.201	3.870	2.181	3.649	3.768	0.267	0.762	1.126	0.531
Log(number of monitoring robots)	0.0319***	0.0353***	0.113***	0.00794	0.0263***	-0.0452	-0.0644	-0.0149	-0.0893**
	(0.00772)	(0.00761)	(0.0384)	(0.00854)	(0.00708)	(0.0355)	(0.0498)	(0.0585)	(0.0437)
Log(number of mobility robots)	0.000720	0.00631	-0.0238	-0.00320	0.00644	-0.0465	0.101	0.236*	0.283**
	(0.0109)	(0.0119)	(0.0519)	(0.0127)	(0.0101)	(0.0481)	(0.0865)	(0.121)	(0.117)
Log(number of transfer robots)	-0.0183	-0.00755	0.103	-0.0468***	-0.0166	0.0602	-0.00445	-0.122	-0.0312
	(0.0139)	(0.0192)	(0.0705)	(0.0154)	(0.0148)	(0.0530)	(0.0864)	(0.123)	(0.109)
Observations	240	240	240	240	240	241	238	237	233
R-squared	0.325	0.271	0.321	0.368	0.271	0.218	0.327	0.290	0.272
Mean of dep. var.	4.203	3.870	2.198	3.646	3.768	0.261	0.765	1.126	0.544

Notes: All regressions include nursing home and year fixed effects, and control variables. Control variables include resident case-mix controls for the log number of residents with care levels 1-3, 4, and 5; technology adoption controls for each non-robot technology used in the nursing homes; management practices control for human resource management practices; and Covid-19 prevalence controls including cases and deaths. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 9. Task automation and staffing by worker type

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	log(care workers)				log(nurses)			
	Total	Non-regular	Regular	Full-time equivalent	Total	Non-regular	Regular	Full-time equivalent
<i>Panel A. Average task automation</i>								
Task automation index	0.0931*** (0.0260)	0.171** (0.0776)	0.0480* (0.0285)	0.0617* (0.0363)	-0.0821 (0.0528)	-0.184* (0.106)	0.00411 (0.0587)	-0.0209 (0.0465)
Observations	461	461	461	461	461	461	461	461
R-squared	0.215	0.158	0.143	0.210	0.109	0.123	0.103	0.116
Mean of dep. var.	3.491	1.760	3.306	3.379	1.565	0.734	1.464	1.371
<i>Panel B. Task automation by task groups</i>								
Monitoring task automation index	0.0400* (0.0205)	-0.00529 (0.0727)	0.0360 (0.0264)	0.0544** (0.0254)	-0.0306 (0.0496)	-0.0642 (0.0949)	-0.0285 (0.0558)	-0.0145 (0.0413)
Mobility task automation index	0.0430 (0.0291)	0.133 (0.0826)	0.000707 (0.0321)	-0.0144 (0.0356)	-0.0367 (0.0518)	-0.193** (0.0919)	0.0473 (0.0482)	0.0165 (0.0430)
Transfer task automation index	0.0260 (0.0274)	0.130 (0.0978)	0.00470 (0.0298)	-0.00942 (0.0427)	-0.0457 (0.0677)	-0.0340 (0.114)	0.0164 (0.0845)	-0.0158 (0.0677)
Observations	458	458	458	458	458	458	458	458
R-squared	0.217	0.167	0.145	0.214	0.108	0.132	0.104	0.113
Mean of dep. var.	3.492	1.762	3.306	3.380	1.567	0.738	1.464	1.373

Notes: All regressions include nursing home and year fixed effects, and control variables. Control variables include resident case-mix controls for the log number of residents with care levels 1-3, 4, and 5; technology adoption controls for each non-robot technology used in the nursing homes; management practices control for human resource management practices; and Covid-19 prevalence controls including cases and deaths. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 10. Robots and care worker staffing by experience

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Log employment of care workers with 0 to 5 years of experience			Log employment of care workers with more than 5 years of experience		
	Total	Non-regular	Regular	Total	Non-regular	Regular
<i>Panel A: Robot adoption</i>						
Adopt robots	0.113* (0.0655)	0.0944 (0.1000)	0.0891 (0.0720)	-0.0450 (0.0940)	0.0582 (0.0839)	-0.0609 (0.0944)
Observations	468	468	468	468	468	468
R-squared	0.270	0.103	0.297	0.252	0.238	0.228
Mean of dep. var.	2.667	1.242	2.407	2.842	1.107	2.672
<i>Panel B: Robot adoption by type</i>						
Adopt monitoring robots	0.104* (0.0536)	0.0224 (0.0911)	0.103* (0.0572)	0.0203 (0.0766)	0.0559 (0.0763)	0.0143 (0.0776)
Adopt mobility robots	0.0959* (0.0554)	0.159 (0.109)	0.0685 (0.0642)	-0.196** (0.0985)	-0.0677 (0.104)	-0.189** (0.0937)
Adopt transfer robots	-0.154** (0.0601)	-0.154* (0.0795)	-0.0895 (0.0717)	0.00505 (0.0792)	0.0329 (0.0883)	-0.0114 (0.0746)
Observations	468	468	468	468	468	468
R-squared	0.293	0.116	0.309	0.268	0.241	0.243
Mean of dep. var.	2.667	1.242	2.407	2.842	1.107	2.672
<i>Panel C: Number of robots in use</i>						
Log(number of robots in use)	-0.0385 (0.0365)	0.0573*** (0.0197)	0.0413 (0.0326)	-0.0220 (0.0389)	0.0282 (0.0311)	-0.0273 (0.0385)
Observations	447	447	447	447	447	447
R-squared	0.293	0.136	0.305	0.246	0.264	0.227
Mean of dep. var.	2.666	1.238	2.406	2.846	1.121	2.673
<i>Panel D: Number of robots in use by type</i>						
Log(number of monitoring robots in use)	0.0551*** (0.0205)	0.0457 (0.0339)	0.0505** (0.0226)	0.00901 (0.0349)	0.0206 (0.0319)	0.00666 (0.0348)
Log(number of mobility robots in use)	0.0249 (0.0390)	0.0390 (0.0551)	0.0110 (0.0410)	-0.0960* (0.0561)	-0.0259 (0.0505)	-0.0893 (0.0562)
Log(number of transfer robots in use)	-0.0504 (0.0392)	-0.0643 (0.0454)	-0.0344 (0.0427)	-0.0540 (0.0776)	0.00656 (0.0811)	-0.0550 (0.0648)
Observations	447	447	447	447	447	447
R-squared	0.300	0.145	0.308	0.261	0.262	0.240
Mean of dep. var.	2.666	1.238	2.406	2.846	1.121	2.673

Notes: All regressions include nursing home and year fixed effects, and control variables. Control variables include resident case-mix controls for the log number of residents with care levels 1-3, 4, and 5; technology adoption controls for each non-robot technology used in the nursing homes; management practices control for human resource management practices; and Covid-19 prevalence controls including cases and deaths. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix B. Nursing Home (*Kaigo*) Neediness Index

Level 1

1. Requires some form of help in taking care of the surroundings (such as cleaning).
2. Requires some form of assistance for complex movements such as standing up.
3. Requires some form of support for walking and remaining in a standing position.
4. Mostly able to eat and use the bathroom independently.
5. Exhibits problematic behavior or decline in understanding.

Level 2

1. Requires some form of help for all tasks to take care of the surroundings.
2. Requires some form of assistance for complex movements such as standing up.
3. Requires some form of support for walking and remaining in a standing position.
4. Requires some form of support for eating and using the bathroom.
5. Exhibits problematic behavior or decline in understanding.

Level 3

1. Unable to take care of the surroundings on one's own.
2. Unable to do complex movements such as standing up.
3. At times unable to walk or remain in a standing position.
4. Unable to use the bathroom independently.
5. Exhibits several instances of problematic behavior and all-round decline in understanding.

Level 4

1. Hardly able to take care of one's surroundings.
2. Hardly able to do complex movements such as standing up.
3. Unable to walk or remain in a standing position on one's own.
4. Unable to use the bathroom.
5. Exhibits many instances of problematic behavior or decline in understanding.

Level 5

1. Hardly able to take care of one's surroundings.
2. Hardly able to do complex movements such as standing up.
3. Hardly able to walk or remain in a standing position.
4. Unable to use the bathroom and eat.
5. Exhibits many instances of problematic behavior or decline in understanding.