

Hospital volume and mortality for 25 types of inpatient treatment in German hospitals – Observational study using complete national data from 2009 to 2014

Appendix table 1 Inclusion and exclusion criteria for case definition

	Inclusion	Exclusion
COMMON EMERGENCY CONDITIONS		
Acute myocardial infarction	PD I21 I22; direct admission	
Heart failure	PD I50 I110 I130 I132; direct admission	
Ischemic stroke	PD I63; direct admission	
Pneumonia	PD A481 J100 J110 J12 J13 J14 J15 J16 J17 J18; direct admission	SD U6900 (nosocomial acquired pneumonia)
Chronic obstructive pulmonary disease	PD J44; direct admission	
Hip fracture	PD S720 S721; direct admission	
ELECTIVE HEART AND THORACIC SURGERY		
Isolated surgical aortic valve replacement	OPS 53510	OPS 53502 53503 53504 53505 53506 53507 5350x 5350y 53511 53512 53513 53514 5351x 5351y 53521 53522 53523 5352y 53531 53532 53533 53534 53535 5353x 5353y 53541 53542 53543 53544 5354y 53581 53582 53583 53584 53585 5358x 5358y 536 538a0 538a1 538233 53823x 53845 53846 5384x 5384y 538a7 538a8 538230 538232 538401 538402 53840x 538411 538412 53841x 538421 538422 53842x 538431 538432 53843x 53844 5355 5356 5357 5359 5371 53725 53732 53733 53734 53735 53736 53737 53738 5373x 5373y 5375 537a (other heart surgery); OPS 535a0 (transcatheter aortic valve replacement); PD I33 I38 I39 (endocarditis)
Transcatheter aortic valve replacement	OPS 535a0	
Isolated coronary artery bypass graft	OPS 536	OPS 5350 5351 5352 5353 5354 5358 535a 5379a 5379b 538a0 538a1 538233 53823x 53845 53846 53847 5384x 5384y 538a7 538a8 538230 538232 538401 538402 53840x 538411 538412 53841x 538421 538422 53842x 538431 538432 53843x 53844 5355 5356 5357 5359 5371 53725 53732 53733 53734 53735 53736 53737 53738 5373x 5373y 5375 537a (other heart surgery); PD I21, I22 (acute myocardial infarction)
Partial lung resection for carcinoma	OPS 5321 5322 5323 5324 5325; PD or SD C34 D022	OPS 5327 5328 (pneumonectomy)
ELECTIVE MAJOR VISCERAL SURGERY		
Colorectal resection for carcinoma	OPS 5455 5456 5458 5484 5485; PD or SD C18 C19 C20 C218 D010 D011 D012	
Colorectal resection for diverticulosis	OPS 5455 5456 5458 5484 5485; PD K572 K573 K574 K575 K578 K579	SD C18 C19 C20 C218 D010 D011 D012 (colorectal carcinoma)
Total nephrectomy for carcinoma	OPS 55544 55545 55546 55547 5554a 5554b 5554x 5554y; PD or SD C64 C65 C66	OPS 55547 55549 5555 (post mortem resection, graft resection, donor resection or transplantation of kidney)
Cystectomy for carcinoma	OPS 5576 56870 56872 56873; PD or SD C67 D090 D414	
Complex oesophageal surgery for carcinoma	OPS 5423 5424 5425 5426 54270 54271 54380 54381 5438x; PD or SD C15 C160	
Pancreatic resection for carcinoma	OPS 5521 5522 5523 5524 5525; PD or SD C25 C241	OPS 55253 55254 5528 (post mortem resection, graft resection, or transplantation of pancreas)
ELECTIVE VASCULAR SURGERY		
Open repair of unruptured abdominal aortic aneurysm	OPS 538233 53823x 53845 53846 53847 5384x 5384y; PD or SD I7100 I7101 I7102 I7103 I712 I714 I716 I719	PD or SD I7104 I7105 I7106 I7107 I711 I713 I715 I718 (ruptured aortic aneurysm); OPS 538230 538232 53840 53841 53842 53843 53844 53848 538a7 538a8 538aa 538ab (surgical repair of thoracic aortic aneurysm); OPS 538a0 538a1 (endovascular repair of abdominal aortic aneurysm)
Endovascular repair of unruptured abdominal aortic aneurysm	OPS 538a0 538a1; PD or SD I7100 I7101 I7102 I7103 I712 I714 I716 I719	PD or SD I7104 I7105 I7106 I7107 I711 I713 I715 I718 (ruptured aortic aneurysm); OPS 538230 538232 53840 53841 53842 53843 53844 53848 538a7 538a8 538aa 538ab (surgical repair of thoracic aortic aneurysm)
Surgical lower extremity revascularization for atherosclerosis	OPS 53805 53807 53808 53815 53817 53818 538253 538254 538255 53825x 53827 53828 538352 538353 538354 538355 53835x 53837 53838 539333 539335 539336 539338 539341 539342 539343 539344 539345 539346 539347 53934x 53935 53936 53937 539552 539553 539554 539555 53955x 53957 53958 53965 53967 53968 53975 53977 53978; PD or SD I7020 I7021 I7022 I7023 I7024	OPS 538233 53823x 53845 53846 53847 5384x 5384y 538a0 538a1 538230 538232 53840 53841 53842 53843 53844 53848 538a7 538a8 538aa 538ab 53805 53807 53808 53815 53817 53818 538253 538254 538255 53825x 53827 53828 538352 538353 538354 538355 53835x 53837 53838 539333 539335 539336 539338 539341 539342 539343 539344 539345 539346 539347 53934x 53935 53936 53937 539552 539553 539554 539555 53955x 53957 53958 53965 53967 53968 53975 53977 53978 5864 5865 (heart surgery, aortic aneurysm repair, lower extremity revascularization, lower limb amputation); PD or SD C00 C01 C02 C03 C04 C05 C06 C07 C08 C09 C10 C11 C12 C13 C14 C15 (neoplasm of ear, nose or throat)
Carotid endarterectomy	OPS 53800 53810 53820 53830 538c01 53950 53970	OPS 535 536 5370 5371 5372 5373 5374 5375 53791 53796 53797 53798 53799 5379a 5379b 5379c 537620 537621 537630 537631 537640 537641 537650 537651 537660 537661 537670 537671 537680 537681 537690 537691 537694 537a 538233 53823x 53845 53846 53847 5384x 5384y 538a0 538a1 538230 538232 53840 53841 53842 53843 53844 53848 538a7 538a8 538aa 538ab 53805 53807 53808 53815 53817 53818 538253 538254 538255 53825x 53827 53828 538352 538353 538354 538355 53835x 53837 53838 539333 539335 539336 539338 539341 539342 539343 539344 539345 539346 539347 53934x 53935 53936 53937 539552 539553 539554 539555 53955x 53957 53958 53965 53967 53968 53975 53977 53978 5864 5865 (heart surgery, aortic aneurysm repair, lower extremity revascularization, lower limb amputation); PD or SD C00 C01 C02 C03 C04 C05 C06 C07 C08 C09 C10 C11 C12 C13 C14 C15 (neoplasm of ear, nose or throat)

Appendix table 1 (continued)

ELECTIVE LOW-RISK SURGERY		
Cholecystectomy for cholelithiasis	OPS 55110 55111 55112 5511x 5511y; PD K80	SD C D0 (malign neoplasm); OPS 55113 55114 55115 (extended or simultaneously performed cholecystectomy)
Inguinal or femoral hernia repair	OPS 5530 5531; PD K40 K41	OPS 5451 5452 5453 5454 5455 5456 5458 5459 5460 5461 5462 5463 5464 5465 5466 5467 5468 5469 5484 5485 55304 55308 55314 55318 (other intestinal surgery)
Primary hip replacement for arthrosis or arthritis	OPS 582000 582001 582002 582010 582011 582012 582020 582021 582022 582030 582031 582040 582041 582060 582061 582080 582081 582082 582092 582093 582094 582095 582096 5820x0 5820x1 5820x2; PD M05 M06 M07 M08 M160 M161 M162 M163 M166 M167 M169 M87	OPS 5829c 5829g 5829n 57854d 582810 582840 582860 5829k 5829m (replacement for malign neoplasm, modular prosthesis, two-stage revision); SD M8005 M8085 M8415 M8445 M8485 M8495 M8505 M8545 M8555 M8565 M9075 M9688 Q650 Q651 S324 (osteoporosis, other osteopathy, hip fracture, congenital deformity of hip)
Primary knee replacement for arthrosis or arthritis	OPS 58221 58222 58223 58224 58226 58227 58229 5822a 5822b 5822d 5822e 5822g 5822h 5822j 5822k 582200 582201 582202; PD M05 M06 M07 M08 M170 M171 M174 M175 M179 M87	OPS 5829c 5829g 5829n 57854d 582810 582840 582860 5829k 5829m (replacement for malign neoplasm, modular prosthesis, two-stage revision); SD M8000 M8005 M8080 M8085 M8400 M8405 M8406 M8505 M8506 M8545 M8546 M8555 M8556 M8565 M8566 (osteoporosis or other osteopathy)
Transurethral resection of prostate	OPS 5601	

PD: principal diagnosis (ICD-10-GM); SD: secondary diagnosis (ICD-10-GM); OPS: procedure classification code [Operationen- und Prozedurenschlüssel]; direct admission: patient was not transferred-in from another acute care hospital.

Official classifications according to the German Institute of Medical Documentation and Information (DIMDI):

<http://www.dimdi.de/static/en/klassi/icd-10-gm/index.htm> (ICD-10-GM); <http://www.dimdi.de/static/en/klassi/ops/index.htm>

(OPS).

The case definitions rely on previous work on hospital quality indicators which were modified for the purpose of this analysis:

Mansky T, Nimptsch U, Cools A, Hellerhoff F. G-IQI | German Inpatient Quality Indicators. Version 5.0. - Band 2:

Definitionshandbuch für das Datenjahr 2016. Berlin: Universitätsverlag der TU Berlin. [https://depositonce.tu-](https://depositonce.tu-berlin.de/handle/11303/5819)

[berlin.de/handle/11303/5819](https://depositonce.tu-berlin.de/handle/11303/5819)

Appendix table 2 Definition of covariates used for risk adjustment

Covariate	Definition
Calendar year of treatment	2009, 2010, 2011, 2012, 2013, 2014
Demographics	
Age	5-year age groups
Female sex	
Comorbidity	
Cardiac arrhythmia	PD or SD I442 I48 Z450 Z950
Heart failure or cardiomyopathy	PD or SD I50 I110 I130 I132 I420 I426 I427 I428 I429
Chronic ischemic heart disease	PD or SD I25
Hypertension (without heart or renal failure)	PD or SD I10 I119 I129 I139 I15
Valvular disease	PD or SD I340 I342 I350 I351 I352 I050 I051 I052 I060 I061 I062 Q231 Q232 Q233
Atherosclerosis of peripheral arteries	PD or SD I702
Sequelae of cerebrovascular disease	PD or SD I69
Chronic pulmonary disease	PD or SD J41 J42 J44 J45 J47
Mucoviscidosis	PD or SD E84
Chronic liver disease	PD or SD B18 I864 I982 K70 K73 K74 K760 K761 K765 K766 K767 Q446 Q447
Chronic pancreatitis	PD or SD K860 K861
Severe renal disease or chronic renal failure	PD or SD I120 I131 I132 N03 N04 N05 N07 N08 N11 N12 N14 N15 N16 N18 N19 Z992
Diabetes mellitus	PD or SD E10 E11 E12 E13 E14
Obesity	PD or SD E66
Cachexia or malnutrition	PD or SD R64 R634 E43 E44
Coagulopathy	PD or SD D66 D67 D680 D681 D682 D684 D685 D686 D688 D689 D691 D693 D694
Malign neoplasm	PD or SD C00-C97
Metastatic cancer	PD or SD C77 C78 C79
Specific risk factors	
ST-elevation myocardial infarction	PD I210 I211 I212 I213
Cardiogenic shock	PD or SD R570
Subsequent myocardial infarction	PD I22
Heart failure NYHA classification stage IV	PD I5014
Chronic obstructive pulmonary disease FEV1 <35%	PD J4400 J4410 J4480 J4490
Fracture of neck of femur	PD S720
Complex disease of intestine	PD or SD K55 K56 K593 K630 K631
Peripheral vascular disease stage	PD or SD I + II: I7020 I7021; III: I7022; IV: I7023 I7024
Acute cholecystitis	PD K800 K810
Trans-apical aortic valve replacement	OPS 535a01 535a02
Extended colorectal resection	OPS 5458 54540 54541 54542 54543 54544 54545 54546 5501 5502 5437 5436 5454x 5454y
Resection of visceral organs other than pancreas	OPS 5437 5436 5502 5501 5455 5456 54540 54541 54542 54543 54544 54545 54546 5454x 5454y

PD: principal diagnosis (ICD-10-GM); SD: secondary diagnosis (ICD-10-GM); OPS: procedure classification system [Operationen- und Prozedurenschlüssel]. Official classifications according to the German Institute of Medical Documentation and Information (DIMDI): <http://www.dimdi.de/static/en/klassi/icd-10-gm/index.htm> (ICD-10-GM);

<http://www.dimdi.de/static/en/klassi/ops/index.htm> (OPS).

Appendix table 3 Application of covariates used to estimate risk-adjusted in-hospital mortality

	Calendar year of treatment	5-year age groups	Female sex	Cardiac arrhythmia	Heart failure or cardiomyopathy	Chronic ischemic heart disease	Hypertension (without heart or renal failure)	Valvular disease	Atherosclerosis of peripheral arteries	Sequelae of cerebrovascular disease	Chronic pulmonary disease	Mucoviscidosis	Chronic liver disease	Chronic pancreatitis	Severe renal disease or chronic renal failure	Diabetes mellitus	Obesity	Cachexia or malnutrition	Coagulopathy	Malign neoplasm	Metastatic cancer	ST-elevation myocardial infarction	Cardiogenic shock	Subsequent myocardial infarction	Heart failure NYHA classification stage IV	Chronic obstructive pulmonary disease FEV1 <35%	Fracture of neck of femur	Complex disease of intestine	Peripheral vascular disease stage	Acute cholecystitis	Trans-apical aortic valve replacement	Extended colorectal resection	Resection of visceral organs other than pancreas	Area under the curve (c-statistic)		
COMMON EMERGENCY CONDITIONS																																				
Acute myocardial infarction	x	x	x				x	x	x		x		x		x	x	x	x	x	x		x	x	x										0,827		
Heart failure	x	x	x	x		x		x	x	x	x		x		x	x	x	x	x	x					x									0,729		
Ischemic stroke	x	x	x		x	x	x	x	x		x		x		x	x	x	x	x	x														0,743		
Pneumonia	x	x	x	x	x	x	x	x	x			x		x	x	x	x	x	x	x														0,715		
Chronic obstructive pulmonary disease	x	x	x	x	x	x	x	x	x				x		x	x	x	x	x	x						x								0,716		
Hip fracture	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x	x								x							0,782	
ELECTIVE HEART AND THORACIC SURGERY																																				
Isolated surgical aortic valve replacement	x	x	x	x	x	x	x		x		x		x		x	x	x	x	x	x														0,772		
Transcatheter aortic valve replacement	x	x	x	x	x	x	x		x		x		x		x	x	x	x	x	x												x			0,710	
Isolated coronary artery bypass graft	x	x	x	x	x	x	x		x		x		x		x	x	x	x	x	x															0,786	
Partial lung resection for carcinoma	x	x	x	x	x	x	x		x				x		x	x	x	x	x			x													0,782	
ELECTIVE MAJOR VISCERAL SURGERY																																				
Colorectal resection for carcinoma	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x			x							x			x			0,825	
Colorectal resection for diverticulosis	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x										x				x			0,908
Total nephrectomy for carcinoma	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x			x														0,826
Cystectomy for carcinoma	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x			x														0,765
Complex oesophageal surgery for carcinoma	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x			x														0,751
Pancreatic resection for carcinoma	x	x	x	x	x	x	x		x		x		x		x	x	x	x	x			x												x		0,776
ELECTIVE VASCULAR SURGERY																																				
Surgical lower extremity revascularization for atherosclerosis	x	x	x	x	x	x	x	x			x		x		x	x	x	x	x	x										x						0,853
Open repair of abdominal aortic aneurysm	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x	x																0,771
Endovascular repair of abdominal aortic aneurysm	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x	x																0,814
Carotid endarterectomy	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x	x																0,758
ELECTIVE LOW-RISK SURGERY																																				
Cholecystectomy for cholelithiasis	x	x	x	x	x	x	x	x	x		x		x	x	x	x	x	x	x											x						0,943
Inguinal or femoral hernia repair	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x	x																0,938
Primary hip replacement for arthrosis or arthritis	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x	x																0,869
Primary knee replacement for arthrosis or arthritis	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x	x																0,820
Transurethral resection of prostate	x	x		x	x	x	x	x	x		x		x		x	x	x	x	x	x																0,868