Gesundheit Österreich GmbH

Comorbidities and COVID-19 hospitalisation, ICU admission and hospital mortality in Austria: a retrospective cohort study

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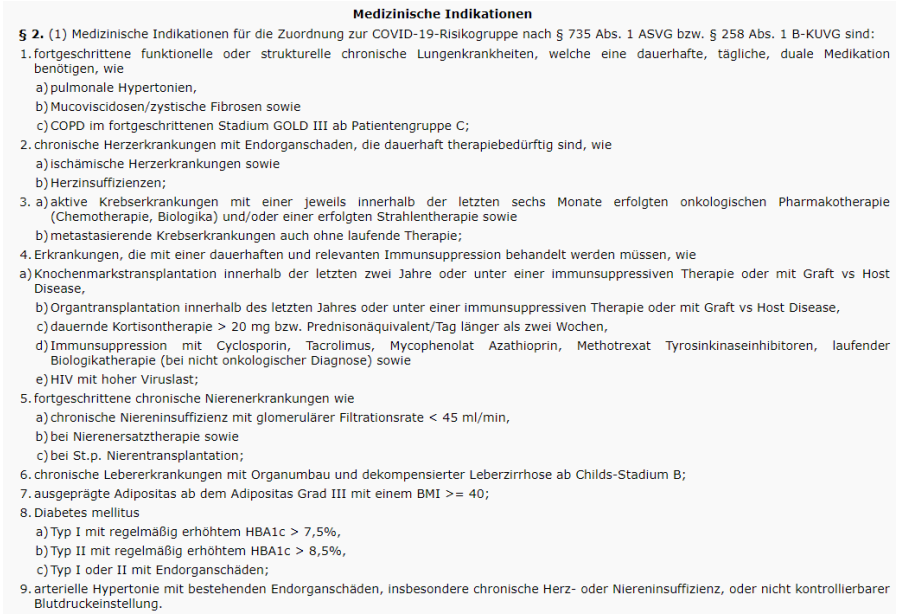
Contents

Background

» Protection of vulnerable populations as a central task in managing the COVID-19 pandemic to avoid severe courses of COVID-19 and the risk of health care system capacity being exceeded

» The Austrian COVID-19 risk group regulation defines the high risk group based on medical conditions drawing from available evidence by May 2020:

1. chronic lung diseases
2. chronic heart diseases
3. cancer
4. diseases treated with immunosuppression
5. chronic kidney diseases
6. chronic liver diseases
7. obesity (BMI >= 40)
8. diabetes mellitus (type I and II)
9. hypertension with existing end organ damage



Medizinische Indikationen

§ 2. (1) Medizinische Indikationen für die Zuordnung zur COVID-19-Risikogruppe nach § 735 Abs. 1 ASVG bzw. § 258 Abs. 1 B-KUVG sind:

1. fortgeschrittene funktionelle oder strukturelle chronische Lungenkrankheiten, welche eine dauerhafte, tägliche, duale Medikation benötigen, wie
   a) pulmonale Hypertonien,
   b) Mucoviscidosen/zystische Fibrosen sowie
   c) COPD im fortgeschrittenen Stadium GOLD III ab Patientengruppe C;
2. chronische Herzerkrankungen mit Endorganschaden, die dauerhaft therapiebedürftig sind, wie
   a) ischämische Herzerkrankungen sowie
   b) Herzinsuffizienzen;
3. a) aktive Krebserkrankungen mit einer jeweils innerhalb der letzten sechs Monate erfolgten onkologischen Pharmakotherapie (Chemotherapie, Biologika) und/oder einer erfolgten Strahlentherapie sowie
   b) metastasierende Krebserkrankungen auch ohne laufende Therapie;
4. Erkrankungen, die mit einer dauerhaften und relevanten Immunsuppression behandelt werden müssen, wie
   a) Knochenmarkstransplantation innerhalb der letzten zwei Jahre oder unter einer immunsuppressiven Therapie oder mit Graft vs Host Disease,
   b) Organtransplantation innerhalb des letzten Jahres oder unter einer immunsuppressiven Therapie oder mit Graft vs Host Disease,
   c) dauernde Kortisontherapie > 20 mg bzw. Prednisonäquivalent/Tag länger als zwei Wochen,
   d) Immunsuppression mit Cyclosporin, Tacrolimus, Mycophenolat Azathioprin, Methotrexat Tyrosinkinaseinhibitoren, laufender Biologikatherapie (bei nicht onkologischer Diagnose) sowie
   e) HIV mit hoher Viruslast;
5. fortgeschrittene chronische Nierenerkrankungen wie
   a) chronische Niereninsuffizienz mit glomerulärer Filtrationsrate < 45 ml/min,
   b) bei Nierenersatztherapie sowie
   c) bei St.p. Nierentransplantation;
6. chronische Lebererkrankungen mit Organumbau und dekompensierter Leberzirrhose ab Childs-Stadium B;
7. ausgeprägte Adipositas ab dem Adipositas Grad III mit einem BMI >= 40;
8. Diabetes mellitus
   a) Typ I mit regelmäßig erhöhtem HBA1c > 7,5%,
   b) Typ II mit regelmäßig erhöhtem HBA1c > 8,5%,
   c) Typ I oder II mit Endorganschäden;
9. arterielle Hypertonie mit bestehenden Endorganschäden, insbesondere chronische Herz- oder Niereninsuffizienz, oder nicht kontrollierbarer Blutdruckeinstellung.

» **Research Questions**:
  » Which comorbidities are risk factors for severe courses of COVID-19 in Austria?
  » Do we observe sex differences of comorbidities as risk factors?

Background

» **Ahlström et al. (2021)** identified asthma (OR 3.61, 95% CI 2.76–4.71), type 2 diabetes (2.42, 2.10–2.79), obesity (2.33, 1.78–3.05) and chronic renal failure (2.28, 1.62–3.23) as the strongest risk factors for COVID-19 ICU admission in Sweden.

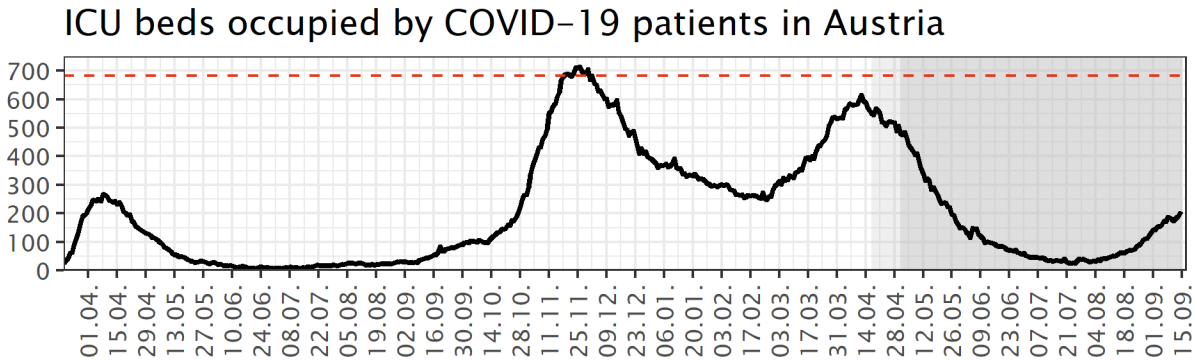
» Using the Charlson comorbidity index (CCI), **Cho et al. (2021)** identified renal disease (OR 4.95; 95% CI 2.37–10.31), diabetes (OR 2.22; 95% CI 1.63–2.95), and cancer (OR 1.88; 95% CI 1.17–3.02), amongst others, as risk factors for COVID-19 mortality based on a cohort study in South-Korea.

» Jun et al. (2021) analysed sex differences of comorbidities as risk factors in New York and found that obesity increase women's risk of intubation and intensive care in their primary cohort. However, the results could not be replicated in the validation cohort.

» However, study results on the impact of major chronic conditions such as cancer remain heterogeneous and inconclusive. Furthermore, hardly any cohort studies on sex differences of comorbidities as risk factors exists (sex differences can be expected due to differences in cytokines between men and women with COVID-19).

» In order to fill these gaps, we estimate the effect of comorbidities on COVID-19 hospitalisation, ICU admission, and mortality, respectively, based on a matched cohort study using nationwide hospital billing data from Austria

Methods



- Retrospective cohort study
  - Baseline period: 2015/01 – 2019/12
  - Follow-up period: 2020/02 – 2021/04

- Inclusion criteria:
  - at least one inpatient stay at **baseline** in Austria in order to measure comorbidities
  - at least one contact in the inpatient, outpatient or ambulatory care setting (with discharge types other than deceased) in 2019 in order to reduce attrition bias

- N = 3,604,788 patients (study population, approx. 40% of general Austrian population)
  34,649 patients with COVID-19 hospitalization (70% of COVID-19 patients 2020/02 – 2021/04)
  3,570,139 patients without COVID-19 hospitalization (used for exact matching; for each COVID-19 patient and outcome five controls of the same age group, sex and health care region were drawn)

- Endpoints
  - COVID-19 hospitalization, ICU admission and hospital mortality

Methods

» Main data source: hospital billing data related to the Austrian DRG-like system administrated by the Federal Ministry of Social Affairs, Health, Care and Consumer Protection

» Consideration of principal and additional diagnosis (ICD 10) for measuring comorbidities at baseline and identifying COVID-19 patients during follow-up

» Comorbidities are clustered according to the main medical conditions of the Charlson Comorbidity Index (CCI) following Cho et al. (2021) in order to obtain an easily comparable number of 19 comorbidities (using the R package `comorbidity` of Gasparini 2018). More granulated diagnoses categories used for robustness checks (categories, groups and chapters)

» We employ multivariable logistic regression to estimate adjusted odds ratios (OR) with 95 confidence intervals (95% CI) of comorbidities on the COVID-19 outcomes (using the `glm` function of the `stats` package and the `summ` function of the `jtools` package in R).

Results

Table 1: COVID-19 hospitalisations, ICU admissions and hospital mortality of the study population (26 Feb. 2020 – 30 Apr. 2021)

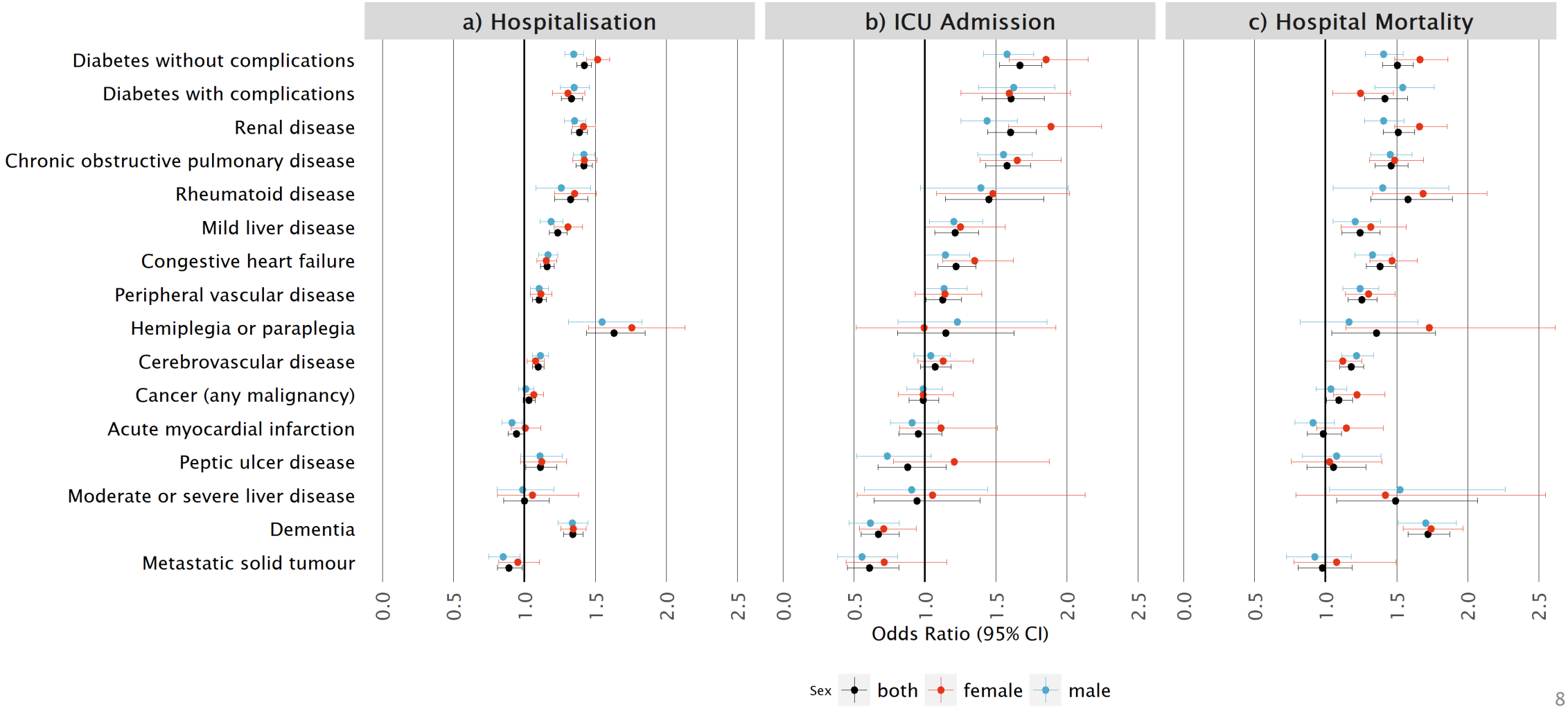
Sex	Age	Study Population	COVID-19 Hospitalisation		COVID-19 ICU Admission		COVID-19 Hospital Mortality	
		N	N	per 100k pop	N	per 100k pop	N	per 100k pop
M	0-19	278,194	232	83	21	8	5	2
M	20-39	285,320	811	284	93	33	13	5
M	40-49	196,537	1,259	641	192	98	39	20
M	50-59	289,215	2,756	953	594	205	187	65
M	60-69	252,818	3,672	1,452	952	377	618	244
M	70-79	230,143	5,353	2,326	1,100	478	1,508	655
M	80+	109,095	3,516	3,223	323	296	1,509	1,383
M	Tot.	1,641,322	17,599	1,072	3,275	200	3,879	236
F	0-19	229,324	350	153	16	7	0	0
F	20-39	516,960	1,500	290	93	18	11	2
F	40-49	230,423	1,117	485	101	44	29	13
F	50-59	289,928	1,840	635	252	87	100	34
F	60-69	248,519	2,398	965	445	179	265	107
F	70-79	268,091	4,848	1,808	681	254	870	325
F	80+	180,221	4,997	2,773	316	175	1,570	871
F	Tot.	1,963,466	17,050	868	1,904	97	2,845	145
M+F	Tot.	3,604,788	34,649	961	5,179	144	6,724	187

Notes: pop refers to total population, and k refers to 1,000, respectively. Hospital data only cover data from hospitals funded via regional health funds (which accounted for 92% of all acute care admissions in 2019). COVID-19 is considered both as main and secondary diagnosis. Patients without valid patient-ID (5% of COVID-19 ICU admissions) and patients who were not discharged by 31 March 2021 (2.323 patients with COVID-19, thereof 540 ICU patients) are not included.

1% of inpatient population had COVID-19 stay

Results

Figure 1: Adjusted effect sizes (OR) with 95 % CIs of risk factors for COVID-19 hospitalisation, ICU admission and hospital mortality



Results

Table 2: Adjusted effect sizes (OR) with 95 % CIs of risk factors for COVID-19 hospitalisation

Diagnosis (Group)	Adjusted OR (95% CI) male and female	Adjusted OR (95% CI) male	Adjusted OR (95% CI) female
Hemiplegia or paraplegia	1.63 (1.44, 1.85)***	1.55 (1.31, 1.83)***	1.76 (1.45, 2.13)***
AIDS/HIV	1.43 (0.88, 2.33)	1.14 (0.61, 2.11)	2.35 (1.04, 5.34)**
Diabetes without complications	1.42 (1.37, 1.47)***	1.35 (1.28, 1.42)***	1.52 (1.44, 1.60)***
Chronic obstructive pulmonary disease	1.42 (1.36, 1.48)***	1.42 (1.35, 1.50)***	1.42 (1.34, 1.51)***
Renal disease	1.39 (1.33, 1.44)***	1.35 (1.28, 1.43)***	1.42 (1.34, 1.50)***
Dementia	1.34 (1.28, 1.41)***	1.34 (1.24, 1.45)***	1.34 (1.26, 1.43)***
Diabetes with complications	1.33 (1.26, 1.41)***	1.35 (1.25, 1.46)***	1.31 (1.20, 1.42)***
Rheumatoid disease	1.32 (1.21, 1.45)***	1.26 (1.08, 1.47)***	1.35 (1.21, 1.51)***
Mild liver disease	1.24 (1.17, 1.30)***	1.19 (1.11, 1.27)***	1.31 (1.21, 1.41)***
Congestive heart failure	1.16 (1.11, 1.21)***	1.16 (1.10, 1.23)***	1.15 (1.09, 1.23)***
Peptic ulcer disease	1.11 (1.01, 1.23)**	1.11 (0.97, 1.27)	1.12 (0.97, 1.30)
Peripheral vascular disease	1.10 (1.06, 1.15)***	1.10 (1.04, 1.17)***	1.11 (1.04, 1.19)***
Cerebrovascular disease	1.10 (1.06, 1.14)***	1.11 (1.06, 1.17)***	1.08 (1.02, 1.14)***
Cancer (any malignancy)	1.03 (0.99, 1.07)	1.01 (0.96, 1.07)	1.07 (1.00, 1.14)*
Moderate or severe liver disease	1.00 (0.85, 1.17)	0.99 (0.81, 1.21)	1.06 (0.81, 1.38)
Acute myocardial infarction	0.94 (0.89, 1.00)*	0.91 (0.84, 0.99)**	1.01 (0.91, 1.12)
Metastatic solid tumour	0.89 (0.81, 0.98)**	0.85 (0.75, 0.97)**	0.95 (0.82, 1.11)
Total number of observations	207,894	105,594	102,300

Notes: *, **, *** refers to significance at the p<0.10, p<0.05, and p<0.01 level, respectively. Results refer to odds ratios (OR) and 95% confidence intervals (95% CI) obtained from logistic regression; analyses were adjusted for age group, sex and health care region.

Results

Table 3: Adjusted effect sizes (OR) with 95 % CIs of risk factors for COVID-19 ICU admission

Diagnosis (Group)	Adjusted OR (95% CI) male and female	Adjusted OR (95% CI) male	Adjusted OR (95% CI) female
Diabetes without complications	1.67 (1.52, 1.82)***	1.58 (1.41, 1.76)***	1.85 (1.59, 2.15)***
Diabetes with complications	1.61 (1.40, 1.84)***	1.62 (1.38, 1.91)***	1.59 (1.25, 2.02)***
Renal disease	1.60 (1.44, 1.78)***	1.44 (1.25, 1.65)***	1.89 (1.59, 2.24)***
Chronic obstructive pulmonary disease	1.58 (1.43, 1.74)***	1.55 (1.37, 1.75)***	1.65 (1.39, 1.96)***
Rheumatoid disease	1.45 (1.14, 1.84)***	1.39 (0.97, 2.01)*	1.48 (1.08, 2.02)**
Congestive heart failure	1.22 (1.09, 1.36)***	1.14 (1.00, 1.31)*	1.35 (1.12, 1.62)***
Mild liver disease	1.21 (1.07, 1.38)***	1.20 (1.03, 1.41)**	1.25 (1.00, 1.57)*
Hemiplegia or paraplegia	1.14 (0.81, 1.63)	1.23 (0.81, 1.86)	0.99 (0.51, 1.92)
Peripheral vascular disease	1.12 (1.01, 1.26)**	1.13 (0.99, 1.29)*	1.14 (0.93, 1.40)
Cerebrovascular disease	1.07 (0.97, 1.18)	1.04 (0.92, 1.18)	1.13 (0.95, 1.34)
Cancer (any malignancy)	0.99 (0.89, 1.10)	0.99 (0.87, 1.12)	0.99 (0.81, 1.20)
Acute myocardial infarction	0.95 (0.81, 1.12)	0.91 (0.75, 1.10)	1.11 (0.82, 1.51)
Moderate or severe liver disease	0.94 (0.64, 1.39)	0.91 (0.57, 1.44)	1.05 (0.52, 2.13)
Peptic ulcer disease	0.88 (0.67, 1.15)	0.73 (0.52, 1.04)*	1.21 (0.78, 1.87)
AIDS/HIV	0.77 (0.22, 2.74)	0.61 (0.13, 2.80)	1.42 (0.14, 14.64)
Dementia	0.67 (0.55, 0.82)***	0.62 (0.46, 0.82)***	0.71 (0.54, 0.94)**
Metastatic solid tumour	0.61 (0.45, 0.81)***	0.56 (0.38, 0.81)***	0.71 (0.44, 1.15)
Total number of observations	31,074	19,650	11,424

Notes: *, **, *** refers to significance at the p<0.10, p<0.05, and p<0.01 level, respectively. Results refer to odds ratios (OR) and 95% confidence intervals (95% CI) obtained from logistic regression; analyses were adjusted for age group, sex and health care region.

Results

Table 4: Adjusted effect sizes (OR) with 95 % CIs of risk factors for COVID-19 hospital mortality

Diagnosis (Group)	Adjusted OR (95% CI) male and female	Adjusted OR (95% CI) male	Adjusted OR (95% CI) female
AIDS/HIV	1.84 (0.44, 7.72)	1.78 (0.31, 10.35)	2.10 (0.18, 24.32)
Dementia	1.72 (1.58, 1.87)***	1.70 (1.51, 1.92)***	1.74 (1.54, 1.97)***
Rheumatoid disease	1.58 (1.32, 1.89)***	1.40 (1.05, 1.87)**	1.69 (1.33, 2.13)***
Renal disease	1.51 (1.41, 1.63)***	1.41 (1.27, 1.55)***	1.66 (1.49, 1.85)***
Diabetes without complications	1.51 (1.40, 1.62)***	1.41 (1.28, 1.55)***	1.66 (1.49, 1.86)***
Moderate or severe liver disease	1.49 (1.08, 2.07)**	1.52 (1.03, 2.26)**	1.42 (0.79, 2.55)
Chronic obstructive pulmonary disease	1.46 (1.35, 1.58)***	1.46 (1.32, 1.61)***	1.49 (1.31, 1.69)***
Diabetes with complications	1.42 (1.27, 1.58)***	1.54 (1.35, 1.76)***	1.24 (1.05, 1.48)**
Congestive heart failure	1.38 (1.28, 1.49)***	1.33 (1.20, 1.47)***	1.47 (1.31, 1.65)***
Hemiplegia or paraplegia	1.36 (1.04, 1.77)**	1.16 (0.82, 1.65)	1.73 (1.14, 2.62)***
Peripheral vascular disease	1.26 (1.16, 1.36)***	1.24 (1.12, 1.37)***	1.30 (1.14, 1.49)***
Mild liver disease	1.24 (1.11, 1.38)***	1.21 (1.05, 1.39)***	1.32 (1.11, 1.57)***
Cerebrovascular disease	1.18 (1.10, 1.27)***	1.22 (1.11, 1.34)***	1.12 (1.00, 1.25)*
Cancer (any malignancy)	1.09 (1.00, 1.19)**	1.04 (0.93, 1.15)	1.22 (1.05, 1.42)***
Peptic ulcer disease	1.06 (0.87, 1.28)	1.08 (0.84, 1.39)	1.03 (0.76, 1.39)
Acute myocardial infarction	0.98 (0.87, 1.11)	0.91 (0.78, 1.06)	1.15 (0.94, 1.41)
Metastatic solid tumour	0.98 (0.80, 1.19)	0.92 (0.72, 1.18)	1.08 (0.78, 1.50)
observations	40,344	23,274	17,070

Notes: *, **, *** refers to significance at the p<0.10, p<0.05, and p<0.01 level, respectively. Results refer to odds ratios (OR) and 95% confidence intervals (95% CI) obtained from logistic regression; analyses were adjusted for age group, sex and health care region.

Discussion

- Our analysis revealed several comorbidities associated with an elevated risk of severe COVID-19
  - Diabetes without complications constitutes the highest risk factor for hospitalisation (OR 1.42, 95% CI 1.37–1.47) and ICU admission (1.67, 1.52–1.82), followed by COPD (OR hospitalisation 1.42 (1.36–1.48), OR ICU admission 1.58 (1.43–1.74)), and renal disease (OR hospitalisation 1.39 (1.33–1.44), OR ICU admission 1.60 (1.44–1.78)).
  - For the endpoint of COVID-19, hospital mortality dementia represents the highest risk factor with an OR of 1.72 (1.58–1.87), followed by rheumatoid disease (1.58, 1.32–1.89), renal disease (OR 1.51, 1.41–1.63) and diabetes without complications (OR 1.51, 1.40–1.62).
  - Diabetes without complications is a significantly higher risk factor for COVID-19 hospitalisation for women (1.52, 1.44–1.60) compared to men (1.35, 1.28–1.42).

- Our results are partly in line with other published cohort studies.
  - Our results for diabetes as a risk factor for hospitalisation and ICU admission are very similar to the adjusted results from Rawshani et al. (2021) for Sweden (1.40, 1.34–1.47, and 1.42, 1.25–1.62, respectively) [6].
  - In contrast to Bennett et al. (2021) and Cho et al. (2021) we hardly find any association of cancer and COVID-19 hospitalisation and mortality. We do not find an association of cancer and COVID-19 ICU admission, which is in line with Ahlström et al. (2021).

Discussion

- **Limitations**
- **Causal inference is limited** due to the observational nature of our data. Since the causal effect of observed comorbidities may be confounded by unobserved factors such as socio-economic status, our results should be interpreted with caution.
  - The results for obesity or diabetes mellitus may be confounded by socioeconomic status.
  - Effect of dementia and paraplegia may be associated with living in LTC institutions and/or behavioral factors (e.g. prioritisation of patients with better health status when ICU load is high)

- **Coding quality is limited**: Since the data is primarily collected for accounting purposes issues such as upcoding or incomplete diagnoses coding with respect to additional diagnoses exists.

- **Limited external validity**: Focus on hospital inpatient sector due to limited availability of data on comorbidities for other healthcare settings in Austria. Aiming at identifying vulnerable population groups this limitation may be acceptable as vulnerable population likely has an inpatient stay in 2015-2019.

- **Individual behaviour such as risk aversion** may impact upon the results: i.e., patients with conditions listed on top of the risk group regulation such as chronic pulmonary disease or cancer may behaved more risk averse comparted to patients with other conditions, which may have led to a **self-defeating prophecy**.

Conclusion

- Our results may be used for sharpening the risk group definition and public health measures policies to protect vulnerable populations, or for prioritizing vaccination programmes.

- In particular, our study may contribute to raise awareness of large population groups such as diabetics by communicating the risk of severe courses of COVID -19 and thus communicating the benefits of vaccination.

- Further research should include subgroup analysis with respect to recovered population, vaccination status or different COVID-19 variants as reinfections, infections after vaccination or changes in severity due to new variants of concerns becomes more and more important.
  - E.g. which comorbidities are risk factors for severe courses of COVID-19 in fully vaccinated patients

Literature

[1] Bachner F, Bobek J, Habimana K, Ladurner J, Lepuschütz L, Ostermann H, et al. Austria. Health system review; Copenhagen: World Health Organization; 2018.

[2] Bennett KE, Mullooly M, O'Loughlin M, Fitzgerald M, O'Donnell J, O'Connor L, et al. Underlying conditions and risk of hospitalisation, ICU admission and mortality among those with COVID-19 in Ireland: A national surveillance study. The Lancet Regional Health - Europe. 2021;5.

[3] McGurnaghan SJ, Weir A, Bishop J, Kennedy S, Blackbourn LAK, McAllister DA, et al. Risks of and risk factors for COVID-19 disease in people with diabetes: a cohort study of the total population of Scotland. The Lancet Diabetes & Endocrinology. 2021;9(2): 82-93.

[4] Working group for the surveillance control of COVID-19 in Spain. The first wave of the COVID-19 pandemic in Spain: characterisation of cases and risk factors for severe outcomes, as at 27 April 2020. Eurosurveillance. 2020;25(50): 2001431.

[5] Ahlström B, Frithiof R, Hultström M, Larsson I-M, Strandberg G, Lipcsey M. The swedish covid-19 intensive care cohort: Risk factors of ICU admission and ICU mortality. Acta Anaesthesiologica Scandinavica. 2021;65(4): 525-33.

[6] Rawshani A, Kjölhede EA, Rawshani A, Sattar N, Eeg-Olofsson K, Adiels M, et al. Severe COVID-19 in people with type 1 and type 2 diabetes in Sweden: A nationwide retrospective cohort study. The Lancet Regional Health - Europe. 2021;4: 100105.

[7] Cho SI, Yoon S, Lee H-J. Impact of comorbidity burden on mortality in patients with COVID-19 using the Korean health insurance database. Scientific Reports. 2021;11(1): 6375.

[8] Griffith GJ, Morris TT, Tudball MJ, Herbert A, Mancano G, Pike L, et al. Collider bias undermines our understanding of COVID-19 disease risk and severity. Nature Communications. 2020;11(1): 5749.

[9] Hernán MA, Hernández-Díaz S, Robins JM. A structural approach to selection bias. Epidemiology. 2004;15(5): 615-25. Epub 2004/08/17.

[10] Hernán MA. The C-Word: Scientific Euphemisms Do Not Improve Causal Inference From Observational Data. American Journal of Public Health. 2018;108(5): 616-9.

[11] Hernán MA, Robins JM. Using Big Data to Emulate a Target Trial When a Randomized Trial Is Not Available. American journal of epidemiology. 2016;183(8): 758-64. Epub 2016/03/18.

[12] Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. Journal of Chronic Diseases. 1987;40(5): 373-83.

[13] Gasparini A. Comorbidity: An R package for computing comorbidity scores. Journal of Open Source Software. 2018;3(23): 648.

[14] R Core Team. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing, 2019.

[15] BMSGPK. Diagnosen- und Leistungsdokumentation des Bundesministeriums für Soziales, Gesundheit, Pflege und Konsumentenschutz. Vienna: Federal Ministry of Social Affairs, Health, Care and Consumer Protection, 2021.

[16] EMS. Epidemiologisches Meldesystem. Vienna: Federal Ministry of Social Affairs, Health, Care and Consumer Protection, 2021.

[17] BMI/BMSGPK. Dateneinmeldung der Bundesländer an BMI und BMSGPK. Vienna: Federal Ministry of the Interior,
Federal Ministry of Social Affairs, Health, Care and Consumer Protection, 2021.

[18] VanderWeele TJ. Mediation Analysis: A Practitioner's Guide. Annu Rev Public Health. 2016;37: 17-32. Epub 2015/12/15.

[19] Naimi AI, Cole SR, Kennedy EH. An introduction to g methods. Int J Epidemiol. 2017;46(2): 756-62. Epub 2017/01/01.

[20] Jun, T., et al. (2021). "Analysis of sex-specific risk factors and clinical outcomes in COVID-19." Communications Medicine 1(1): 3.

Conclusion

Thank you very much for your attention!

Remarks and questions are highly welcome,
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