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ORIGINAL ARTICLE

Diabetes IN hospital – Glucose and Outcomes in the COVID-19 pandemic (DINGO COVID-19): the 2020 Melbourne hospital experience prior to novel variants and vaccinations

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Abstract

Background and Aims: A relationship between diabetes, glucose and COVID-19 outcomes has been reported in international cohorts. This study aimed to assess the relationship between diabetes, hyperglycaemia and patient outcomes in those hospitalised with COVID-19 during the first year of the Victorian pandemic prior to novel variants and vaccinations.

Design, setting: Retrospective cohort study from March to November 2020 across five public health services in Melbourne, Australia.

Participants: All consecutive adult patients admitted to acute wards of participating institutions during the study period with a diagnosis of COVID-19, comprising a large proportion of patients from residential care facilities and following dexamethasone becoming standard-of-care. Admissions in patients without known diabetes and without inpatient glucose testing were excluded.

Results: The DINGO COVID-19 cohort comprised 840 admissions. In 438 admissions (52%), there was no known diabetes or in-hospital hyperglycaemia, in 298 (35%) patients had known diabetes, and in 104 (12%) patients had hyperglycaemia without known diabetes. ICU admission was more common in those with diabetes (20%) and hyperglycaemia without diabetes (49%) than those with neither (11%, $P < 0.001$ for all comparisons). Mortality was higher in those with diabetes (24%) than those without diabetes or hyperglycaemia (16%, $P = 0.02$) but no difference between those with in-hospital hyperglycaemia and either of the other groups. On multivariable analysis, hyperglycaemia was associated with increased ICU admission (adjusted odds ratio (aOR) 6.7, 95% confidence interval (95% CI) 4.0–12, $P < 0.001$) and longer length of stay (aOR 173, 95% CI 11–2793, $P < 0.001$), while diabetes was associated with reduced ICU admission (aOR 0.55, 95% CI 0.33–0.94, $P = 0.03$). Neither diabetes nor hyperglycaemia was independently associated with in-hospital mortality.

Conclusions: During the first year of the COVID-19 pandemic, in-hospital hyperglycaemia and known diabetes were not associated with in-hospital mortality, contrasting with published international experiences. This likely mainly relates to hyperglycaemia indicating receipt of mortality-reducing dexamethasone therapy. These differences in published experiences underscore the importance of understanding

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population and clinical treatment factors affecting glycaemia and COVID-19 morbidity within both local and global contexts.

Introduction

In 2020, the first year of the coronavirus disease 2019 (COVID-19) pandemic, 20 368 of Australia's 28 327 cases (72%) were diagnosed in the state of Victoria.[1] The Victorian health system thus bore the brunt of the early healthcare response, in the process developing the broadest experience with COVID-19 prior to vaccination programmes commencing in Australia. With the emergence in 2021 of new variants, such as B.1.1.529 (Omicron), where existing vaccines have reduced effectiveness in preventing infection,[2] the pre-vaccination experience remains relevant, particularly as there are relatively few documented Australian COVID-19 inpatient experiences to date.[3–6]

Both diabetes and new hyperglycaemia have been associated with increased risk of adverse outcomes in patients hospitalised with COVID-19 in international cohorts, with odds ratios (ORs) for mortality conferred by pre-existing diabetes ranging from 1.49 to 3.64.[7–11] Similarly, those with diabetes or uncontrolled hyperglycaemia have been shown to have higher mortality than those with neither (28.8 vs 6.2%).[11] With approximately 5% of the Australian population[12] and up to 35% of Melbourne hospital inpatients having known diabetes,[13,14] it is likely that diabetes is a significant co-factor in COVID-19 morbidity and mortality in Australia.

To inform future inpatient management of glycaemic disorders in those with COVID-19 in Australia, we assessed the relationship between diabetes, hyperglycaemia and outcomes in those hospitalised with COVID-19 during the first year of the Victorian pandemic (Box 1).

BOX 1 Findings in context

Background: Diabetes and hyperglycaemia have been associated with adverse outcomes in patients hospitalised for COVID-19 in international experiences.

Key findings: During 2020, in the Victorian COVID-19 pandemic, in-hospital hyperglycaemia and known diabetes were not associated with in-hospital mortality, likely related to changing demographics and standard of care.

Implications: This underscores the importance of understanding factors affecting COVID-19 morbidity and mortality within both local and global contexts.

Methods

Study design and participants

The Diabetes IN-hospital – Glucose and Outcomes in the COVID-19 pandemic (DINGO COVID-19) retrospective cohort study was conducted in the first year of the pandemic between March and November 2020, a period that included the first two waves of COVID-19 in Victoria, Australia.[15]

Participating institutions (Austin Health, Melbourne Health, Northern Health, St Vincent's Health and Western Health) predominantly serve the central, western and northern geographic regions of Melbourne, where most COVID-19 cases during this period occurred.[15] All institutions are teaching hospitals affiliated with the University of Melbourne. All consecutive adult patients admitted with COVID-19, diagnosed at admission or during the stay, were included. Patients were not included where admission was for purely social purposes, for example, asymptomatic COVID-19-positive patients whose usual carers were unwell with COVID-19. Inpatient stays occurring entirely within a 'hospital-in-the-home' context were not included. Where multiple admissions included discharge coding consistent with COVID-19, only the first was included. We subsequently excluded admissions without a history of diabetes where there was no inpatient glucose testing as hyperglycaemia or the lack thereof could not be established.

COVID-19 was defined by discharge coding and required detection of the SARS-CoV-2 virus by nucleic acid testing. Wave 1 of the Victorian pandemic included admissions from 1 March 2020 to 30 June 2020. Wave 2 included admissions from 1 July 2020 to 30 November 2020.[15] This demarcation aligns with the July re-intensification of restrictions on a postcode basis. Of note, COVID-19 vaccines became available in Australia from February 2021.

Known diabetes was defined as a clinical diagnosis of diabetes, pre-hospital prescription of glucose-lowering medications or pre-admission $HbA_{1c} \geq 6.5\%$ (≥48 mmol/mol). An elevated HbA_{1c} value during the admission did not contribute to this definition. In-hospital hyperglycaemia in people with and without known diabetes was defined as ≥1 blood glucose (BG) measurement ≥11.1 mmol/L (≥200 mg/dL). This threshold was selected as the conventional threshold for diabetes diagnosis on random testing and the upper range of target inpatient

glucose in a major guideline.[16] Glucocorticoid treatment was defined as any oral, intravenous or intramuscular glucocorticoids regardless of dose.

During the study period, COVID-19 was treated with supportive therapies including supplemental oxygen, mechanical ventilation and haemodynamic support. Therapies, including dexamethasone[17] and remdesivir,[18] both entered widespread use in Victoria from July 2020.

During the study period, diabetes and glucose management protocols differed between institutions with some institutions developing protocols specific to glucose management in COVID-19. Typically, all patients admitted to hospital with a respiratory illness such as COVID-19 receive at least one blood gas assessment, which includes a glucose result, while patients admitted with known diabetes are typically commenced on glucose monitoring four times per day. It was also typical for patients without known diabetes who were commenced on glucocorticoids to receive glucose testing for a period, often a few days.

Data collection

Patient information, investigation results and outcomes were collected directly from progress notes, pathology results systems and administrative databases by clinicians using REDCap hosted at the University of Melbourne.[19] A standard dataset was collected for all patients. For those patients with known diabetes or inpatient hyperglycaemia, extended data collected included the modified Charlson Comorbidity Index (CCI)[20] (excluding age and diabetes items, considered separately), diabetes type, diabetes duration, inpatient therapies (oxygen, intubation, vasopressor or inotropic medications, remdesivir, glucocorticoids, total parenteral nutrition or enteral nutrition (TPN/EN)), and biochemical values (admission haemoglobin (Hb) and creatinine, peak white cell count (WCC), C-reactive protein (CRP) and HbA_{1c}).

Outcome measures

Outcomes assessed for the entire cohort were intensive care unit (ICU) admission, in-hospital mortality and length of stay (LOS). For LOS analyses, patients who died in hospital were excluded as was any 'hospital-in-the-home' period. For the extended dataset, additional outcomes included a requirement for vasopressor or inotropic medications and a requirement for intubation.

Statistical analysis

For the purpose of population description, we categorised patients in two ways. The first was by glycaemic status. The second categorisation was by admission date: wave 1 versus wave 2. To evaluate the effects of various predictors upon outcomes, multivariable analyses were conducted using binomial logistic regression models for binary outcomes and linear regression models for LOS (reported as fractional days). Where incomplete data were available for biochemical parameters, multiple imputation using fully conditional specification was performed.[21] Collinearity was assessed using the variance inflation factor (VIF) method. The Wilcoxon rank-sum test was used for continuous data and the chi-squared for categorical. Statistical analyses were performed in R version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria). Non-base packages used for the analyses included mice version 3.12.0.

Ethical approval

The study was approved by the Melbourne Health Human Research Ethics Committee (MH2020066).

Results

During the study period, 958 admissions met the inclusion criteria. Of these, there was no glucose testing in 118 admissions, which were excluded from further analysis (characteristics described in Table S1). The remaining 840 admissions comprised the DINGO COVID-19 cohort; clinical characteristics are described in Table 1 (additional characteristics reported in Tables S2–S6). Sixty-seven (8%) patients were diagnosed with COVID-19 as inpatients, having been asymptomatic at admission (noting that asymptomatic testing at admission was not routine at the time).

When categorised by glycaemic status, those with known diabetes (group B) and no known diabetes with hyperglycaemia (group C) had higher mean weight and were more likely to be male than those without diabetes or hyperglycaemia (group A), while those with diabetes (group B) were older than patients in both of the other groups. Patient characteristics did not differ significantly between waves 1 and 2 (Box 1).

There were 438 admissions for patients without diabetes or hyperglycaemia (group A) and 402 admissions for patients with either known diabetes ($n = 298$) or hyperglycaemia without known diabetes ($\underline{n} = 104$) (groups B and C). These admissions formed the diabetes/hyperglycaemia subset for which extended data were collected (described in Table 2).

Compared with those who had known diabetes (group B), patients with hyperglycaemia without diagnosed diabetes (group C) had fewer comorbidities (even after removing age and diabetes from the CCI) and were more

Table 1 Demographics for entire cohort (standard dataset) categorised by glycaemic status

	A. No known diabetes and no in-hospital hyperglycaemia	B. Known diabetes	C. In-hospital hyperglycaemia and no known diabetes	Entire cohort
N	438	298	104	840
Age (IQR)	64 (47–83)	74 (60–84)	65 (55–78)	70 (54–83)
P-value (WRS vs A)	–	<0.001***	0.85	–
P-value (WRS vs B)	–	–	<0.001***	–
Male (%)	184 (42%)	156 (52%)	63 (61%)	403 (48%)
P-value (χ^2 vs A)	–	0.007**	<0.001***	–
P-value (χ^2 vs B)	–	–	0.18	–
Weight in kg (±SD)	76.1 ± 21.5	80.1 ± 22.0	83.5 ± 22.2	79 ± 22
P-value (WRS vs A)	–	0.04*	0.004**	–
P-value (WRS vs B)	–	–	0.18	–
Height in cm (±SD)	166 ± 9.1	165 ± 13.1	166 ± 9.0	166 ± 10.8
P-value (WRS vs A)	–	0.95	0.55	–
P-value (WRS vs B)	–	–	0.75	–

Data presented as median (IQR), mean ± SD or number (percentage). Continuous comparisons are by Wilcoxon rank-sum test, categorical comparisons are by chi-squared test. IQR, interquartile range; SD, standard deviation; WRS, Wilcoxon rank-sum test; χ^2, chi-squared test.
*Indicates statistical significance at $P < 0.05$.
**Indicates statistical significance at $P < 0.01$.
***Indicates statistical significance at $P < 0.001$.

Table 2 Additional demographics, inpatient therapy and biochemistry for diabetes/hyperglycaemia subset categorised by diabetes/hyperglycaemia status

	B. Known diabetes	C. In-hospital hyperglycaemia and no known diabetes	*P*-values for comparisons	Extended subset (groups B and C)
N	298	104	–	402
Modified Charlson Comorbidity Index (IQR)	1 (0–3)	0 (0–2)	0.001**	1 (0–3)
Inpatient therapies received				
Glucocorticoids (%)	161 (54%)	88 (85%)	<0.001***	249 (62%)
Remdesivir (%)	53 (18%)	36 (35%)	<0.001***	89 (22%)
Oxygen (%)	207 (70%)	90 (88%)	<0.001***	297 (75%)
TPN/EN (%)	33 (11%)	32 (31%)	<0.001***	65 (16%)
Biochemistry				
Haemoglobin (g/L) (±SD)	126 ± 21.5	134 ± 22.6	0.001**	128 ± 22.1
White cell count ($\times 10^9$/L) (±SD)	11.4 ± 6.9	13.9 ± 6.7	<0.001***	12.1 ± 6.9
Creatinine (μmol/L) (±SD)	124 ± 101	104 ± 113	0.0097**	119 ± 104
C-reactive protein (mg/L) (±SD)	127 ± 99.5	156 ± 97.1	0.002**	134 ± 99.6
HbA1c (%) (±SD)	8.1 ± 1.9	6.8 ± 1.7	<0.001***	7.8 ± 1.9
HbA1c (mmol/mol) (±SD)	65 ± 15	51 ± 13	<0.001***	62 ±15

Data presented as median (IQR), mean ± SD, or number (percentage). Continuous comparisons are by Wilcoxon rank-sum test, categorical comparisons are by chi-squared test. IQR, interquartile range; SD, standard deviation.
**Indicates statistical significance at $P < 0.01$.
***Indicates statistical significance at $P < 0.001$.

likely to receive therapy with glucocorticoids, remdesivir, oxygen and TPN/EN. These patients in group C also had higher mean Hb, WCC and CRP but lower creatinine and HbA_{1c} values than those in group B. Of note, HbA_{1c} was only available for 172 (58%) of the patients with known diabetes (group B) and 44 (42%) of the patients with hyperglycaemia without diagnosed diabetes (group C). Patients with diabetes or hyperglycaemia admitted during wave 2 had a greater comorbidity burden and were more likely to receive glucocorticoid therapy than during wave 1 (Box 2).

Patients in the DINGO COVID-19 cohort received a median of 10 glucose tests (interquartile range (IQR) 4–26.5). Of note, for those patients with hyperglycaemia

BOX 2 Key characteristics of waves 1 and 2 of the Victorian 2020 COVID-19 pandemic

Wave 1 (March–June 2020)
- Predominantly returned travellers and international visitors to Victoria.
- Lower proportion aged >70 years.
- Low hospital admission and mortality rate.
- No specific therapies approved (though some used off-label) or vaccine available.

Wave 2 (July–November 2020)
- Community transmission centred on the northern and western suburbs of Melbourne.
- Higher proportion aged >70 years.
- Outbreaks in community housing towers, residential aged care facilities and subacute hospital wards.
- Specific therapies of dexamethasone and remdesivir approved and instituted as standard-of-care. No vaccine available.

without diagnosed diabetes (group C), 27% of all glucose results were ≥11.1 mmol/L.

Sampling representativeness

To ensure representative sampling, admission dates for the DINGO COVID-19 cohort were compared with the number of daily new cases in Victoria as reported by the Department of Health and Human Services (Fig. 1).[1]

Outcomes

Entire cohort

Those in group C (in-hospital hyperglycaemia and no known diabetes) were more likely to be admitted to ICU than both those in groups A (no in-hospital hyperglycaemia and no known diabetes) and B (known diabetes) (A: 11%, B: 20% and C: 49%, $P < 0.001$ for all intergroup comparisons) (Table S7). Mortality was higher in those with diabetes (group B, 24%) than those without diabetes or hyperglycaemia (group A, 16%, $P = 0.02$ for group B vs A), but no different between those with in-hospital hyperglycaemia (group C, 21%) and any other group. Median LOS was longer in both groups B (9 days, IQR 4–18) and C (12 days, IQR 7–20) than group A (6 days, IQR 3–13, $P < 0.001$ for groups B and C vs A). While ICU admission rates were higher in wave 1 (29%) versus wave 2 (18%, $P = 0.045$), inpatient mortality was higher in wave 2 (20%) than wave 1 (7%, $P = 0.01$).

Extended subset

Of the two additional outcomes assessed in the extended subset, those with hyperglycaemia without diagnosed diabetes (group C), compared with those with diabetes (group B), had higher rates for the use of vasopressors/inotropes (32% vs 12%, $P < 0.001$) and intubation (36% vs 13%, $P < 0.001$) (Table S8). Neither of these outcomes differed between waves 1 and 2.

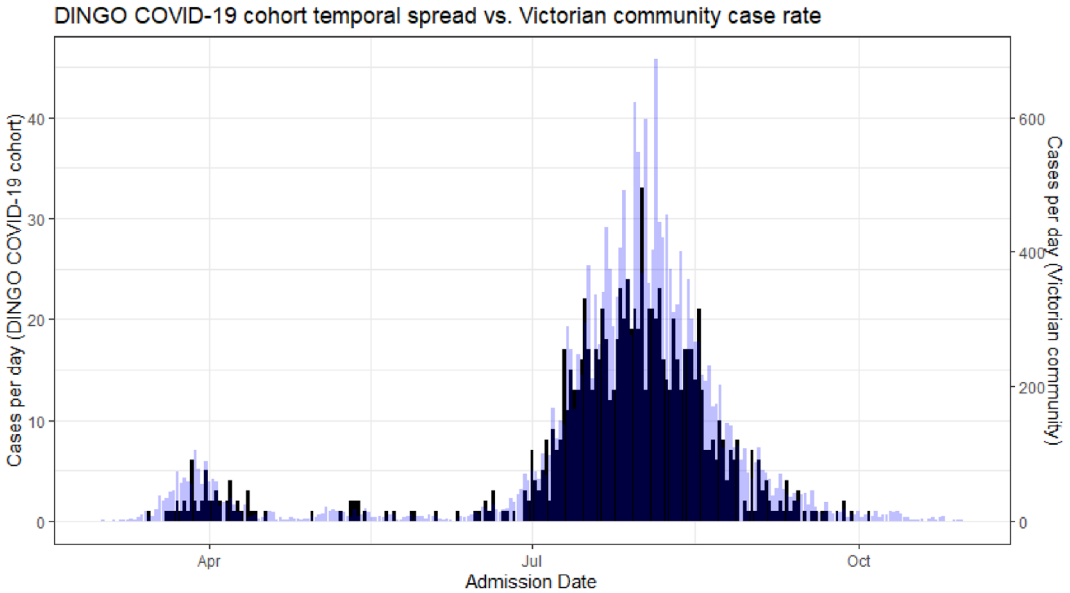

Figure 1 DINGO COVID-19 cohort admission date histogram (black, left axis) with the Victorian daily community case rate histogram (transparent purple, right axis) overlaid.

Multivariable analyses

For all reported multivariable analyses collinearity was absent (the VIF for each covariate in each regression model remained below 2.0). To assess the independent effects of diabetes and hyperglycaemia, mutually exclusive categorisations used for descriptive statistics and group-based analysis were not retained. Thus, hyperglycaemia was reportable both in patients with and without known diabetes. Of the 298 patients with diabetes, 230 (77%) experienced in-hospital hyperglycaemia. Of the 542 patients without diabetes who had glucose testing, 104 (19%) experienced in-hospital hyperglycaemia. Height was only available in 17%, weight in 73% and smoking status in 64%, so they were excluded as covariates from multivariable analysis.

Entire cohort

On multivariable analysis including seven covariates (known diabetes, in-hospital hyperglycaemia (BG ≥ 11.1 mmol/L; in patients both with and without diabetes), glucocorticoid use, wave 1 vs 2, age, gender and residential status), in-hospital hyperglycaemia was independently associated with a greater risk of ICU admission and longer LOS (Fig. 2). Known diabetes was associated with a lower risk of ICU admission. Neither in-hospital hyperglycaemia nor diabetes was associated with in-hospital mortality (Fig. 2). Of the other covariates that were independently associated with the aforementioned outcomes, age was associated with each (Fig. 2). Older age was associated with a higher risk of in-hospital mortality and longer LOS and with a lower incidence of admission to the ICU. Full details of the binomial logistic regression models are reported in Table S9.

Extended subset

Extended subset analyses included existing covariates and an additional seven covariates (modified CCI, remdesivir therapy, Hb, WCC, Cr, CRP and HbA_{1c}). For the requirements for vasopressor/inotrope therapy and intubation, the receipt of glucocorticoids, WCC and CRP was each associated with both outcomes. Older age was associated with a decreased incidence of both outcomes (Table S9).

Discussion

The DINGO COVID-19 cohort represents the largest assessment to date of glycaemic disorders in relation to adverse clinical outcomes in patients admitted to hospital with COVID-19 in Australia. On multivariable analysis, in contrast to international experiences,[7] we did not find diabetes to be independently associated with an increased mortality, ICU admission or longer LOS. This finding may reflect the particular characteristics of the Victorian pandemic's second wave, which contributed to the majority of this cohort's patients. Several outbreaks occurred in residential aged care facilities, where diabetes prevalence is at least twice that of the general community,[22] as well as an outbreak at the subacute campus of one of the contributing institutions, the characteristics of which have been previously described.[3,23] These changing demographics are illustrated by the skewed age distribution in the second compared with the first wave (Fig. 3). With over a quarter of our cohort residing in a care facility, diabetes status aligns closely with a patient's burden of comorbidities. Those with diabetes in our cohort had a higher CCI than those with hyperglycaemia and no known diabetes. Diabetes thus denotes a population in whom the goals and outcomes of care would have precluded admission to ICU. Certainly, residence in a care facility was associated with a lower OR for ICU admission than diabetes status.

In our cohort, inpatient hyperglycaemia was associated with increased rates of ICU admission and longer LOS. This could be causative, that is, uncontrolled hyperglycaemia requiring intravenous insulin infusion and prolonging the inpatient stay until euglycemia is achieved. Alternatively, hyperglycaemia could be a surrogate for illness severity more generally,[24] consistent with the multidirectional pathophysiologic relationships between diabetes, hyperglycaemia and COVID-19.[25] Indeed, this would likely explain our observation that those with inpatient hyperglycaemia but no known diabetes experienced greater morbidity than those with diabetes despite having fewer comorbidities.

Many published international experiences have found an association between hyperglycaemia and inpatient mortality; however, these reported on patients admitted before June 2020.[11,26,27] Importantly, in the DINGO COVID-19 cohort, most patients were admitted after July 2020, which followed the RECOVERY trial's preprint release, establishing the glucocorticoid dexamethasone as standard of care in hypoxic or intubated patients hospitalised with COVID-19.[17] Of the 104 patients without known diabetes who experienced hyperglycaemia in our cohort, 90 (88%) required oxygen and 88 (85%) received glucocorticoid therapy, a therapy well established to increase in-hospital hyperglycaemia risk.[28] This suggests that most of those experiencing hyperglycaemia in our cohort did so at least in part due to receiving glucocorticoids, a mortality-reducing therapy, which is prescribed based on greater disease severity. As such, glucocorticoid therapy is likely behaving as a surrogate for disease severity in our cohort, and its association

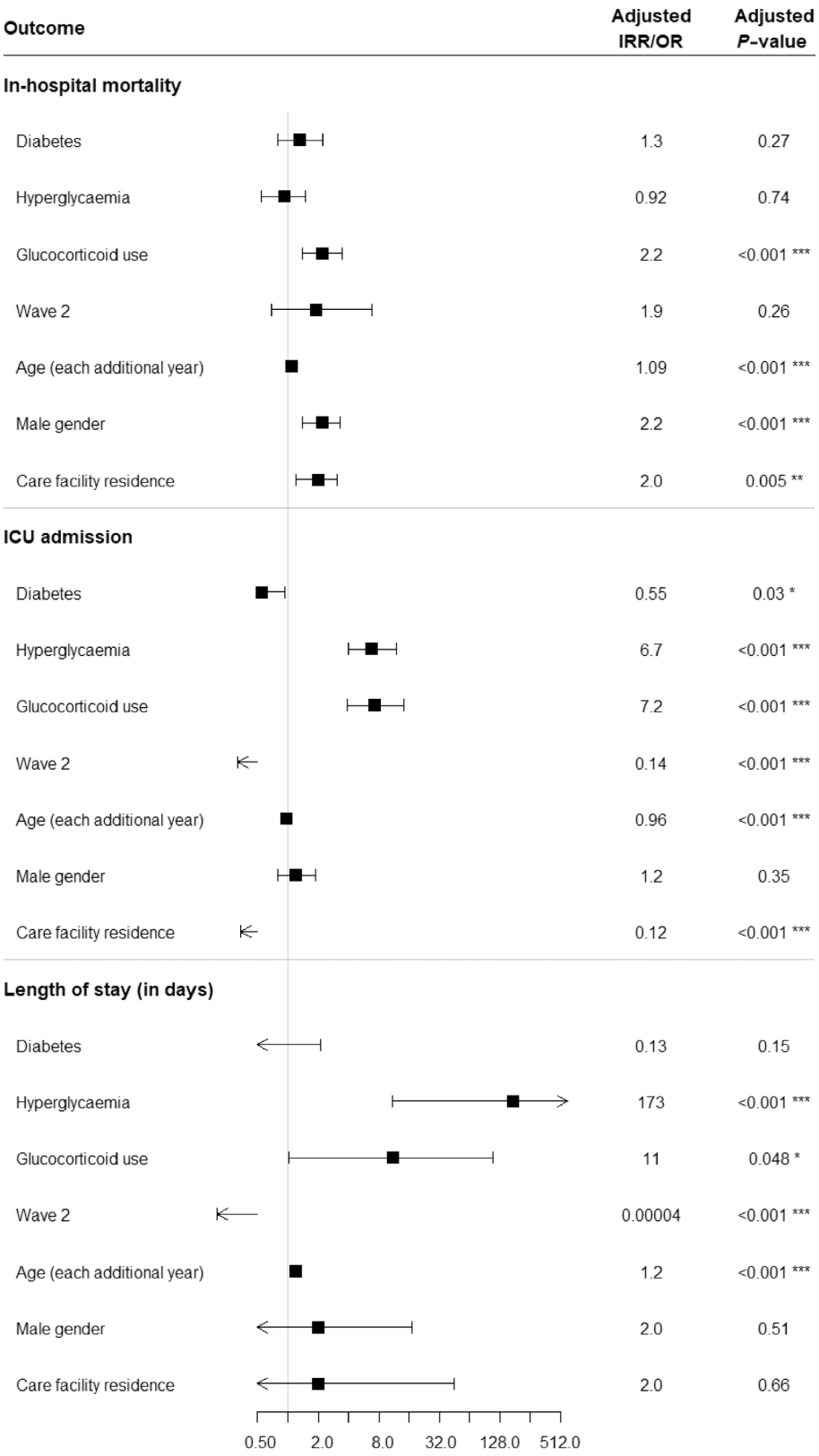

Figure 2 Multivariable associations between candidate predictor covariates and adverse clinical outcomes. Boxes, adjusted incidence rate ratios (IRRs) or odds ratios (ORs). Horizontal lines, 95% confidence intervals. *Indicates statistical significance at $P < 0.05$. ***Indicates statistical significance at $P < 0.001$. Analyses adjusted for known diabetes, in-hospital hyperglycaemia, glucocorticoid use, wave, age, gender and residential status.

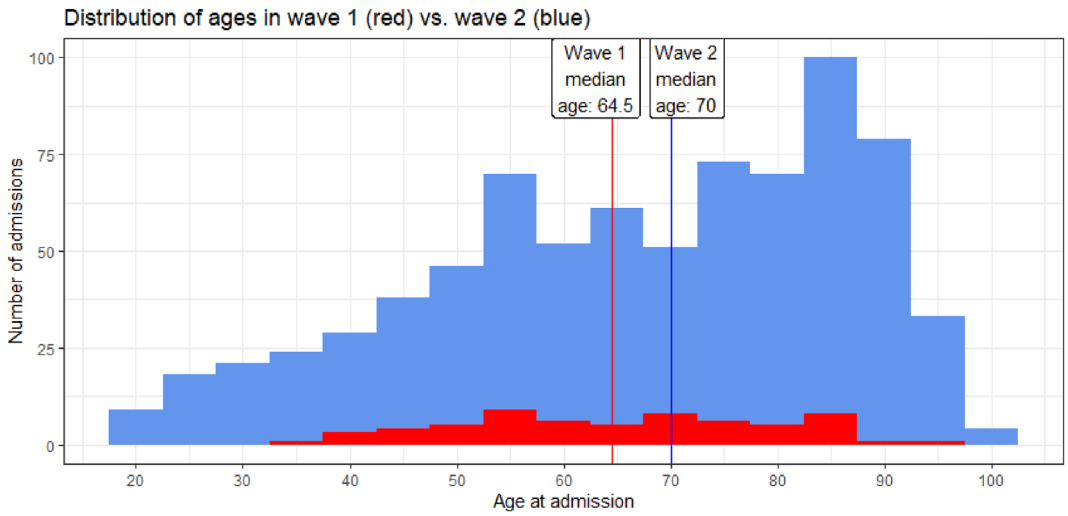

Figure 3 Distribution of age in years at admission in waves 1 (red) and 2 (blue). Histogram bars represent 5 years and centre on the midpoint of each 5-year range.

with increased mortality is unsurprising. The differential findings between our cohort and previously published work underscore the importance of understanding risk factors in context and being alert to the possibility of reverse causality. While treatment of hyperglycaemia may modify COVID-19-related morbidity and mortality, it is unlikely that glycaemic management in Victoria is sufficiently superior to international cohorts to account for the differences seen.

Additional factors associated with in-hospital mortality in our cohort included older age and male gender, consistent with previous published reports.[8,29] Of the other factors found to be independently associated with adverse outcomes, it was notable that admissions during wave 2 were less likely to include an ICU admission and had shorter LOS. During the second wave, when daily Victorian case rates were an order of magnitude higher than the first, clinician thresholds for ICU referral and admission were likely higher and alternatives to hospital admission were available. The markedly higher proportion of patients residing in a care facility in wave 2 (28%) versus 1 (5%), who would mostly have had a ward-based ceiling of care, would have further contributed to these interwave differences.

The outcomes we report for the DINGO COVID-19 cohort from 2020 remain relevant for inpatient COVID-19 management as the pandemic continues into a third year, the efficacy of vaccines developed against earlier variants wanes, and novel COVID-19 mutations arise. While international pre-RECOVERY cohorts reported greater mortality in inpatients with diabetes or hyperglycaemia, the Victorian experience did not reflect this relationship. We believe it is important to acknowledge differences in diabetes cohorts, which may be relevant to interpreting outcomes. For example, in the study by Bode *et al.*[11] mean HbA1c was 8.7 ± 2.4% (72 ± 20 mmol/mol) in a group comprising both diabetes and newly detected diabetes based on HbA1c. By contrast, in our cohort, the group comprising known diabetes only had a lesser severity of pre-admission hyperglycaemia with a mean HbA1c of 8.1 ± 1.9% (65 ± 15 mmol/mol). It is possible that chronic outpatient relative hyperglycaemia increases COVID-19-related adversity. Additionally, our cohort had a median age almost a decade older than the Bode cohort diabetes group (74 vs 65 years), with age clearly associated with increased mortality risk. These major demographic differences in addition to the Bode cohort's pre-RECOVERY time period likely account for the differences seen; however, the differential contribution of time period and demographic differences cannot be disambiguated.

Our data suggest that diabetes status and incident hyperglycaemia are less useful prognostic indicators for patient outcomes than other factors such as age, care facility residence and glucocorticoid use. Thus, it is these other factors, and not diabetes or hyperglycaemia status, that would be better used for rationing management decisions for individual patients should Australian COVID-19 case numbers overwhelm hospitals. The comparisons between waves 1 and 2 reveal important differences reflective of outbreak characteristics and rapidly changing clinical management. It is thus clear that extrapolating the findings of international and even local

experiences must be done with deep contextual understanding.

The strengths of this study include its multi-centre collaborative nature. Our cohort was closely representative of the first two waves of the Victorian pandemic (Fig. 1) and comprised the majority of Victorian COVID-19 hospital admissions during 2020. Reliability of our findings is underscored by clinician-audited data directly from the medical record rather than coding or other derivative sources. Limitations include those inherent in an observational study where only associations can be reported. While multivariable adjustment was performed, there were residual confounders that remained unaccounted for. Height, weight and smoking status in particular were only available in less than 75% of the clinical records and were thus excluded since imputing missing results would likely to biased results. For example, it would have been particularly valuable to have data on the individualised clinician-determined ceiling of care for all patients and in particular those from care facilities. Variable definitions of hyperglycaemia across published studies are another impediment to direct comparison. The size of our cohort, while comparable to many of the published international experiences considering diabetes or hyperglycaemia, was smaller than some with orders of magnitude more patients. It is possible that differences in statistical power account for some of the differences in findings between our and other studies.

Future research in hospitalised COVID-19 patients should attempt to determine the value of preventing and treating hyperglycaemia with regard to adverse outcomes, potentially through a randomised controlled trial of higher compared with lower target glucose ranges.

Conclusion

The DINGO COVID-19 study evaluated outcomes in COVID-19 admissions according to glycaemic status during the first two waves of the Victorian pandemic in 2020. DINGO COVID-19 identified in-hospital hyperglycaemia to be associated with increased ICU admission and longer LOS, while known diabetes was not associated with increased ICU admission or LOS. Neither was associated with increased in-hospital mortality. The differential contribution of diabetes and in-hospital hyperglycaemia to these outcomes compared with international experiences underscores the importance of understanding factors potentially associated with COVID-19 morbidity within both local and global contexts.

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Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web-site:

Table S1. Supporting Information