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Evolution of the COVID-19 Pandemic and Its Impact on Potential Sick Leave in the Federal State of Tyrol

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Abstract. Background: The COVID-19 pandemic strained healthcare systems, with Tyrol, Austria, as an early hotspot due to Alpine tourism. Variants like Alpha, Delta, and Omicron influenced infection and hospitalization trends. Objectives: To assess how different variants affected hospital occupancy, sick leave, and infection rates in Tyrol. Methods: Daily data on infections, hospital occupancy, and variants from 2020–2022 were analyzed using statistical trend assessments. Results: Sick leave peaked at 38,542 days in early 2022 during the Omicron wave. Hospital occupancy rose significantly during Alpha and Omicron surges, despite milder disease severity for Omicron. Preventive measures temporarily reduced absenteeism. Conclusion: Highly transmissible variants caused significant healthcare strain despite lower severity. Adaptable crisis management strategies are essential for mitigating future pandemic impacts.

Keywords. COVID-19, Computational Modelling, Computer Simulations, Sick days

1. Introduction

Since its global outbreak at the end of 2019, the COVID-19 pandemic has had far-reaching effects on healthcare systems, the economy and society. In Austria, the federal state of Tyrol came into focus early on due to its central role in Alpine tourism: it became one of the first hotspots of infection activity as early as spring 2020.

Different virus variants (alpha, beta, gamma, delta and even omicron) emerged as the virus progressed, each with different infection dynamics and disease progression [1,8]. These mutations not only influenced the regional incidence of infection, but also had a direct impact on the burden on healthcare facilities: Both occupancy rates in normal wards and intensive care units as well as staffing requirements and the associated sickness rates changed, in some cases significantly, with the emergence of new variants [8]. The coronavirus wave in particular made it clear that a simultaneously high infection rate and (on average) milder courses can nevertheless lead to enormous pressure on the

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healthcare system, as high infection rates massively reduced staffing levels in hospitals and care facilities.

This paper looks at the development of the different virus variants in Tyrol and systematically examines how the individual mutations have affected infection numbers, hospital occupancy rates and staff shortages [5,6]. The aim is to better understand the different stress scenarios for the healthcare and economic system through a detailed analysis of these parameters and to derive possible recommendations for action for future crisis management. This involves evaluating epidemiological data as well as taking into account the measures taken by politicians and authorities that have influenced these developments. On this basis, the aim is to show how Tyrol had to adapt to different challenges during the COVID-19 pandemic and what lessons can be learned for dealing with comparable crisis situations.

2. Methods

2.1. Data Sources and Collection

Daily counts of active SARS-CoV-2 cases were obtained from the official reports provided by the State of Tyrol. These data were collected and used at the municipality level, ensuring geographically detailed insights into infection dynamics [2-6]. Each report included the date of registration, the number of ongoing infections, and the municipality to which each case was assigned. On a daily basis, all hospitals across Tyrol reported the occupancy levels of intensive care units (ICU) and normal wards (NB) used for COVID-19 patients. These data allowed for an assessment of the healthcare system's capacity and the strain on hospital resources over time. Each record contained the specific date, the hospital identifier (or aggregated for the entire region), and the number of beds occupied by confirmed COVID-19 patients in both ICU and NB sections. Information regarding the circulating SARS-CoV-2 variants was sourced from the Austrian Agency for Health and Food Safety (AGES) [4]. AGES provides variant surveillance data at regular intervals, indicating which variants (e.g., Alpha, Beta, Delta, Omicron) were detected and their approximate share in the total number of sequenced samples. This dataset served to contextualize the observed trends in infection rates and hospital occupancy with the emergence or dominance of specific virus lineages.

2.2. Data Processing and Integration

All datasets (active cases, hospital occupancy, and variant prevalence) covered an overlapping period from 2020 to 2022. For each day, data from different sources were merged using the date as a common key.

While municipality-level data on active cases were available, the hospital occupancy data were often aggregated at the regional (Tyrol-wide) or hospital-level scale. To match these differing granularities, the analysis primarily focused on Tyrol-wide aggregates, ensuring consistency when evaluating trends over time.

2.3. Statistical Analysis

Daily case counts were plotted and summarized to illustrate infection waves and local peaks. For each day, the reported ICU and normal-ward occupancies were combined to track overall trends. Periodic (e.g., weekly or quarterly) averages and medians were calculated to smooth out short-term fluctuations.

The proportion of each variant (Alpha, Beta, Gamma, Delta, Omicron, etc.) was mapped onto the timeline of active cases and hospital occupancy, allowing direct comparison between variant emergence/dominance and changes in infection or hospitalization rates.
In a comparative analysis, we juxtaposed the evolution of infection waves (i.e., daily active cases), hospital occupancy in both intensive care units (ICU) and normal wards (NB), and variant prevalence data from AGES. This approach allowed us to determine how the Tyrolean healthcare system responded to surges of specific variants, to evaluate whether variants with higher transmissibility or severity (such as Alpha or Delta) led to steeper increases in hospital occupancy and missed workdays, and to investigate the temporal offset between rising case numbers and subsequent hospital admissions in ICU versus normal ward.

Data cleaning and transformations were performed with R (version 4.4.1) using packages such as dplyr and tidyr. Visualizations (e.g., line plots, bar charts) were created with ggplot2. All data were available in an anonymous or aggregated format (e.g., total active cases per municipality per day, total daily hospital occupancy), which meant that no patient-level information was ever recorded or disclosed. Consequently, the analysis was conducted in full compliance with Austrian data protection regulations.

3. Results

In Tyrol, the development of sick leave over the COVID pandemic years was characterized by a remarkably positive balance. The federal state consistently had the shortest average duration of sick leave due to COVID-19. While an average of 18.7 days per case was reported in Vorarlberg, this figure remained constant at just 8.7 days in Tyrol. These differences can be partly explained by regional reporting practices, a younger population structure and possibly also milder courses of illness. [4]

The general sickness absence rate in Tyrol was low compared to other federal states and has remained at a consistently low level over the years. During the COVID-19 pandemic, measures such as lockdowns and working from home had a clear impact in Tyrol, reducing general absenteeism, particularly due to respiratory illnesses. In 2020 and 2021, however, sick leave due to COVID-19-specific diagnoses increased. With the gradual normalization of everyday working life, sick leave figures rose again in 2022 and exceeded the 2019 level. The data is presented in Table 1, where the probable sick days are reported quarterly.

Table 1. Quarter report of active infected persons leading to probable sick leave days

period	COVID-19 infections / probable sick leave in days
2020-Q4	771
2021-Q1	4274
2021-Q2	4200

2021-Q3	2009
2021-Q4	1869
2022-Q1	38542
2022-Q2	19955
2022-Q3	13582

In the fourth quarter of 2020 (2020-Q4), the reported absences are still relatively low at 771 days. By this time, however, the alpha variant (B.1.1.7) of SARS-CoV-2 had already emerged, which spread significantly, especially at the beginning of 2021. This can be seen in the first quarter of 2021 (2021-Q1), in which absenteeism rose to 4274 days.

In the second quarter of 2021 (2021-Q2), the level remained similarly high at 4200 days, before falling to 2009 days in the third quarter of 2021 (2021-Q3). Although beta and gamma variants also occurred during this period, they remained less dominant in most regions. At the same time, the delta variant gradually gained in importance, which had an impact on the incidence of infection in some areas.

At the end of 2021 (2021-Q4), absenteeism fell to a similar level as in the previous quarter at 1869 days. Only at the beginning of 2022 was there a significant jump to 38,542 sick days (2022-Q1). This corresponds to the period in which the Omicron variant (B.1.1.529) spread rapidly and led to peak infection figures in many places.

In the further course of 2022 (Q2 and Q3), absenteeism fell again to 19,955 (2022-Q2) and finally 13,582 days (2022-Q3). This decline can be explained on the one hand by increasingly widespread immunity (through vaccinations or surviving infections) and on the other hand by better adaptation in everyday life and in the working environment, for example through working from home and stricter hygiene measures.

The different SARS-CoV-2 variants have not only differed in their infectiousness during the course of the pandemic, but also in their disease severity. This can be seen both in the data on hospital occupancy (normal ward and intensive care unit) and in the development of days of absence. Figure 1 illustrates how the focus of the infection process shifts across the various mutations. A clear change from alpha to delta and finally to omicron can be observed, with an intermediate role for beta and gamma. Table 2 shows the number of hospital admissions for regular beds and intensive care.

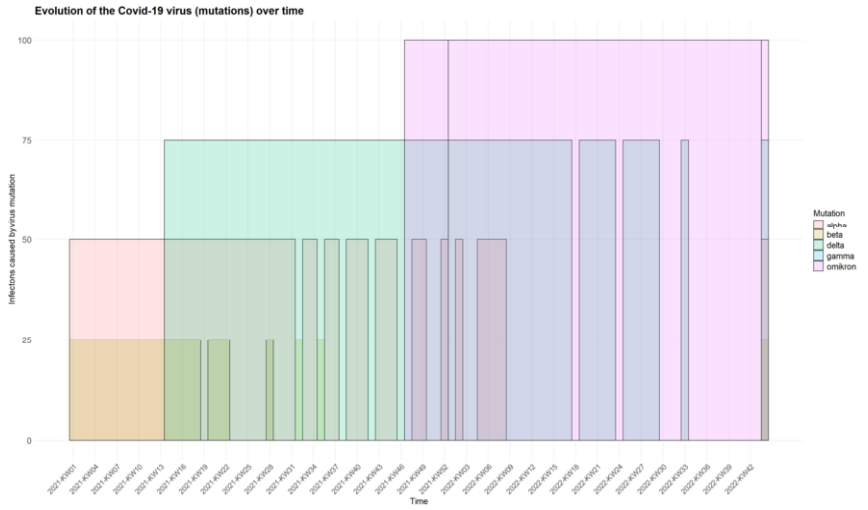

Figure 1. Dominant COVID-19 variants over time. The size of the boxes depicts the infectiousness.

Table 2. Quarterly data on hospital occupancy of normal beds and intensive care beds caused by COVID-19

Quarter	Mean NB	Median NB	IQR NB	Range NB	Mean ICU	Median ICU	IQR ICU	Range ICU
2020-Q1	137.8	145	131.75-154	96-156	45.0	46.0	39-55.25	26-57
2020-Q2	34.4	12.0	3-44	1-159	19.5	7.0	1-35	0-65
2020-Q3	7.5	7.0	2-9.5	1-25	1.0	0.0	0-2	0-5
2020-Q4	184.2	187.0	98.5-283.5	17-385	41.3	46.0	11.75-64.5	3-81
2021-Q3	90.7	94.0	67-111	51-134	25.7	25.0	23-29	18-34
2021-Q4	49.3	38.0	15.5-72.5	5-154	22.3	24.0	14-30	5-39
2022-Q1	19.7	16.5	5-29.75	3-56	5.5	5.0	2-7	0-17
2022-Q2	115.2	99.5	63.5-164.5	34-255	38.1	38.5	17-56	10-72
2022-Q3	163.1	190.0	104.75-208	72-244	23.2	20.0	19-27	14-44
2022-Q4	69.2	54.0	46-81.75	27-189	4.2	3.0	2-5	1-14

During the early phases of the pandemic, from 2020 Q1 to 2020 Q3, hospital occupancy remained at comparatively moderate levels. In 2020 Q1, the normal ward (NB) averaged 137.8 patients (median 145.5, range 96–156, IQR 131.75-154), while the intensive care (ICU) had a mean of 45.0 (median 46.0, range 26–57, IQR 39-55.25). Although the first waves emerged in this quarter, the overall number of severe cases was still low relative to subsequent peaks. By 2020 Q2, NB values dropped markedly (mean 34.5, median 12.0, range 1–159, IQR 3-44), whereas ICU occupancy settled at 19.5 on average (median 7.0, range 0–65, IQR 1-35). The discrepancy between low medians and wide ranges suggests occasional local spikes amid generally quieter periods. During 2020 Q3, NB reached its lowest mean (7.5), and ICU dipped to 1.05 on average, reflecting a calm summer lull before infections rose again toward the end of the year.

In 2020 Q4, hospital load increased visibly (NB mean 184.3, median 187.0, range 17–385, IQR 98.5-283.5; ICU mean 41.3, median 46.0, range 3–81, IQR 11.75-64.5), coinciding with the first major winter wave. Around this time, the Alpha variant (B.1.1.7) emerged, proving more contagious than the original wild type—and apparently somewhat more severe. Given the still-low overall immunity, even a moderate rise in infection rates and disease severity triggered a marked increase in days of absence and a noticeable strain on both normal and intensive care wards. Moving into 2021 Q1, occupancy declined somewhat (NB mean 90.8, ICU mean 25.7). Though Alpha continued to pose challenges, early vaccination efforts and lockdown measures helped keep the numbers below the late-2020 peak.

During 2021 Q2 and Q3, hospital occupancy dropped further (Q2 NB mean 49.4, median 38.0, range 5–154; ICU mean 22.4, median 24.0, range 14-30), suggesting a temporarily relaxed pandemic situation. The Delta variant (B.1.617.2) was starting to spread but would not drive significantly higher occupancy until later. Indeed, by Q3, NB and ICU means (19.7 and 5.5, respectively) were near some of the lowest pandemic levels. By contrast, 2021 Q4 saw occupancy rise again, with NB averaging 115.3 (median 99.5, range 34–255) and ICU at 38.1 (range 10–72). Delta, known for high infectivity and sometimes more severe clinical courses, began exerting a stronger influence, but the surge remained below the extremes of earlier or later waves—likely due to increasing population immunity through vaccination and prior infection.

A distinct peak appears in 2022 Q1, when the Omicron variant (B.1.1.529) spread explosively. Despite milder courses per infection compared to Delta, the sheer number of cases produced record levels of absenteeism and elevated hospital occupancy (NB mean 163.2, median 190.0, range 72–244, IQR 104.75-208; ICU mean 23.3, range 14–44). Normal wards filled especially quickly, followed by rising ICU numbers. As this Omicron wave peaked in the early spring, subsequent quarters saw declines: in 2022 Q2, NB averaged 69.2 and ICU 4.3, reflecting a downturn in infections after Omicron's initial

surge. By 2022 Q3, occupancy remained relatively low (NB mean 84.0, ICU 3.4) despite sporadic local spikes, as indicated by the ranges. In 2022 Q4, NB rose again to 125.2 on average (range 61–205), yet stayed below the earlier peak; ICU reached 6.16 (range 2–12), pointing to partial immunity from widespread vaccinations and previous infections, as well as the circulation of milder Omicron sub-variants.

Overall, the quarterly data underscore how new variants affected both hospital occupancy and days of absence, with transmissibility, disease severity, vaccination coverage, and seasonal factors all playing key roles. Notable surges—namely in late 2020/early 2021 (Alpha) and early 2022 (Omicron)—coincided with high occupancy on normal wards and spikes in ICU use, while quieter intervals, particularly in some summer periods, reveal how rapidly pandemic conditions could shift.

4. Discussion

The data highlight how different SARS-CoV-2 variants clearly influenced hospital occupancy and days of probable sick leave in Tyrol. While Alpha initially caused a sharp rise in ICU use in a largely unimmunized population, Omicron's extreme infectivity in early 2022 led to record occupancy in normal wards and a peak in sick leave—despite relatively milder individual disease courses. These findings demonstrate that high transmissibility can overburden healthcare systems and workforces, even with moderate severity. However, the results are shaped by regional factors, data aggregation levels, and evolving testing/reporting practices. Moving forward, continuous, granular data collection and flexible, targeted interventions are essential for managing pandemic waves and mitigating both clinical and societal impacts. Additional research regarding causal relationships between variants, public health measures is needed.

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