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ORIGINAL RESEARCH

Doctoral Students' Life Satisfaction Throughout the Covid-19 Pandemic: Inequalities by Parenthood and Gender

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Abstract
While large and highly societally relevant, the group of doctoral students still plays a subordinate role in the well-being literature. To narrow this research gap, we investigate how their life satisfaction (LS) trajectories developed throughout the Covid-19 pandemic in Germany. We draw on set-point, adaptation, family, and gender theories to examine doctoral students' LS trajectories before, at the onset of, during, and after the pandemic. Thereby, we consider not only shorter-term but also longer-term consequences of the pandemic. Analysing data from the German National Academics Panel Study (Nacaps) through fixed-effects (FE) panel regression models, we find that doctoral students' LS decreased – first moderately, then substantially – in the two years after the onset of the pandemic. Thereafter, however, their LS re-approached pre-pandemic levels again. Importantly, parenthood and gender substantially moderated doctoral students' LS trajectories. Among doctoral students with children, the decline in LS at the onset of and during the Covid-19 pandemic was stronger than among childless doctoral students – especially for mothers. While childless doctoral students re-attained their pre-pandemic levels of LS after the pandemic, doctoral students with children remained below their pre-pandemic level. These results suggest that individuals strongly reacting to a critical life event might not or only slowly return to their baseline level of LS. On a broader note, our results illustrate the need to apply a long-term social inequalities perspective to fundamentally understand how well-being trajectories unfold during crises scenarios.

Keywords Well-being · Life satisfaction · Covid-19 pandemic · Gender · Parenthood · Fixed-effects panel regression

1 Introduction

Around the globe, the Covid-19 pandemic has – at least temporarily – led to drastic changes of people's daily lives. To keep infection rates low, policy makers repeatedly implemented closures of daycare centres, schools, businesses, and leisure facilities, as well as severe contact restrictions. Where possible, working individuals switched from in-person work to

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remote work. Others were affected by short-time work or unemployment (e.g., Cantillon et al., 2021; Desson et al., 2020; Naumann et al., 2020). Accordingly, a rapidly growing literature suggests that the Covid-19 pandemic has substantially affected individuals' subjective well-being (e.g., Bähr et al., 2022; Bittmann, 2022; Neugebauer et al., 2023; Patzina et al., 2023; Zacher & Rudolph, 2021).

Importantly, this literature also highlights that the Covid-19 pandemic had differential impacts on different population groups. For instance, the likelihood of experiencing declines in well-being during the pandemic was higher among population groups who were younger, living with young children, and suffering from a pre-existing mental health condition (e.g., Beckmannshagen & Graeber, 2024; Fancourt et al., 2022; Huebener et al., 2020). One group that tends to display all these risk factors but has rarely been examined in the well-being literature compared to other groups are doctoral students.

First, doctoral students are younger (median age: 30 years; Statistisches Bundesamt, 2024b) than the overall working population (median age: 43 years; Statistisches Bundesamt, 2024a, own calculation). Second, they reported worse mental health than the overall population, and also than high-skilled individuals working outside academia, already before the pandemic (e.g., Barry et al., 2018; Evans et al., 2018; Hazell et al., 2020; Levecque et al., 2017). Third, being in the 'rush hour of their lives', doctoral students often face the challenge of completing a demanding qualification and starting a family at the same time (Briedis et al., 2021; Consortium for the National Report on Junior Scholars, 2017; Crawford & Windsor, 2021). Considering that doctoral students who were parents mostly had young children needing much care when the pandemic hit, the closures of daycare centres and schools were arguably particularly burdensome for this already burdened group. This challenging situation calls for in-depth analyses of how doctoral students' well-being has developed throughout the Covid-19 pandemic.

To address this research gap, we direct attention to doctoral students in Germany. Germany is a particularly interesting case in this regard: First, more than 200,000 doctoral students were registered at German degree-awarding institutions in 2023 (Statistisches Bundesamt, 2024b). Thus, they constitute a large and highly relevant group in the German knowledge society, which strongly depends on high-skilled talent (Consortium for the National Report on Junior Scholars, 2017). Second, most doctoral students in Germany face the double challenge of combining work on their dissertation with regular employment. The large majority of doctoral students in Germany are employees at higher education institutions, research centres, or companies, while only a minority can exclusively work on their dissertation due to sufficient scholarship funding (Konsortium BuWiK, 2025). Third, the closures of daycare centres and schools lasted comparatively long in Germany (Freundl et al., 2021; Huebener et al., 2024). Fourth, gender inequalities in childcare responsibilities were high already before the pandemic (Zoch et al., 2022). Accordingly, parents – and mothers in particular – tended to experience the greatest decreases in well-being following the outbreak of the pandemic in Germany (Huebener et al., 2021; Schmid et al., 2024). While this finding refers to the overall adult population, it is highly plausible that parenthood and gender substantially moderated well-being trajectories throughout the pandemic also among doctoral students in Germany.

To derive hypotheses on how doctoral students' well-being trajectories developed throughout the Covid-19 pandemic depending on their parenthood status and gender, we draw on set-point, adaptation, family, and gender theories. We test our hypotheses based on data from the German National Academics Panel Study (Nacaps). These data capture

doctoral students' well-being based on their overall life satisfaction (LS).[1] They have the advantage of capturing LS in one-year intervals over five measurement points since 2019. Thus, they allow us to examine doctoral students' LS trajectories before (2019), at the onset of (2020), during (2021), and after the Covid-19 pandemic (2022, 2023). The longitudinal structure of the Nacaps data allows us to deal with undesired unobserved heterogeneity through fixed-effects (FE) panel regressions.

Based on these data and methods, we can examine not only shorter-term but also longer-term consequences of the pandemic. This adds to existing research because previous studies investigating well-being trajectories in the context of the Covid-19 pandemic have mostly focussed on the initial phase of the pandemic, so that empirical research on the longer-term effects of the pandemic is still scarce (for exceptions, see, e.g., Huebener et al., 2024; Neugebauer et al., 2023; Patzina et al., 2025; Zacher & Rudolph, 2024). Using the example of doctoral students, our results illustrate the need to apply a long-term social inequalities perspective to fundamentally understand how well-being trajectories unfold during crises scenarios.

2 Theoretical Considerations and Hypotheses

To illuminate the development of doctoral students' LS throughout the Covid-19 pandemic, we develop our theoretical considerations following a two-step approach. In a first step (section 2.1), we focus on the LS trajectories of all doctoral students. In doing so, we distinguish three phases of the pandemic, in which we assume distinct developments of LS (for a similar approach, see Zacher & Rudolph, 2024): (1) the onset of the pandemic, (2) the time during the pandemic, and (3) the time after the pandemic. For each of these phases, we carve out the idiosyncrasies of doctoral students' work and life situation.

In a second step (section 2.2), we establish a link to family and gender theories by considering that parents – and mothers in particular – tended to experience the greatest decreases in LS during the Covid-19 pandemic (e.g., Huebener et al., 2021; Schmid et al., 2024; Thorsteinsen et al., 2022). Accordingly, we examine doctoral students' LS trajectories contingent on parenthood and gender. Such an analysis is particularly relevant for doctoral students because they are often in a life stage in which they must juggle the demands of completing a demanding qualification and starting a family (Briedis et al., 2021; Consortium for the National Report on Junior Scholars, 2017; Crawford & Windsor, 2021).

2.1 Doctoral Students' Life Satisfaction Throughout the Covid-19 Pandemic

2.1.1 The Onset of the Pandemic: Decreasing Life Satisfaction Due to Sudden Additional Burdens?

The Covid-19 pandemic was a sudden exogenous shock. In Germany, it occurred in March 2020. As in many other countries, policy makers quickly implemented a nationwide lockdown, which severely restricted large parts of public, professional, and private life.

[1] LS represents the cognitive-evaluative facets of subjective well-being, whereas positive and negative feelings constitute its affective facets (Diener et al., 1999).

In German academia, the first lockdown led to a sudden shift from in-person work to remote work. Many scientific facilities (including libraries, laboratories, and archives) were closed or only accessible to a limited extent (Konsortium BuWiK, 2025). Furthermore, some working tasks were eliminated or restricted, including conference attendances and in-person research seminars. Additionally, work involving interaction with study participants (e.g., interviews) was often postponed, which likely caused project delays (Naumann et al., 2022; Paucsik et al., 2022; Sverdlik et al., 2023).

Regarding teaching obligations – which are stipulated in the contracts of many doctoral students in Germany – the first lockdown resulted in an additional burden. Starting with the summer term in mid-April 2020, teaching doctoral students had to adapt their instruction from presence to online teaching head over heels (Harrop et al., 2021). This process often involved the re-design of courses to meet the didactical needs of online education, trouble due to data protection rules, and struggles with technical problems. Such additional challenges may have affected doctoral students' LS negatively.

Moreover, the frequent change to home office often isolated researchers from their networks of colleagues. Arguably, many doctoral students had only had limited time to build stable supportive networks before the pandemic, making them feel overburdened with the sudden 'research in solitude' (Naumann et al., 2022). Importantly, experiencing loneliness and social isolation can have negative effects on LS (Clair et al., 2021; Lorber et al., 2023; Padmanabhanunni & Pretorius, 2021).

These considerations allow us to hypothesise that doctoral students' LS decreased at the onset of the Covid-19 pandemic (**H1**).

2.1.2 During the Covid-19 Pandemic: Accumulation of Fatigue?

After the first Germany-wide lockdown ended in May 2020, regulations were relaxed during summer 2020. As the incidence of Covid-19 cases rose again in fall, however, politicians implemented a 'lockdown light' in November 2020, which was tightened to a second lockdown in January 2021 (Schmid et al., 2024). During the second lockdown, daycare centres, schools, and many businesses had to close, working from home became mandatory again, and contact restrictions were tightened. The second lockdown ended in late April 2021.

When the second lockdown began, not everyone had had a chance to fully recover from the strain of the first lockdown. Furthermore, the second lockdown lasted much longer than first one. Accordingly, the LS of the general population was lower one year after the start of the pandemic than at the onset of the pandemic (Benke et al., 2023; Entringer & Kröger, 2021).

While the hardships experienced during the first lockdown might have been limited for doctoral students, it is plausible that they accumulated fatigue over the course of the pandemic. Mostly working from home, they likely maintained contact with colleagues and supervisors and fulfilled their teaching duties using web conferencing and virtual classroom tools, such as Zoom, Webex, Teams, and BigBlueButton. The excessive use of such tools often led to tiredness and exhaustion – or, as some scholars call it, to a 'Zoom fatigue' (Bailenson, 2021; Bullock et al., 2022), which might have decreased LS.

Moreover, the project and dissertation delays caused by the first lockdown may not have led to negative consequences straight away, as work contracts were not changed

immediately and salaries continued to be paid (Stamp et al., 2021). Over a longer time, however, these delays could have led to financial problems and increased fear of non-completion of the doctorate, considering that contracts sometimes expired without the dissertation being completed (Lokhtina et al., 2022; Naumann et al., 2022).

In line with these thoughts, doctoral students' satisfaction with their working conditions decreased throughout the first year of the Covid-19 pandemic in Germany (Naumann et al., 2022). As scientific work is an important life domain for doctoral students, it is highly plausible that this decrease also affected their overall LS negatively. Further evidence from France shows that doctoral students' stress, depression, and anxiety increased during the first year of the pandemic (Paucsik et al., 2022). Based on these arguments and findings, we hypothesise that doctoral students' LS further decreased following the second lockdown (**H2**).

2.1.3 After the Pandemic: Back to Baseline Satisfaction?

In Germany, there has been no additional official lockdown since late April 2021. However, some restrictions were implemented in the winter of 2021/22, when the Covid-19 case numbers rose again. In April 2022, these restrictions were lifted almost entirely and most higher education institutions returned to presence teaching.

We are not aware of any research examining whether doctoral students' LS re-approached the pre-pandemic levels after the Covid-19 case numbers went down and the restrictions were lifted. However, set-point (Headey & Wearing, 1989, 1992) and adaption theories (Brickman & Campbell, 1971; Brickman et al., 1978) allow us to derive a hypothesis in this regard. These theories postulate that individuals have a fixed average level of well-being. They claim that individual well-being can notably change in the wake of critical life events but tends to return to its baseline level after some time. Previous studies testing this assumption examined the effects of critical life events such as marriage or the death of a spouse on LS. In line with set-point and adaption theories, they found initial changes in LS following these events, but frequent returns to individuals' baseline satisfaction level after some time (Lucas, 2007). Other life events, however, such as divorce, employment loss, or the onset of a disability, appear to have longer-lasting negative effects on LS (Lucas, 2007; Lucas et al., 2004).

Regarding the Covid-19 pandemic, we consider it plausible to assume that LS returned to pre-pandemic levels. In Germany, notable support was available for most societal groups, and public and professional life returned to normal for most people after the end of the pandemic. Moreover, academia was not a sector that was hit particularly hard by the pandemic. Based on set-point and adaption theories, we therefore hypothesise that doctoral students re-attained their pre-pandemic LS level once the pandemic was over (**H3**).

2.2 Heterogeneous Effects by Parenthood and Gender

As we demonstrate below, family and gender theories as well as a growing body of empirical studies suggest that childcare responsibilities may hamper career development. They also suggest that such detrimental effects may be more expressed among women – even among high-skilled individuals and particularly in crises situations such as the Covid-19 pandemic. Accordingly, we consider it plausible that LS trajectories

have developed differently throughout the pandemic depending on whether doctoral students had children when the pandemic struck. While we do not expect major gender differences in the LS trajectories of childless doctoral students, we assume that mothers experienced a stronger and more long-lasting LS decline than fathers.

At the *onset of the Covid-19 pandemic*, childcare facilities and schools were closed. Consequently, parents faced higher domestic demands, especially when they had to combine work from home with childcare and homeschooling (Del Boca et al., 2020; Hudde et al., 2023). Compared to pre-pandemic times, parents thus had an even higher risk of work-family conflicts than childless individuals (Reimann et al., 2022). Accordingly, previous research shows that parents' satisfaction declined at the onset of the Covid-19 pandemic (Huebener et al., 2020, 2021; Möhring et al., 2021; Vicari et al., 2022; Westrupp et al., 2021).

As doctoral students were hardly affected by short-time work or immediate job loss, they often had to juggle job and parenting challenges at home if they had children. Consequently, we hypothesise that doctoral students with children experienced a stronger decline in LS than childless doctoral students at the onset of the Covid-19 pandemic (**H4**).

Social role theories (Eagly, 1987) and ample empirical evidence (e.g., Baxter et al., 2008; Craig & Mullan, 2010; Horne et al., 2018) suggest that women are more involved in childcare and domestic work. At the onset of the Covid-19 pandemic, many men increased their involvement in housework and childcare, especially when they reduced their working hours (Craig & Churchill, 2021; Shafer et al., 2020; Zamberlan et al., 2021). The bulk of the chores, however, were still completed by women (Craig & Churchill, 2021; Hipp & Bünning, 2021; Sevilla & Smith, 2020; Yerkes et al., 2020). Accordingly, several studies show that the decline in satisfaction at the onset of the Covid-19 pandemic was stronger among mothers than among fathers (Hipp & Bünning, 2021; Huebener et al., 2024; Vicari et al., 2022; Zoch et al., 2022).

The gender care gap exists in the academic sector as well: Women in academia are more strongly involved in childcare than men (e.g., Jaksztat et al., 2012; Lind & Samjeske, 2010; Misra et al., 2012). Therefore, we hypothesise that in the group of doctoral students, LS declined more strongly among mothers than among fathers (**H5**).

During the Covid-19 pandemic, daycare centres and schools were closed for an even longer time than at the onset of the pandemic (Bujard et al., 2021). This made it even more difficult for parents to reconcile work and family demands. Accordingly, parents had a lower LS during the second lockdown than childless individuals (Schmid et al., 2024). Moreover, parents' LS was lower during the second than during the first lockdown (Huebener et al., 2024). Therefore, we hypothesise that the decrease in LS during the pandemic was stronger among doctoral students with children than among childless doctoral students (**H6**).

Among doctoral students with children, we expect to find gender inequalities: While men increased their domestic and childcare work at the onset of the pandemic, parents often reverted to their pre-pandemic household work division during the second lockdown, which re-increased women's time spent on chores (Jessen et al., 2022; Rodríguez Sánchez et al., 2021). Accordingly, mothers reported a lower LS than fathers during the second lockdown (Huebener et al., 2024; Schmid et al., 2024). Consequently, we hypothesise that the decrease in LS during the pandemic was strongest among female doctoral students with children (**H7**).

After the pandemic, LS should have returned to pre-pandemic levels according to set-point and adaption theories. However, two arguments suggest that this might not have been the case for doctoral students with children.

First, newer versions of set-point theory assume that the baseline LS level is not fixed, but that it can change substantially for some individuals (Fujita & Diener, 2005). For example, Headey (2008a, 2008b) showed that individuals with certain personality traits or life goals were more likely to report longer-term changes in their LS, independent of the occurrence of major life events. Moreover, research testing set-point theory has shown that individuals who strongly reacted to a critical life event did sometimes not re-attain their baseline LS years later (Lucas et al., 2003). As described above, parents experienced constant stress over a long time due to repeated closures of daycare centres and schools. Arguably, this could have had lasting effects on their health – and thus on their LS.

Second, due to increased childcare responsibilities during the Covid-19 pandemic, doctoral students with children reported a sense of falling behind their childless colleagues (Jackman et al., 2022). During the Covid-19 pandemic, scientists with young children reported the largest declines in accepted project proposals (Gao et al., 2021), newly submitted manuscripts (Rusconi et al., 2020), and time devoted to research (Myers et al., 2020). This could have reduced their LS as compared to the time before the pandemic more permanently. Therefore, we hypothesise that in the years following the pandemic, doctoral students with children did not (yet) re-attain their pre-pandemic LS level (**H8**).

Following a similar line of arguments, it is possible to assume that among doctoral students with children, women might have recovered from the pandemic more slowly than men: Considering that mothers had reported the largest declines in LS at the onset and during the pandemic, they might also have experienced longer-lasting negative effects on their health and LS than fathers. Therefore, we test the hypothesis that in reference to childless doctoral students and fathers, mothers' LS level was furthest below its pre-pandemic level in the years following the pandemic (**H9**).[2]

3 Data and Sample Restrictions

To test our hypotheses, we used data from the German National Academics Panel Study (Nacaps) – a multi-cohort panel study on doctoral students' and doctoral holders' life courses (Briedis et al., 2022). We analysed data on the 2018 cohort, which provide rich information on doctoral students who were registered at German higher education institutions in December 2018. The data on this cohort capture doctoral students across all academic disciplines as well as forms and stages of a doctorate.

As Fig. 1 illustrates, the respondents of the 2018 cohort were surveyed before (2019), at the onset of (2020), during (2021), and after the pandemic (2022 and 2023). Thus, the 2018 Nacaps data offer an excellent design for testing our hypotheses and for investigating doctoral students' longer-term LS trajectories in the context of the Covid-19 pandemic.

The 2018 Nacaps survey targets all registered doctoral students in Germany (Briedis et al., 2022). As there is no centralised register of doctoral students in Germany, field access was organized in two steps: First, higher education institutions were invited to participate in the survey. Second, the participating higher education institutions invited all registered doctoral students to fill out a self-administered online questionnaire.

[2] The (scarce) existing evidence does not support this working hypothesis. In fact, Huebener et al (2024) found that the gap in LS between mothers and fathers had closed by August 2022, when most of the restrictions in educational institutions were lifted. However, this study did not examine the group of doctoral students.

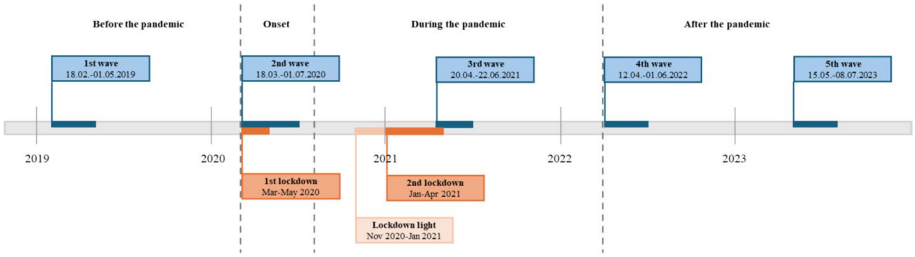

Fig. 1 Overview of Nacaps design, phases of the Covid-19 pandemic, and lockdown periods in Germany **Source**: Own illustration

In total, 53 out of 155 higher education institutions defined in the sampling frame participated in the 2018 Nacaps cohort (Briedis et al., 2022). Of the invited doctoral students, 36.6% participated in the survey (original sample). As Briedis et al. (2022) have shown, there is no evidence of bias resulting from unit non-response at the institutional or individual level.

Considering our interest in doctoral students, we restricted the original sample ($n=$ 28,336) to respondents who were actively working on their doctorate or had only temporarily interrupted it in 2019 (−2,400 cases).[3] As we model LS trajectories over time, we only included respondents who provided at least one additional measure of their LS beyond the measure for the year 2019. This restriction reduced the sample size by another 15,428 cases. To improve the precision of our estimates, we concentrated on respondents who were 22 to 49 years of age in 2019 (−261 additional cases).[4] Finally, our main analyses only included respondents who provided valid information on our core independent variables (parenthood and gender) at the first measurement point (−47 additional cases). As further explained in the variables section, we also excluded doctoral students with non-binary gender identities (−31 additional cases). After applying these sample restrictions, our first-wave analytical sample comprised 10,169 doctoral students from 53 higher education institutions.

Like all longitudinal surveys, Nacaps suffers from panel attrition. As in many surveys, attrition was highest between the first and the second panel waves (see the case numbers in the last row of Table A1). To assess how attrition might affect the interpretation of our results, we ran logistic regression models of panel dropout in a respective panel wave on doctoral students' LS in the respective previous wave, thereby controlling for parenthood, gender, and age (Table A2). The estimated effects of LS on panel dropout in the respective subsequent wave were mostly statistically insignificant and negligible in terms of size in all cases. Similarly, doctoral students' age hardly affected panel dropout. However, we observed a tendency that parenthood and especially male gender moderately correlated with panel dropout – albeit primarily in the second panel wave. Overall, we thus have no reason to assume major distortions of our results due to panel attrition. This assumption is further backed by the fact that the distributions of the variables parenthood, gender, and also academic discipline vary only marginally across our five panel waves (Table A1).

[3] This decision was executed based on a screening question at the beginning of the online questionnaire (Briedis et al., 2022).

[4] Doctoral students have usually studied for at least five years before starting their doctorate. Therefore, we have chosen 22 years as a lower age limit. We have chosen 49 years as an upper age limit because not only the doctorate, but also important career and family decisions are usually taken by that age.

4 Variables

Our dependent variable is an established measure of overall *LS*. Based on a single-item scale (Beierlein et al., 2015), respondents indicated how satisfied they were, all in all, with their life at present. The scale ranged from 0 "not satisfied at all" to 10 "completely satisfied". It was presented in one-year intervals at all five measurement points, so that we can estimate the LS of doctoral students throughout the years 2019 to 2023.

Additionally, we consider doctoral students' parenthood status and gender. In our main analyses, we define *parenthood* as having had at least one child (born in 2002 or later) in 2019, so that parents' children were born before the pandemic.[5] We define childless doctoral students as respondents who did not have a child in 2019.[6] According to our operationalisation, 15.0% of the respondents in our analytical sample indicated to be parents in 2019, while 85.0% indicated to be childless.

Although *gender* is measured in a non-binary way in Nacaps, we stuck to the traditional binary concept distinguishing between females and males because low case numbers inhibited further analyses on non-binary gender identities: Only 31 doctoral students in our analytical sample reported a gender other than male or female, all of whom were childless in 2019. In our analytical sample, 47.4% of the respondents reported being male, while 52.6% reported being female (for further sample descriptives, see Table A3).[7]

We dealt with missing values using listwise deletion. The alternative of using multiple imputation would not have provided major benefits in our case considering that only our dependent variable had a notable share of missing values and that we would have deleted imputed values of our dependent variables after the imputation procedure anyways (Von Hippel, 2007).

5 Estimation Strategy

Because of the longitudinal character of our data and the nature of our dependent variable, we applied FE panel regression models (Allison, 2009; Brüderl & Ludwig, 2015). This allowed us to control for time-invariant person-specific unobserved heterogeneity. We estimated doctoral

[5] Our variable does not indicate whether their children lived in the same household or not (we further discuss this operationalisation in section 7.2).

[6] An alternative to our operationalisation of parenthood would have been to compare doctoral students who had children in at least one wave with those who never had children. We opted against this alternative operationalisation because we assumed that parents' LS trajectories differed depending on whether their children were born before or during the pandemic. While we expected that parents entering the pandemic with children have experienced stronger LS declines, we expected parents with newly born children after 2019 to experience less strong declines in LS, considering that childbirth itself should generally positively influence LS and might have distracted from the pandemic. These assumptions are confirmed by our sensitivity analyses presented in section 6.3, in which we test for both parents and previously childless doctoral candidates whether childbirth after 2019 altered their LS trajectories.

[7] In 2019, doctoral students' average LS value was 7.11. While LS among childless doctoral students (7.04) was statistically significantly lower than among doctoral students with children (7.50), we do not observe any statistically significant gender differences, neither among childless doctoral students nor among parents (Table A3).

students' LS throughout the pandemic (**H1**, **H2**, and **H3**) in reference to a baseline measurement captured before the pandemic, that is, in 2019. We specified our core model as follows:

$$LS_{it} = \beta_t T + \alpha_i + \varepsilon_{it} \tag{1}$$

LS_{it} is our outcome variable, that is, LS for each doctoral student i at each time point t. T represents the year of data collection and β_t represents the estimated average LS change at each year compared to 2019. α_i is a person-level fixed effect that controls for all individual characteristics that are stable over time, and ε_{it} is an error term.

To examine heterogeneous effects, we estimated two additional models: First, we augmented our core model by including an interaction β_{tp} of our year dummies T with the parenthood status P_i. This allows us to assess whether changes in LS differ between doctoral students with and without children (**H4**, **H6**, and **H8**):

$$LS_{it} = \beta_t T + \beta_{tp} T \times P_i + \alpha_i + \varepsilon_{it} \tag{2}$$

Second, we further expanded our model by an interaction term β_{tpf} of the year dummies T, parenthood P_i, and female gender F_i. To be able to separate the raw effect of gender over time, we further included an interaction β_{tf} of year dummies T and female gender F_i. Thereby, we can analyse whether the LS changes induced by parenthood differs between men and women (**H5**, **H7**, and **H9**):

$$LS_{it} = \beta_t T + \beta_{tp} T \times P_i + \beta_{tf} T \times F_i + \beta_{tpf} T \times P_i \times F_i + \alpha_i + \varepsilon_{it} \tag{3}$$

Due to the hierarchical structure of our data, we clustered standard errors at the level of higher education institutions in all models.

6 Results

6.1 Doctoral Students' Life Satisfaction Trajectories Throughout the Covid-19 Pandemic

As hypotheses **H1** to **H3** refer to the LS trajectories of all doctoral students, we tested them for the entire group of doctoral students.[8] Regarding the *onset of the pandemic*, our FE models show that doctoral students' LS statistically significantly declined by 0.07 scale points between 2019 and 2020 (Fig. 2), thus supporting **H1**.

Regarding the time *during the pandemic*, our results show that doctoral students' LS further decreased following the second lockdown, thus supporting **H2**. Between 2020 and 2021, it statistically significantly declined by another 0.27 scale points, amounting to a total decline of 0.34 scale points between 2019 and 2021.

Regarding the time *after the pandemic*, our results show that doctoral students' LS had not reached its pre-pandemic level in 2022 yet, as it was still 0.13 scale points statistically significantly lower than in 2019. In 2023, however, it did not differ statistically significantly anymore from the 2019 level. Overall, we consider this pattern as evidence supporting **H3**.

[8] Table A4 in the appendix presents detailed results of all regression models.

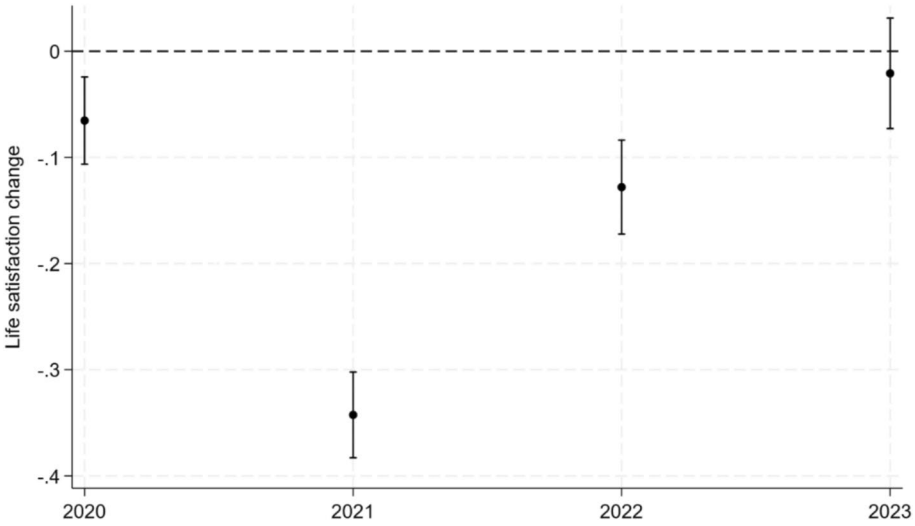

Fig. 2 Changes in LS compared to 2019: Results of FE panel regressions
Data source: Nacaps (2018 cohort), N (individuals) = 10,169, N (observations) = 35,077
Note: The vertical lines indicate 95% confidence intervals

6.2 Heterogenous Effects by Parenthood and Gender

We now turn to the hypotheses assuming heterogeneous effects depending on the parenthood status (**H4**, **H6**, and **H8**). Thereafter, we test the hypotheses suggesting heterogeneous effects by parenthood and gender (**H5**, **H7**, and **H9**). To test for possible heterogeneous effects, we assessed whether the estimated group differences were statistically significant using pairwise comparisons (detailed results available upon request).

At the *onset of the pandemic*, the decline in LS between 2019 and 2020 was statistically significantly stronger among doctoral students with children (−0.20 scale points) than among childless doctoral students (−0.04 scale points) (Fig. 3), thus supporting **H4**.

During the pandemic, LS decreased statistically significantly more strongly between 2019 and 2021 among doctoral students with children (0.58 scale points) than among childless doctoral students (0.30 scale points), thus supporting **H6**.

After the pandemic, the LS of doctoral students with children had not yet reached its pre-pandemic levels – neither in 2022 nor in 2023. These findings support **H8**.

Regarding heterogeneous effects by parenthood and gender, our results show that, at the *onset of the pandemic*, LS declined more strongly among mothers than among fathers (Fig. 4). Pairwise comparisons show that this difference is marginally significant ($p = 0.096$), thus providing moderate support for **H5**.

During the pandemic, LS decreased more strongly between 2019 and 2021 among mothers (−0.69 scale points) than among fathers (−0.43 scale points) (Fig. 4, Table A4). Furthermore, LS declined more strongly among mothers than among childless men (−0.35 scale points) and childless women (−0.25 scale points) (Fig. 5). Both differences are statistically significant according to pairwise comparisons. These findings support **H7**.

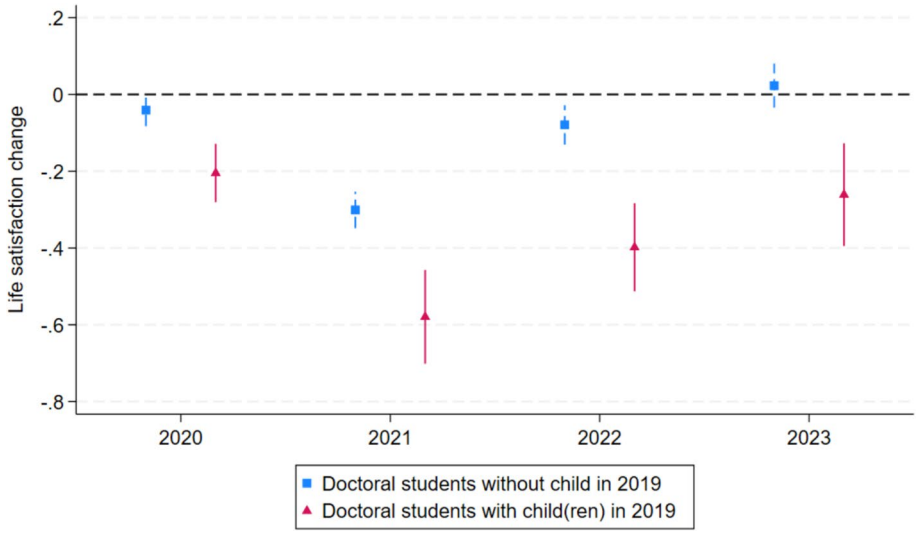

Fig. 3 Changes in LS compared to 2019 by parenthood status: Results of FE panel regressions
Data source: Nacaps (cohort 2018), N (individuals) = 10,169, N (observations) = 35,077
Note: The vertical lines indicate 95% confidence intervals

Regarding the time *after the pandemic*, our results show that there was no difference between mothers and fathers regarding their LS changes if we compare the years 2019 and 2022 (Fig. 4). In 2023, childless doctoral students of both genders had re-attained their pre-pandemic level of LS (Fig. 5). In contrast, fathers' and mothers' LS was still below

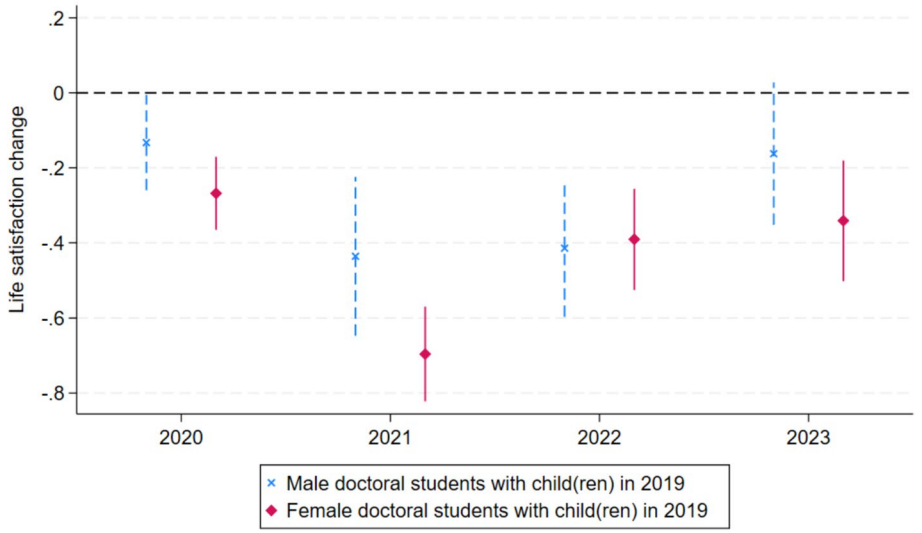

Fig. 4 Changes in LS compared to 2019 by gender among doctoral students with children: Results of FE panel regressions
Data source: Nacaps (cohort 2018), N (individuals) = 1,524, N (observations) = 5,198
Note: The vertical lines indicate 95% confidence intervals

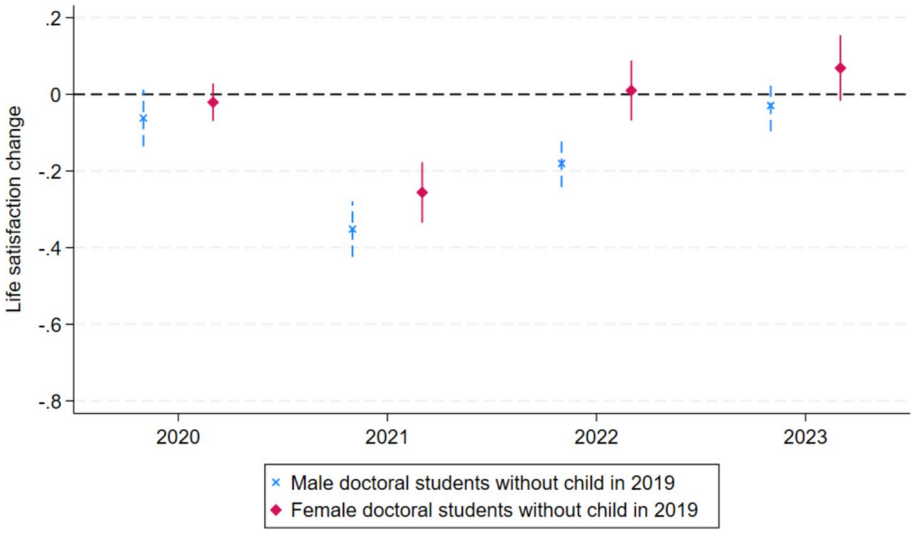

Fig. 5 Changes in LS compared to 2019 by gender among childless doctoral students: Results of FE panel regressions
Data source: Nacaps (cohort 2018), N (individuals) = 8,645, N (observations) = 29,879
Note: The vertical lines indicate 95% confidence intervals

its pre-pandemic level in 2023 (Fig. 4). Pairwise comparisons show that the LS difference between mothers and fathers in 2023 was only marginally significant ($p = 0.110$). As case numbers are low because we estimate a threefold interaction in the fifth panel wave, we consider this as (weak) support for the hypothesis that mothers' LS level was furthest below its pre-pandemic level (**H9**).

In summary, our results are mostly in line with our hypotheses (see Table 1). Moreover, they also largely support our assumption that there were no major gender

Table 1 Overview of hypotheses and main results

Hypotheses	Results in line with hypotheses
H1: LS decline at the onset of Covid-19 pandemic	Yes
H2: Further LS decline following the second lockdown	Yes
H3: Re-attainment of pre-pandemic LS after the pandemic	Yes (in 2023)
H4: Stronger LS decline at the onset of the pandemic among parents (vs. childless)	Yes
H5: Stronger LS decline at the onset of the pandemic among mothers (vs. fathers)	(Yes)
H6: Stronger LS decline during the pandemic among parents (vs. childless)	Yes
H7: Strongest LS decline during the pandemic among mothers (vs. fathers and childless)	Yes
H8: No re-attainment of pre-pandemic LS after the pandemic among parents	Yes
H9: LS was furthest below its pre-pandemic level after the pandemic among mothers (vs. fathers and childless)	(Yes, in 2023)

Note: The parentheses in "(Yes)" indicate that the estimated coefficients are not significant at a 95% confidence level

differences in LS trajectories of doctoral students who did not have children in 2019 (Fig. 5). In fact, we found no statistically significant gender differences in the group of childless doctoral students at the *onset of* and *during the pandemic*. *After the pandemic*, there were gender differences: In 2022, women had re-attained their pre-pandemic level of LS, while men's LS was still below its pre-pandemic level.[9] However, we found no statistically significant gender differences in the group of childless doctoral students in 2023 anymore (Table A4).

6.3 Sensitivity Analyses

Based on our fully specified model (see formula 3 in section 5), we performed several sensitivity analyses to ensure the robustness of our results.

First, we considered the effects of childbirth after 2019 (Table A5). Estimating a model including a time-variant variable capturing childbirth, we found similar LS trajectories for all groups of doctoral students as in the fully specified main model (see section 6.2). Generally, this underscores the robustness of our main results. More specifically, it suggests that the comparatively early return of childless women (i.e., who did not have a child in 2019) to their pre-pandemic LS level in 2022 (Fig. 5) is not explained by childbirth effects. An interesting finding on its own is that childbirth has a notably positive effect on LS.

Second, we checked for differences in LS trajectories related to the age of doctoral students. Given the limited age range within our sample, we opted for a median sample split to ensure sufficiently large age groups for this analysis. The results (Tables A6 and A7) show that younger doctoral students reported a greater decline in LS at all measurement points in reference to 2019 than older doctoral students, except for childless men in 2023. Moreover, we checked for differences in LS trajectories based on children's age. We split the sample into parents whose youngest child was 0 to 4 years of age and 5 to 16 years of age in 2019. This allowed us to consider whether their youngest child was already in school at the beginning of the pandemic. In our sample, most parents (75.7%) reported that their youngest child was between 0 and 4 years of age in 2019. The results of FE regressions (Tables A8 and A9) show that the observed decreases in LS were more strongly negative among parents with younger children at all measurement points; exceptions to this pattern were the LS decreases of mothers at the onset of the pandemic (2020), which were similar among both mothers with younger and with older children. Consistent with our main results, mothers and fathers in both groups reported a similar LS change in 2022 in reference to 2019. However, at all other measurement points, mothers reported a greater decline in LS in reference to 2019 than fathers whose children were in the same age group.

Third, we checked whether the estimated LS trajectories were driven by doctoral students completing or dropping out of their doctorate. Both completing and dropping out of the doctorate have notably positive effects on LS (Table A10). When controlling for completion and dropout, the declines of doctoral students' LS during the Covid-19 pandemic are stronger. Furthermore, childless doctoral students no longer reach their pre-pandemic level of LS in 2023. We consider these results plausible because doctoral students who have neither completed nor abandoned their doctorate for at least five years may constitute

[9] To ensure that this pattern was not driven by gender-specific effects of childbirth, we estimated a model including a dummy variable indicating whether doctoral students became parents after 2019 (see section 6.3).

a selective group with a generally lower LS than those individuals who have already left behind a (potentially stressful) doctoral project.

Finally, data collection in 2020 partially overlapped with the first nationwide lockdown (Fig. 1). In this year, most respondents answered the questionnaire during the lockdown, while only a small share answered it afterwards. As our theoretical considerations related to the effects of the lockdown on LS, we therefore re-estimated our full model including only those respondents who answered the questionnaire during the first lockdown (Table A11). This robustness check yields results for the onset of the pandemic that lend further support to our main conclusions.

7 Discussion

7.1 Main Findings and Contributions

Our study intends to advance research on how subjective well-being has developed throughout the Covid-19 pandemic by focusing on the LS trajectories of doctoral students in Germany. Although doctoral students are a large and highly relevant group for modern knowledge societies, they had rarely been examined in the well-being literature compared to other groups – especially in Germany. To narrow this research gap, we drew on set-point, adaptation, family, and gender theories and applied these to the specific situation of doctoral students. Using data from the 2018 Nacaps cohort and applying FE panel regression models, we analysed doctoral students' LS trajectories before (2019), at the onset of (2020), during (2021), and after the pandemic (2022, 2023). Thereby, we considered not only shorter-term but also longer-term consequences of the pandemic.

Our results for all doctoral students show that at the *onset of the pandemic* (in 2020), doctoral students' LS slightly but statistically significantly declined compared to 2019 (supporting **H1**). Previous research on this period of the pandemic had produced mixed results – for both the group of (young) academics and for the overall adult population. While some studies reported an increase in mental health problems, stress, and burnout among doctoral students at the onset of the pandemic (Chirikov et al., 2020; Harrop et al., 2021), others found no change in LS during the first months of the pandemic among academics (Ghasemy & Frömbling, 2022; Raabe et al., 2020). Similarly, some studies reported decreasing LS at the onset of the pandemic in the overall adult population (Bittmann, 2022; Bojanowska et al., 2021; Zacher & Rudolph, 2021), while others did not find any statistically significant LS changes (Aknin et al., 2022; Entringer et al., 2020; Wettstein et al., 2022). Overall, these results on the initial phase of the pandemic are difficult to compare because the respective studies analysed not only different population (sub)groups, but also different dependent variables and time frames.

Regarding the time *during the pandemic* (in 2021), we found that doctoral students' LS further declined (supporting **H2**). This decline was far stronger than the initial decline between 2019 and 2020, probably because doctoral students had been exposed to restrictive measures for a long time at that point in time (Konsortium BuWiK, 2025). Our findings are consistent with previous research showing that stress, depression, and anxiety statistically significantly increased among doctoral students during the first year of the pandemic (Paucsik et al., 2022). Moreover, our findings align with those studies

on the overall adult population showing that LS declined during the first year of the pandemic (Benke et al., 2023; Entringer & Kröger, 2021). Thus, studies on different population groups tend to align in that most of them report substantial declines in LS following the fatigue that people had accumulated by 2021. Interestingly, the ample resources that doctoral students disposed of because of their high educational levels did not appear to fully shield them from the hardships of the pandemic. This interpretation also aligns with previous research on the overall adult population showing that higher levels of education (Wanberg et al., 2020) and more abundant financial and social resources did not necessarily mitigate the negative effects of the pandemic on LS (Delhey et al., 2023; Patzina et al., 2023).

After the pandemic, however, doctoral students had re-approached their baseline level of LS in 2022 and re-attained it on average in 2023 (supporting **H3** for the year 2023). This finding is in line with set-point theory (Headey & Wearing, 1989, 1992) and adaption theory (Brickman & Campbell, 1971; Brickman et al., 1978). We are not aware of studies for other population groups examining pandemic-related LS trajectories until 2023.

Our models examining heterogeneous effects show that doctoral students' LS trajectories differ by parenthood and gender. At the *onset of the pandemic*, male and female doctoral students without children still seemed to be resilient, as their LS did not statistically significantly differ as compared to the time before the pandemic. However, doctoral students with children, and even slightly more so among mothers, experienced a strong decline in LS between 2019 and 2020 (supporting **H4** and **H5**). These findings are consistent with studies for the overall adult population reporting declines in LS among parents (e.g., Huebener et al., 2021; Vicari et al., 2022), and among mothers in particular (Hipp & Bünning, 2021; Huebener et al., 2020; Patzina et al., 2023; Zoch et al., 2022).

During the pandemic (in 2021), male and female doctoral students without children experienced a substantial decline in their LS. LS declines were even stronger among parents (supporting **H6**), and strongest among mothers (supporting **H7**). Again, these findings align with the results of previous research on the overall adult population (Hudde et al., 2023; Huebener et al., 2024; Schmid et al., 2024).

After the pandemic (in 2023), childless doctoral students had re-attained their pre-pandemic level of LS. While we are not aware of previous research on pandemic-related LS trajectories until the year 2023, this finding resonates with set-point theory (Headey & Wearing, 1989, 1992) and adaption theory (Brickman & Campbell, 1971; Brickman et al., 1978). In contrast, parents had not (yet) re-attained their pre-pandemic level of LS in 2023 (supporting **H8**). This finding is interesting considering Fujita and Diener's (2005) observation that individuals with a higher average LS tend to show a greater stability in their LS over time. In our study, however, mothers had the highest average LS levels in 2019, but they were the group who had least recovered from their pandemic-related LS declines in 2023 (supporting **H9**), thus contradicting Fujita and Diener's (2005) observation. It should be noted, though, that Fujita and Diener (2005) focus on general changes in LS over time, while our study examines a crisis creating additional demands for the group of parents, and especially for mothers. This might explain why mothers might have experienced such a strong strain during the pandemic that they had not (yet) re-attained their 2019 level of LS in 2023. In summary, our results are thus rather consistent with Lucas et al.'s (2003) finding that individuals with a strong initial

reaction to a critical life event do not necessarily re-attain their baseline level afterwards – or potentially only after a longer time.

Although the academic sector was arguably not hit as hard by the pandemic as other sectors, as most researchers could switch to remote work and were not affected by short-time work or unemployment, our study illustrates that doctoral students' LS in Germany has been strongly negatively affected by the Covid-19 pandemic. Based on the assessment of Spieß et al. (2023), we consider the observed overall decrease in LS between 2019 and 2021 (−0.34 scale points) to be a medium-size effect. However, the decreases among parents (−0.58 scale points), and especially among mothers (−0.69 scale points), can be considered large effects. Interestingly, the changes in parents' (and especially mothers') LS were higher than those following events such as marriage (0.2 to 0.3 points) and divorce (−0.4 to −0.5 points), while they were similar to the effect of falling into unemployment (−0.7 points) (Spieß et al., 2023). One reason for the comparatively large LS declines observed for parents, and mothers in particular, might be that around three-quarters of all parents had younger children when the pandemic hit. According to our sensitivity analyses, parents with young children experienced the strongest declines in their LS.

Apparently, flexible work from home during the Covid-19 pandemic did not protect parents from the consequences of the stressful situation resulting from the loss of institutional childcare. While working from home can generally have positive effects by increasing autonomy and eliminating commuting times (Gajendran & Harrison, 2007; Kroesen, 2022; Tao et al., 2023), it can also have negative effects by favouring overtime work and social isolation (Sardeshmukh et al., 2012; Wöhrmann & Ebner, 2021). Notably, Mergener et al. (2025) showed that mental health advantages of home office diminished as the hours working from home increased. Considering that most doctoral students had to switch to home office entirely during the Covid-19 pandemic might thus even contribute to explaining the decrease in doctoral students' LS – especially of those having children.

In summary, our study illustrates the importance of considering that crises, such as the Covid-19 pandemic, likely have a differential impact on different social groups. This pattern calls for targeted relief measures. In the group of doctoral students in Germany, parents (and especially mothers) would have needed additional support throughout the pandemic to compensate for the stress resulting from simultaneous childcare and work (at home). Critically, the experiences during the pandemic still seem to affect mothers' LS after several years. In conclusion, our results thus highlight the need to apply a long-term social inequalities perspective to understand how well-being trajectories unfold during crises scenarios.

7.2 Limitations and Further Research

Our study points to several limitations that could be addressed by future research. While our robustness checks did not suggest major distortions of our results due to panel attrition, we observed moderate correlations between parenthood and male gender with panel dropout in the second wave. For us to determine whether this pattern led to a (slight) over- or under-estimation of Covid-19-related changes in LS between 2019 and 2020, future

research would first have to establish whether (specific) individuals with a higher or with lower LS baseline level were more prone to experiencing greater pandemic-related LS shifts (see also the corresponding discussion about set-point and adaptation theories in the previous section).

Second, our data did not include information on whether doctoral students with children were living in the same household as their children. Therefore, the group of parents in our sample may have been heterogeneous in terms of the demands they faced throughout the pandemic. Future research could investigate whether the pandemic has differently affected the LS of parents depending on whether their children lived in the same or another household.

Third, future research on (inequalities in) LS trajectories could additionally consider doctoral students with non-binary gender identities. Judged by their very small case number in our already large dataset, future surveys might have to oversample this group to allow for robust conclusions on their LS trajectories, or opt for qualitative designs.

Fourth, going beyond the description of LS trajectories during the Covid-19 pandemic, future research could try to better quantify the causal effects of (specific concomitants of) the pandemic. In this respect, previous research has suggested, for instance, to use Covid-19 incidence rates to better approximate causal effects of the pandemic on LS (e.g., Patzina et al., 2023).

Fifth, we have not empirically examined possible mediating mechanisms that may further explain the observed LS trajectories and corresponding social inequalities. This would have required not only additional theory development, but also empirical modelling that precludes bias resulting from unaddressed reverse causality, so that we can control potential effects of LS on the mediators. Based on such modelling, future research could investigate potential determinants of LS that were notably influenced by the pandemic, possibly to different extents across the examined social groups. These potential determinants include doctoral students' physical and mental health, experience of loneliness, employment situation (e.g., employment status, working hours, and income), hours spent on childcare, and the availability of external childcare services. Additionally, the role of having, getting, or losing a partner as well as the living situation could further explain heterogeneous effects of parenthood and gender on LS trajectories. Specifically for the group of doctoral students, it would also be relevant to examine (social group-specific) LS trajectories depending on the academic discipline, supervisor support, teaching obligations, and institutional support. We would also be interested in the effects of specific governmental interventions (e.g., lockdowns on the one hand and continued payment of salaries or the extension of contracts on the other hand) on doctoral students' LS throughout the pandemic.

Sixth, the relative importance of the above-mentioned explanatory mechanisms could be examined from an internationally comparative perspective. In this respect, it would also be expedient to distinguish LS trajectories throughout the Covid-19 pandemic depending on whether the doctoral studies were employment-based, scholarship-based, company-funded, or self-funded. National differences regarding the most prevalent PhD funding schemes might explain differences in the impact of the Covid-19 pandemic on doctoral students' LS trajectories.

Finally, future research could examine whether mothers will re-attain their pre-pandemic level of LS in the future or whether the pandemic will have a permanent impact on their subjective well-being. Regarding all analysed groups of doctoral students, future research should monitor whether long-term effects of the Covid-19 pandemic remain or become visible (again) many years after the pandemic. Has the experience of (overcoming) the Covid-19 pandemic made (different groups of) doctoral students more resilient or more vulnerable in the long run?

Appendix

Table A1 Sample composition of the 2018 Nacaps cohort: Distributions of parenthood, gender, and academic discipline across survey waves

	2019 (wave 1)		2020 (wave 2)		Difference 2019 to 2020	2021 (wave 3)		Difference 2019 to 2021	2022 (wave 4)		Difference 2019 to 2022	2023 (wave 5)		Difference 2019 to 2023
	N	in %	*N*	in %	in % points	*N*	in %	in % points	*N*	in %	in % points	*N*	in %	in % points
Parenthood in 2019														
Without child	8,645	85.0	6,788	86.2	1.2	5,272	85.4	0.4	5,130	84.6	–0.4	4,044	84.3	–0.7
With child(ren)	1,524	15.0	1,089	13.8	–1.2	902	14.6	–0.4	932	15.4	0.4	751	15.7	0.7
Gender														
Male	4,824	47.4	3,682	46.7	–0.7	2,866	46.4	–1.0	2,816	46.5	–1.0	2,174	45.3	–2.1
Female	5,345	52.6	4,195	53.3	0.7	3,308	53.6	1.0	3,246	53.6	1.0	2,621	54.7	2.1
Academic discipline														
Humanities	1,330	13.1	1,026	13.0	–0.1	835	13.5	0.4	817	13.5	0.4	683	14.2	1.1
Sports	87	0.9	69	0.9	0.0	52	0.8	–0.1	57	0.9	0.0	40	0.8	–0.1
Law, economics and social sciences	2,188	21.5	1,713	21.8	0.3	1,329	21.5	0.0	1,333	22.0	0.5	1,066	22.2	0.7
Mathematics, natural sciences	2,968	29.2	2,312	29.4	0.2	1,847	29.9	0.7	1,771	29.2	0.0	1,394	29.1	–0.1
Medicine and health sciences	1,288	12.7	979	12.4	–0.3	796	11.4	–1.3	713	11.8	–0.9	561	11.7	–1.0
Agriculture, forestry, nutritional sciences, veterinary medicine	312	3.1	242	3.1	0.0	197	3.2	0.1	192	3.2	0.1	138	2.9	–0.2
Engineering	1,544	15.2	1,181	15.0	–0.2	923	15.0	–0.8	913	15.1	–0.1	698	14.6	–0.6
Arts	228	2.2	174	2.2	0.0	144	2.3	0.1	136	2.2	0.0	100	2.1	–0.1
No information/not included	224	2.2	181	2.3	0.1	141	2.3	0.1	130	2.1	–0.1	115	2.4	0.2
Total	10,169	100	7,877	100		6,174	100		6,062	100		4,795	100	

Data source: Nacaps (cohort 2018)

Note: Academic disciplines are defined according to the classification of the German Federal Statistical Office

Table A2 Results of logistic regressions of panel dropout across survey waves (average marginal effects)

	2020 (wave 2)			2021 (wave 3)			2022 (wave 4)			2023 (wave 5)		
LS in the previous wave	–0.004	(0.002)	**	0.003	(0.003)	n.s.	0.000	(0.004)	n.s.	–0.001	(0.003)	n.s.
Control variables												
Age	–0.004	(0.001)	***	0.001	(0.001)	n.s.	0.000	(0.001)	n.s.	0.000	(0.001)	n.s.
Male (ref. female)	0.070	(0.007)	***	0.035	(0.014)	*	0.007	(0.013)	n.s.	0.028	(0.015)	n.s.
With child(ren) (ref. without child)	0.035	(0.009)	***	0.025	(0.020)	n.s.	–0.002	(0.021)	n.s.	–0.013	(0.014)	n.s.
N (observations)	20,970			7,906			6,196			6,085		

Data source: Nacaps (cohort 2018)

Significance levels: n.s. = not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table A3 Sample descriptives

	N	%	LS in 2019		
			Mean	(SD)	Sig.
Parenthood in 2019					
Without child	8,645	85.0	7.04	(1.91)	***
With child(ren)	1,524	15.0	7.50	(1.81)	
Gender					
Male	4,824	47.4	7.13	(1.95)	n.s.
Female	5,345	52.6	7.10	(1.86)	
Gender and parenthood in 2019					
Childless men	4,115	40.5	7.07	(1.96)	n.s.
Childless women	4,530	44.5	7.02	(1.86)	
Fathers	709	7.0	7.44	(1.87)	n.s.
Mothers	815	8.0	7.55	(1.77)	
LS	10,169	100	7.11	(1.90)	

Data source: Nacaps (cohort 2018), $N = 10{,}169$

Significance levels: n.s. = not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Note: The last column indicates whether the mean differences in LS are statistically significant

Table A4 Changes in LS compared to 2019: Results of FE panel regressions

	Model 1			Model 2			Model 3		
Year (ref. 2019)									
2020	–0.07	(0.02)	**	–0.04	(0.02)	n.s.	–0.06	(0.04)	n.s.
2021	–0.34	(0.02)	***	–0.30	(0.02)	***	–0.35	(0.04)	***
2022	–0.13	(0.02)	***	–0.08	(0.03)	**	–0.18	(0.03)	***
2023	–0.02	(0.03)	n.s.	0.02	(0.03)	n.s.	–0.03	(0.03)	n.s.
Interaction: Year#Parenthood									
2020#with child(ren)				–0.16	(0.04)	***	–0.07	(0.06)	n.s.
2021#with child(ren)				–0.28	(0.07)	***	–0.08	(0.11)	n.s.
2022#with child(ren)				–0.32	(0.06)	***	–0.23	(0.10)	*
2023#with child(ren)				–0.28	(0.07)	***	–0.13	(0.10)	n.s.
Interaction: Year#Gender									
2020#female							0.04	(0.04)	n.s.
2021#female							0.10	(0.06)	n.s.
2022#female							0.19	(0.05)	***
2023#female							0.10	(0.05)	n.s.
Interaction: Year#Parenthood#Gender									
2020#with child(ren)#female							–0.18	(0.08)	*
2021#with child(ren)#female							–0.36	(0.13)	**
2022#with child(ren)#female							–0.17	(0.11)	n.s.
2023#with child(ren)#female							–0.28	(0.12)	*
Constant	7.12	(0.01)	***	7.12	(0.01)	***	7.12	(0.01)	***

Data source: Nacaps (cohort 2018), *N* (individuals) = 10,169, *N* (observations) = 35,077

Significance levels: n.s. = not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table A5 Changes in LS compared to 2019 considering the effect of childbirth: Results of FE panel regressions

Year (ref. 2019)			
2020	–0.08	(0.04)	*
2021	–0.37	(0.04)	***
2022	–0.21	(0.03)	***
2023	–0.06	(0.03)	n.s.
Interaction: Year#Parenthood			
2020#with child(ren)	–0.07	(0.06)	n.s.
2021#with child(ren)	–0.14	(0.12)	n.s.
2022#with child(ren)	–0.26	(0.10)	*
2023#with child(ren)	–0.06	(0.10)	n.s.
Interaction: Year#Gender			
2020#female	0.04	(0.04)	n.s.
2021#female	0.10	(0.06)	n.s.
2022#female	0.19	(0.05)	***
2023#female	0.10	(0.05)	n.s.
Interaction: Year#Parenthood#Gender			
2020#with child(ren)#female	–0.18	(0.08)	*
2021#with child(ren)#female	–0.33	(0.13)	**
2022#with child(ren)#female	–0.16	(0.11)	n.s.
2023#with child(ren)#female	–0.29	(0.13)	*
Childbirth after 2019	0.36	(0.04)	***
Constant	7.12	(0.01)	***

Data source: Nacaps (cohort 2018), N (individuals) = 10,169, N (observations) = 35,077

Significance levels: n.s. = not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table A6 Changes in LS compared to 2019 among doctoral students who were born before 1990: Results of FE panel regressions

Year (ref. 2019)			
2020	–0.01	(0.05)	n.s.
2021	–0.25	(0.05)	***
2022	–0.11	(0.06)	n.s.
2023	–0.05	(0.05)	n.s.
Interaction: Year#Parenthood			
2020#with child(ren)	–0.12	(0.08)	n.s.
2021#with child(ren)	–0.10	(0.13)	n.s.
2022#with child(ren)	–0.26	(0.13)	*
2023#with child(ren)	–0.06	(0.12)	n.s.
Interaction: Year#Gender			
2020#female	0.04	(0.07)	n.s.
2021#female	0.11	(0.08)	n.s.
2022#female	0.21	(0.10)	*
2023#female	0.20	(0.08)	n.s.
Interaction: Year#Parenthood#Gender			
2020#with child(ren)#female	–0.17	(0.12)	n.s.
2021#with child(ren)#female	–0.45	(0.17)	**
2022#with child(ren)#female	–0.23	(0.14)	n.s.
2023#with child(ren)#female	–0.40	(0.15)	**
Constant	6.98	(0.02)	***

Data source: Nacaps (cohort 2018), *N* (individuals) = 5,511, *N* (observations) = 18,955

Significance levels: n.s. = not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table A7 Changes in LS compared to 2019 among doctoral students who were born after 1989: Results of FE panel regressions

Year (ref. 2019)			
2020	–0.11	(0.04)	n.s.
2021	–0.45	(0.04)	***
2022	–0.26	(0.03)	***
2023	0.00	(0.05)	n.s.
Interaction: Year#Parenthood			
2020#with child(ren)	–0.06	(0.06)	n.s.
2021#with child(ren)	–0.65	(0.11)	*
2022#with child(ren)	–0.58	(0.12)	**
2023#with child(ren)	–0.55	(0.12)	*
Interaction: Year#Gender			
2020#female	0.05	(0.04)	n.s.
2021#female	0.09	(0.07)	n.s.
2022#female	0.18	(0.06)	*
2023#female	0.01	(0.08)	n.s.
Interaction: Year#Parenthood#Gender			
2020#with child(ren)#female	–0.19	(0.08)	n.s.
2021#with child(ren)#female	0.23	(0.13)	n.s.
2022#with child(ren)#female	0.17	(0.11)	n.s.
2023#with child(ren)#female	0.02	(0.12)	n.s.
Constant	7.28	(0.01)	***

Data source: Nacaps (cohort 2018), *N* (individuals) = 4,658, *N* (observations) = 16,122

Significance levels: n.s. = not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table A8 Changes in LS compared to 2019 among doctoral students with children aged 0–4 years: Results of FE panel regressions

Year (ref. 2019)			
2020	–0.16	(0.06)	*
2021	–0.50	(0.11)	***
2022	–0.48	(0.09)	***
2023	–0.17	(0.09)	n.s.
Interaction: Year#Gender			
2020#female	–0.11	(0.09)	n.s.
2021#female	–0.25	(0.13)	*
2022#female	0.02	(0.12)	n.s.
2023#female	–0.20	(0.10)	n.s.
Constant	7.57	(0.03)	***

Data source: Nacaps (cohort 2018), *N* (individuals) = 1,153, *N* (observations) = 3,934

Significance levels: n.s. = not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table A9 Changes in LS compared to 2019 among doctoral students with children aged 5–16 years: Results of FE panel regressions

Year (ref. 2019)			
2020	–0.05	(0.11)	n.s.
2021	–0.21	(0.19)	n.s.
2022	–0.19	(0.21)	n.s.
2023	–0.11	(0.19)	n.s.
Interaction: Year#Gender			
2020#female	–0.23	(0.15)	n.s.
2021#female	–0.32	(0.26)	n.s.
2022#female	–0.02	(0.26)	n.s.
2023#female	–0.13	(0.25)	n.s.
Constant	7.34	(0.05)	***

Data source: Nacaps (cohort 2018), *N* (individuals) = 371, *N* (observations) = 1,264

Significance levels: n.s. = not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table A10 Changes in LS compared to 2019 considering the effect of dropping out of or completing the doctorate: Results of FE panel regressions

Year (ref. 2019)			
2020	–0.10	(0.04)	**
2021	–0.46	(0.04)	***
2022	–0.34	(0.04)	***
2023	–0.19	(0.06)	**
Interaction: Year#Parenthood			
2020#with child(ren)	–0.10	(0.06)	n.s.
2021#with child(ren)	–0.10	(0.13)	n.s.
2022#with child(ren)	–0.31	(0.11)	**
2023#with child(ren)	–0.20	(0.14)	n.s.
Interaction: Year#Gender			
2020#female	0.04	(0.04)	n.s.
2021#female	0.05	(0.06)	n.s.
2022#female	0.15	(0.05)	**
2023#female	0.06	(0.07)	n.s.
Interaction: Year#Parenthood#Gender			
2020#with child(ren)#female	–0.16	(0.08)	n.s.
2021#with child(ren)#female	–0.31	(0.14)	*
2022#with child(ren)#female	–0.03	(0.14)	n.s.
2023#with child(ren)#female	–0.19	(0.18)	n.s.
Status of the doctorate			
Graduation	0.25	(0.03)	***
Dropout	0.82	(0.10)	***
Constant	7.10	(0.01)	***

Data source: Nacaps (cohort 2018), *N* (individuals) = 10,169, *N* (observations) = 30,125

Significance levels: n.s. = not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table A11 Changes in LS compared to 2019 among doctoral students who answered the questionnaire during the first lockdown: Results of FE panel regressions

Year (ref. 2019)			
2020	–0.07	(0.04)	n.s.
2021	–0.38	(0.04)	***
2022	–0.20	(0.03)	***
2023	–0.04	(0.05)	n.s.
Interaction: Year#Parenthood			
2020#with child(ren)	–0.13	(0.06)	*
2021#with child(ren)	–0.17	(0.11)	n.s.
2022#with child(ren)	–0.31	(0.12)	*
2023#with child(ren)	–0.21	(0.12)	n.s.
Interaction: Year#Gender			
2020#female	0.05	(0.04)	n.s.
2021#female	0.09	(0.07)	n.s.
2022#female	0.17	(0.06)	*
2023#female	0.09	(0.08)	n.s.
Interaction: Year#Parenthood#Gender			
2020#with child(ren)#female	–0.09	(0.08)	n.s.
2021#with child(ren)#female	–0.17	(0.13)	n.s.
2022#with child(ren)#female	–0.05	(0.11)	n.s.
2023#with child(ren)#female	–0.19	(0.12)	n.s.
Constant	7.15	(0.01)	***

Data source: Nacaps (cohort 2018), N (individuals) = 7,355, N (observations) = 27,201

Significance levels: n.s. = not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

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Data Availability Waves 1 to 4 of the 2018 Nacaps data are available via the DZHW Research Data Centre: https://doi.org/10.21249/DZHW:nac2018:2.0.0.

Declarations

Research Ethics The results presented in this article do not allow for deductive disclosure of the survey participants' identities. Participation in the survey was voluntary, and participants' confidentiality was protected.

Competing Interests We declare that we have no conflicts of interest.

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