

Article

# Experiences Shared by the (Future) Public Health Workforce during the COVID-19 Pandemic in Germany: Results of A Survey on Workload, Work Content, and Related Challenges among Students and Young Professionals

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**Abstract:** Although previous studies have focused on the adverse effects of the COVID-19 pandemic on various professional groups (particularly in the health and nursing care sector), this study aims to close a research gap by assessing perspectives of students and young professionals in epidemiology and public health in Germany in terms of shifts in workload, work content, and related challenges caused by the pandemic. We conducted a cross-sectional survey between mid-February and mid-March 2022. Quantitative data were analyzed via standardized mean differences. Qualitative data based on answers to open-ended questions were analyzed via a qualitative content analysis. Overall, 172 individuals participated in this survey. Results indicate that students felt burdened the most by lack of exchange with other students and lecturers. Study participants employed in public health experienced changes in their employment, because they had changes in their work content- and administration-wise, which was accompanied with a high burden due to the workload. Multiple demands that can have an impact on both acquired skills and mental health during the professional qualification phase were mentioned by the participants. Therefore, more in-depth analyses are needed for investigating the impact the pandemic will have on the (future) public health workforce in the long run.

**Keywords:** public health; epidemiology; SARS-CoV-2; employment; education; training

## 1. Introduction

Since the outbreak of the novel coronavirus COVID-19 (coronavirus disease 2019 which is caused by the pathogen SARS-CoV-2) in Wuhan, China in December 2019, the situation has become a global threat [1]. It has been declared as a worldwide pandemic in March 2020 by the World Health Organization [2], leading to containment measures varying over time and region, such as physical distancing (in terms of local, regional or national shutdowns or lockdowns), hygiene measures and the halt of all non-essential travel installed by political administrations all over the world [3,4]. While these strategies aimed at reducing risks of transmitting the infection, particularly lockdown regulations (e.g., staying at home, distance learning at schools and universities) may hinder important means for socializing, finding a partner, and building meaningful relationships which are of pivotal importance according to personality development theories [3,5,6].

Therefore, the COVID-19 pandemic is not merely a medical issue, but also a behavioral and social phenomenon that needs to be addressed by public health measures, of which vaccination and adequate treatment only are parts in a complex network of social, economic and political interventions necessary to cope with the pandemic [7].

Although consequences for human health – in terms of direct and indirect health effects – are compiled in different reviews [8,9], also related to mental health issues among healthcare workers [10,11]. However, the effects may differ due to the heterogeneity of population subgroups. Until now, studies have mainly focused on vulnerable populations such as children, elderly or chronically ill people and focused on issues directly related to health and well-being.

Due to the dearth of evidence of COVID-19 pandemic's impact on study and working conditions of young professionals in the area of public health and epidemiology we focused on this subgroup for closer investigations. Previous literature has shown that the COVID-19 pandemic in Germany, as in many other parts of the world, resulted in additional challenges for students enrolled in health degree programs [12]. In addition to general physical distancing measures and the closure of businesses, higher education mainly switched to distance learning only, demanding major restructuring of curricula and examinations. Furthermore, students enrolled in health-related higher education (such as epidemiologic students or public health degree students) were particularly affected by the COVID-19 pandemic as their workforce was especially demanded during this crisis [12,13].

Amidst this backdrop, many global and public health projects have been interrupted, with research activities involving travel, study recruitment, and data collection coming to a temporary halt and/or needing to be rethought [14]. The impact of temporarily halting projects and having to rethink them impact researchers differently. While such repercussions impact senior researchers through funding competition postponements or changes in project timelines [15], additional burdens fall on early-career researchers who may not have secure academic positions and/or funding [14,16,17].

Furthermore, this precariousness in the pandemic context is accentuated by their limited decision-making abilities, strict obligations in meeting deadlines which are instrumental to personal gains such as graduation or career advancement, and salary uncertainty, as income is often fueled by larger projects submitted to funding competitions that may have been postponed [14].

For these reasons, we conducted a cross-sectional study among young professionals in public health and epidemiology in Germany to assess their experiences related to workload, work content, and related challenges during the COVID-19 pandemic.

## **2. Materials and Methods**

### *2.1. Study design and participants*

We conducted an online-based survey which was based on standardized items and additionally two open-ended questions to retrospectively assess the workload, work content, and related challenges during the COVID-19 pandemic among young professionals in epidemiology and public health. We defined young professionals either as current students in epidemiology or public health related study programs or people who are in their first years of employment within the public health workforce.

Study participants were contacted via the e-mail distribution list and Facebook group section of early-career researchers of the German Society of Epidemiology (DGEpi) and via the e-mail distribution list the German Network of Young Professionals in Public Health (NOEG). In addition, several universities in Germany offering study programs related to public health and epidemiology were asked to forward the invitation via e-mail distribution list among their students. We identified the respective e-mail addresses for the latter through an extraction of relevant study programs from the Higher Education Compass, which is a public database of the German Rectors' Conference publishing

information from state and state-recognized German universities about their study and doctoral programs.

The survey was prepared and released via EvaSys. It was accessible from February 14 till March 10, 2022. We received an ethical waiver for the study by the ethics committee of Bielefeld University (2022-023; January 27, 2022).

## 2.2. Data collection

We designed a questionnaire for this study which considered the results of previous studies, which mainly focused on stress levels, mental health, or the appraisal on digital teaching within the university setting. Instead, we assessed data on workload, changes in work content, and challenges related with these issues. The questionnaire contains two socio-demographic questions on age (in years) and gender (male, female, diverse), six questions about study and working status and conditions (e.g. current number of semesters absolved, graduation status during the COVID-19 pandemic, job type, and job experience). In addition, there were overall 15 either four- or five-tiered Likert scales where study participants had to appraise some statements regarding their own situation. We used a filter beforehand to pose the statements regarding study condition (5 items) and working conditions (10 items) only to those study participants who stated beforehand that they were either studying or working or doing both.

The five statements for assessing specific study conditions (and one further item for additional conditions) all used a four-tiered Likert scale from “not burdened” to “very burdened”. All statements started with “During the COVID-19 pandemic, I experienced...” and went on with the following phrases to be judged according to their burden on the Likert scale:

- “...financing my student status as...”
- “...lack of exchange with lecturers as...”
- “...lack of exchange with fellow students as...”
- “...lack of access to learning materials as...”
- “...lack of access to undisturbed/quiet workplaces as...”
- “...something else I would like mention as...”

For assessing the working conditions, we used 10 items and one further item to allow respondents adding an additional condition. Here, the answering options at the Likert scales differed according to the question. All statements started with “During the COVID-19 pandemic, I experienced...” and were closed by the following phrases:

- “...I became involved in infectious diseases either professionally or during my studies for the first time.” (answer options: “disagree” to “agree”)
- “...my work content has changed.” (answer options: “disagree” to “agree”)
- “...how has your average workload changed as a result of the COVID-19 pandemic?” (answer options: “greatly reduced” to “greatly increased”)
- “...I had insufficient access to necessary funding/grants.” (answer options: “not burdened” to “very burdened”)
- “...I experienced lengthy reviews by the ethic committee.” (answer options: “not burdened” to “very burdened”)
- “...I experienced lack of exchange with colleagues from the own institute/department.” (answer options: “not burdened” to “very burdened”)
- “...I had lack of opportunities for cooperation with other (research) institutes.” (answer options: “not burdened” to “very burdened”)
- “...I had insufficient access to the target group during data collection.” (answer options: “not burdened” to “very burdened”)

- "...access to training of congress participation was easier." (answer options: "disagree" to "agree")
- "...training/congress quality decreased." (answer options: "disagree" to "agree")
- "...I experiences something else that I would like to notice here." (answer options: "not burned" to "very burdened")

In addition, the questionnaire included two open-ended questions to assess 1) changes in methods and contents of research projects and 2) potentially facilitating factors for conducting research during the COVID-19 pandemic.

The questionnaire was pretested by four students. They not only tested the online-based questionnaire for technical functionality, but also provided feedback to questions which were not easy to understand or difficult to answer. Based on their feedback, we adjusted the questionnaire.

### 2.3. Data analyses

The cross-sectional design allows us to quantify standardised differences stratified for participants characteristics. To see who was affected most and in which areas due to the COVID-19 pandemic and the associated containment measures as well as changes in workload and work content for the (future) public health workforce, we quantified standard mean differences (SMD). We conducted the SMD analysis for two subsets, namely students and people currently employed within the public health workforce. For students, we considered gender (female, male), age (in years), number of semesters (below 3, 4–10, above 10), and graduation status (yes, no) in the SMD analyses. For people being currently active in the public health workforce, we considered gender (female, male), age (in years), job experience (below 2 years, 2–10 years, above 10 years), and job type (research, education, public health service) in the SMD analyses. The statistical software R version 4.2.0 was used for the analysis.

For qualitative data assessed via the open-ended questions, we used a content analysis. We used a deductive approach for the first step of categorizing the statements, based on the topics which have been assessed within the quantitative items of the questionnaire. This was followed by an inductive approach to generate further sub-themes based on the content of the statements itself.

The quantitative and qualitative results are combined in the results section, because the qualitative statements elaborated more on specific quantitative results and provided further explanations or concretization.

## 3. Results

### 3.1. Characteristics of study participants

Overall, 172 participants completed the questionnaires. Their age ranges from 18 to 61 years, with a median age of 28 years and a mean of 29.71 years. 38 males (22.1%), 133 females (77.3%) and one person of diverse gender (0.6%) answered the questionnaire. From the 172 participants, 116 stated to be students, while 102 were employed in the public health workforce at time of data collection (Table 1). Combining these two variables gives 53 (30.8%) people working and studying, 63 (36.6%) merely studying, 49 (28.5%) merely working, six (3.5%) neither working or studying, and one person providing no answer on this issue.

About one third of students stated to be enrolled in no higher than the third semester at the time of data collection, indicating that these students gained their experiences at university only at times during the COVID-19 pandemic. Furthermore, 46 (27.7%) participants graduated within their study program during the COVID-19 pandemic. Of these, 17 gained a Bachelor's degree, 21 a Master's degree, and eight a doctoral degree. Of the people working, 34 report a work experience of less than two years (indicating an entry in the employment during the COVID-19 pandemic), 30 people work since two to

five years and 36 are working more than 10 years, whereas two participants provided no information regarding their work experience (Table 1).

**Table 1.** Characteristics of study participants (n=172).

<b>Characteristics</b>	<b>n</b>	<b>%</b>
<b>Gender</b>		
Male	38	22.1
Female	133	77.3
Diverse	1	0.6
<b>Age</b>		
<20 years	6	3.5
20–24 years	48	27.9
25–29 years	42	24.4
30–34 years	35	20.3
≥35 years	41	23.8
<b>Studying and employment status</b>		
Student	63	36.6
Student and employed in the public health workforce	53	30.8
Employed in the public health workforce	49	28.5
None or no information	7	4.1
<b>Current semester<sup>1</sup></b>		
≤3	37	32.7
4–10	48	42.5
≥11	28	24.8
<b>Graduation during COVID-19 pandemic<sup>2</sup></b>		
No graduation	126	73.3
Bachelor's degree	17	9.9
Master's degree	21	12.2
Doctoral degree	2	4.7
<b>Job type<sup>3</sup></b>		
Research	66	64.7
Education	23	22.5
Public health services	29	28.4
Else (e.g. politics)	22	21.6
<b>Job experience<sup>4</sup></b>		
<2 years	34	34.0
2–10 years	51	51.0
>10 years	33	33.0

<sup>1</sup> This analysis applies only to those students who have been enrolled in a study program at the time of data collection (n=63).

<sup>2</sup> This analysis applies to all participants, because it was retrospectively assessed whether one graduated in a study program during the COVID-19 pandemic.

<sup>3</sup> This analysis applies to all people who states to be employed at the time of data collection (n=102). The percentage does not sum up to 100% due to the possibility of multiple responses.

<sup>4</sup> This analysis applies to all people who states to be employed at the time of data collection and who provided information about their job experience (n=100).

For the analysis of differences in the COVID-19 pandemic situation of students and young professionals, we excluded two people: This applies for the person of diverse gender and the person which did not provide any information on job or student status. Therefore, the analysis was run with 170 participants.

### 3.2. Situation of students during the COVID-19 pandemic

Table 2 contains the results for experiences of students during the COVID-19 pandemic. The majority of students reported that they were not burdened (66 out of 116) or less burdened (22 out of 116) in financing their studies during the COVID-19 pandemic, while 15 students felt burdened and another 7 students felt very burdened in this situation.

In scope of an affected communication during the COVID-19 pandemic, most students felt burdened or very burdened due to a lack of exchange with their lecturer (23 and 42 out of 116, respectively) or fellow students (38 and 58 out of 116, respectively). Regarding the experience of a lack of access to learning materials during the COVID-19 pandemic, 7 students felt very burdened, 31 felt burdened, 33 felt less burdened and 42 felt not burdened, while 3 students gave no response to this question. There is no trend visible regarding the experience of an affected access to undisturbed or quiet workplaces for students during the COVID-19 pandemic. The distribution of the 116 responding students ordered from very burdened to not burdened was 33, 24, 26, and 31.

The opportunity to report further experiences related to their student status during the pandemic was only taken by 19 students. Out of them, 12 students reported situations very burdened to themselves. According to the free text answers, these burdening situations mainly relate to a lack of professional and social exchange. The respondents indicated inadequate balance between private and study life. A doctoral student illustrated: "No more time for the dissertation. Everything else (research, children) is more urgent." Apart from taking care of children, it was also emphasized that the COVID-19 pandemic led to limited access to compensatory activities (such as sports and cultural events). Furthermore, conversations were mainly focussed only on one topic – namely the COVID-19 pandemic itself – and social isolation occurred, because roommates in shared apartments were not present or places where one could meet each other (e.g. canteen) were closed. In addition, a missing focus on the study was described, as it was not easy to motivate oneself. This was particularly highlighted by one respondent with attention deficit hyperactivity disorder (ADHD): "As a person with ADHD, structure is extremely important to me, especially when it is imposed from the outside."

Our analysis reveals no relevant gender differences in the burden of experiences of financing student status, communication with lecturers and fellow students, access to learning materials or quiet places (all SMDs below 0.500; Table 2).

However, the age in years category reveals differences in the contact with other students, which was a higher burden for younger students (SMD of 0.789), and in the lack of quiet workplaces, which did not burden older students (SMD of 0.882). There seem to be only small difference between age groups regarding experiences of exchange with lecturer and access to learning materials.

The number of semesters absolved and if the students have graduated during the pandemic show small to medium differences in terms of SMDs. Students in higher semesters ( $\geq 11$  semesters) felt more frequently very burdened by a lack of undisturbed or quiet workplaces compared to participants studying  $\leq 3$  semesters in total (SMD of 0.650). A tendency with the same direction is shown for the affected exchange with lecturers: Students in higher semesters felt more frequently very burdened due to this situation during the pandemic (SMD of 0.542).

In order to assess the pre-pandemic experience of student status, we excluded participants who absolved  $\leq 3$  semesters for a sensitivity analysis of changes in student's situation during the COVID-19 pandemic. Accordingly, 76 out of 116 students were included in this analysis. Results are displayed in supplemented Table S1 and indicates that experience of being student for at least 4 semesters took small additional influence on the degree of burden due to lack of exchange with lecturers or fellow students and due to lack of access to undisturbed/quiet workplaces. Subgroup analyses of the SMD showed that younger students ( $\leq 27$  years old) reported higher burden due to lack of communication to lecturers and fellow students compared to older students. Students aged between 28 and 37 years reported more burden due to lack of access to learning

materials compared to younger and compared to older students. Younger students ( $\leq 27$  years old) reported more burden due to lack of access to undisturbed/quiet workplaces than older ones (Table S1).

**Table 2.** Experiences of students, stratified for gender, age, number of semesters absolved, and graduation status (n=116).

	Gender		SMD	Age in years			SMD	Semesters absolved			SMD	Graduation during COVID-19 pandemic		SMD
	Male	Female		$\leq 27$	28–38	$\geq 38$		$\leq 3$	4–10	$\geq 11$		yes	no	
n	28	87		71	35	10		37	48	28		24	90	
<b>Money</b>			0.455				0.778				0.352			0.315
very burdened	0 (0.0)	6 (7.1)		3 (4.4)	3 (8.8)	1 (12.5)		4 (11.1)	1 (2.2)	2 (7.4)		1 (4.2)	6 (7.1)	
burdened	3 (12.0)	12 (14.3)		11 (16.2)	4 (11.8)	0 (0.0)		6 (16.7)	5 (10.9)	4 (14.8)		3 (12.5)	12 (14.3)	
less burdened	4 (16.0)	18 (21.4)		16 (23.5)	6 (17.6)	0 (0.0)		5 (13.9)	13 (28.3)	4 (14.8)		7 (29.2)	14 (16.7)	
not burdened	18 (72.0)	48 (57.1)		38 (55.9)	21 (61.8)	7 (87.5)		21 (58.3)	27 (58.7)	17 (63.0)		13 (54.2)	52 (61.9)	
NA=6														
<b>Lecturer</b>			0.309				0.153				0.542			0.254
very burdened	6 (23.1)	17 (20.2)		15 (21.1)	7 (21.2)	1 (14.3)		3 (8.6)	12 (25.0)	8 (29.6)		6 (25.0)	17 (20.0)	
burdened	9 (34.6)	33 (39.3)		26 (36.6)	13 (39.4)	3 (42.9)		10 (28.6)	22 (45.8)	10 (37.0)		7 (29.2)	35 (41.2)	
less burdened	5 (19.2)	23 (27.4)		19 (26.8)	8 (24.2)	2 (28.6)		14 (40.0)	9 (18.8)	6 (22.2)		7 (29.2)	21 (24.7)	
not burdened	6 (23.1)	11 (13.1)		11 (15.5)	5 (15.2)	1 (14.3)		8 (22.9)	5 (10.4)	3 (11.1)		4 (16.7)	12 (14.1)	
NA=5														
<b>Co-student</b>			0.302				0.789				0.314			0.186
very burdened	14 (51.9)	44 (51.8)		43 (60.6)	12 (36.4)	3 (33.3)		14 (38.9)	28 (58.3)	16 (59.3)		13 (54.2)	45 (51.7)	
burdened	7 (25.9)	30 (35.3)		19 (26.8)	17 (51.5)	2 (22.2)		15 (41.7)	14 (29.2)	8 (29.6)		7 (29.2)	30 (34.5)	
less burdened	3 (11.1)	7 (8.2)		6 (8.5)	1 (3.0)	3 (33.3)		3 (8.3)	4 (8.3)	2 (7.4)		3 (12.5)	7 (8.0)	
not burdened	3 (11.1)	4 (4.7)		3 (4.2)	3 (9.1)	1 (11.1)		4 (11.1)	2 (4.2)	1 (3.7)		1 (4.2)	5 (5.7)	
NA=3														
<b>Material</b>			0.247				0.397				0.429			0.160
very burdened	3 (11.1)	4 (4.7)		4 (5.6)	3 (9.1)	0 (0.0)		1 (2.8)	4 (8.3)	2 (7.4)		2 (8.3)	5 (5.7)	
burdened	7 (25.9)	23 (27.1)		19 (26.8)	10 (30.3)	2 (22.2)		9 (25.0)	14 (29.2)	8 (29.6)		7 (29.2)	23 (26.4)	
less burdened	7 (25.9)	26 (30.6)		23 (32.4)	7 (21.2)	3 (33.3)		9 (25.0)	18 (37.5)	5 (18.5)		6 (25.0)	27 (31.0)	
not burdened	10 (37.0)	32 (37.6)		25 (35.2)	13 (39.4)	4 (44.4)		17 (47.2)	12 (25.0)	12 (44.4)		9 (37.5)	32 (36.8)	
NA=3														
<b>Quiet place</b>			0.230				0.822				0.650			0.403
very burdened	8 (28.6)	25 (29.4)		21 (29.6)	12 (35.3)	0 (0.0)		4 (11.1)	16 (33.3)	12 (42.9)		10 (41.7)	23 (26.1)	
burdened	4 (14.3)	19 (22.4)		16 (22.5)	7 (20.6)	1 (11.1)		6 (16.7)	11 (22.9)	7 (25.0)		3 (12.5)	20 (22.7)	
less burdened	7 (25.0)	19 (22.4)		16 (22.5)	6 (17.6)	4 (44.4)		9 (25.0)	11 (22.9)	5 (17.9)		6 (25.0)	20 (22.7)	
not burdened	9 (32.1)	22 (25.9)		18 (25.4)	9 (26.5)	4 (44.4)		17 (47.2)	10 (20.8)	4 (14.3)		5 (20.8)	25 (28.4)	
NA=2														
<b>Something else</b>			0.761				1.242				1.170			1.386
very burdened	4 (80.0)	8 (57.1)		8 (72.7)	3 (50.0)	1 (50.0)		4 (80.0)	3 (37.5)	4 (80.0)		2 (33.3)	10 (76.9)	
burdened	1 (20.0)	3 (21.4)		2 (18.2)	2 (33.3)	0 (0.0)		0 (0.0)	3 (37.5)	1 (20.0)		2 (33.3)	2 (15.4)	
less burdened	0 (0.0)	1 (7.1)		1 (9.1)	0 (0.0)	0 (0.0)		0 (0.0)	1 (12.5)	0 (0.0)		0 (0.0)	1 (7.7)	
not burdened	0 (0.0)	2 (14.3)		0 (0.0)	1 (16.7)	1 (50.0)		1 (20.0)	1 (12.5)	0 (0.0)		2 (33.3)	0 (0.0)	
NA=97														

Legend: "During the COVID-19 pandemic, I experienced..."

Money: "...financing my student status as..."; Lecturer: "...lack of exchange with lecturers as..."; Co-student: "...lack of exchange with fellow students as..."; Material: "...lack of access to learning materials as..."; Quiet place: "...lack of access to undisturbed/quiet workplaces as..."; Something else: "...something else I would like mention as...".

NA: not applicable; SMD: standard mean difference

### 3.3. Situation of young professionals during the COVID-19 pandemic

Table 3 shows the experiences of young professionals of the public health workforce during the COVID-19 pandemic. The majority of young professionals reported that they have not or rather not been involved into infectious diseases for the first time on a professional basis during the COVID-19 pandemic (63 and 10 out of 102 participants, respectively). Only 22 participants reported that they were (rather) involved with infectious diseases in their work during this situation for the first time. Almost two third of participants agreed or rather agreed to the statement that the work content has changed during the pandemic (40 and 26 participants, respectively). Within the open-ended

questions, some participants stated that more research was conducted related to infection control, particularly in terms of COVID-19, but also on aspects related to Long COVID. One participant also stated that due to high amounts of money spent on COVID-19 related research, some older third-party research grant applications have been “recycled” and complemented by aspects related to COVID-19. Others highlighted that they “have dealt with health-related inequality and their political and social determinants already beforehand”, but COVID-19 has now served as a “case study” or “magnifying glass” for these issues. One respondent coming from politics emphasized that there has been a shift in thematic focuses, because health has suddenly been included in several other political areas – as proposed by the concept of health in all policies. Finally, it has been stated that the COVID-19 pandemic has “led to conducting fast evidence syntheses (e.g. rapid reviews) and products for knowledge translation (e.g. policy briefs, issue briefs)”.

Many young professionals reported that their workload during the pandemic greatly increased or increased (38 and 31 out of 102). In 26 individuals, workload did not change. Only one participant reported a reduced workload. Although studies on COVID-19 were visible quite early, these research activities burdened the researchers: “All projects had to be designed and implemented extremely quickly. This built up a tremendous amount of pressure and led to a really large amount of overtime. In fact, I had to work the most over the Christmas vacations (both 20/21 and 21/22).”

Free text answers clearly indicated that many researchers had to adapt the design of their studies, mostly for qualitative interviews which were conducted via telephone or videoconferencing tools instead of face-to-face. Although some participants stated that these digital tools for data collection led to saving time and money, some also highlighted that approvals for these adaptations of study protocols needed time and that, overall, these changes lead to “massive time delays” within the projects. One participant pointed to the experience that a change from centralized to hybrid and decentralized studies was observable, which also allows to gain larger sample sizes more easily.

However, the respondents also acknowledged that some target groups were no longer available for empirical research (e.g. particularly vulnerable groups with limited communication ability or mental disabilities). This has led to “considerable impairment of study designs (suspension/severe delay of survey waves in longitudinal designs, drastic increase of loss to follow-up)”.

The free text answers also indicate a debate about pros and cons of digital technologies for qualitative data collection. On the one hand, respondents stated that interviews via videoconference tools went very well, particularly because there was no loss of study participants due to non-attendance. On the other hand, the challenge of limited or instable internet access was mentioned. One critical remark regarding methodology overall was as follows: “Qualitative social research – beyond the individual expert interview – is more difficult or almost impossible to conduct, e.g. ethnomethodological observations, focus groups, etc. A shift to quantitative methods does not always make sense from an epistemological point of view. Here, in case of doubt, one should wait before applying a quantitative questionnaire that cannot depict what was originally issued as the research objective.”

About half of participants gave no answer to the questions regarding their experience with grants/funding and ethics committees during the COVID-19 pandemic (63 and 68 missings, respectively). Of those who gave response, 28 each felt not or less burdened due to insufficient access to grants/funding or lengthy reviews by ethics committees, respectively. One study participant stated that the COVID-19 pandemic has led to faster decisions at the ethic committee.

Although there was proportionally high number of missing values in the data on contact and collaboration with colleagues and external collaborations, about two-thirds of persons who responded to this question felt (very) burdened because of a lack of exchanges with their in-house colleagues. Almost the opposite result has been observed for communication and collaboration with external colleagues. This might be due to the

fact that many participants stated the benefits of digital technologies for inter-institutional collaborations and cooperation, both nationally and internationally.

In scope of experiences with access to training or congress participation during the pandemic, 36 out of 102 young professionals agreed that access was easier, further 30 rather agreed, another 13 rather disagreed and 10 disagreed an easier access while 13 participants gave no response. Some participants explicitly stated that visiting congresses – particularly international ones – was much easier due to digital formats. One participant elaborated: “Participation in digital training courses, congresses and (international) networks is much more convenient. This offers an opportunity for all those who have additional private liabilities (care, children, physical limitations...). Maybe it can be considered as a suitable measure for promoting equality.”

In this context, half of participants disagreed or rather disagreed with the statement that quality of trainings and congresses decreased during the COVID-19 pandemic (20 and 32 participants, respectively). Another 13 young professionals rather agreed to decreased quality and 10 agreed this situation while 29 participants gave no answer to this question.

Moreover, only 11 young professionals took the opportunity to report further experiences related to their working situation during the COVID-19 pandemic. 7 out of 11 individuals reported very burdened situations, which mainly relate to taking care of children (e.g. coordinating home schooling; closed or at least partially restricted availability of kindergartens).

Of the 102 people who were employed in the public health workforce during the COVID-19 pandemic, gender did not have a relevant influence on the perceived burden assessed in our study. The SMDs displayed in Table 3 vary from 0.234 in the category quality of training and conferences decreased to 0.724 in the category regarding access to training or congresses. It seems that females agreed or rather agreed more frequently to the experience of an easier access to training/congress participation compared to males. Moreover, the trend for increased workload is displayed for both gender but there seems to be a difference in the extent, with larger increases reported by females.

Participants aged 38 years or older seem to have experienced more often changes in their work content during the pandemic, because 22 of 26 of them agreed or rather agreed to this statement – compared to 25 of 48 participants aged between 28-37 years and 19 of 28 participants aged 27 years or younger (SMD of 0.570). Similar differences are shown for years of work experience (SMD of 0.590). Furthermore, participants aged 38 years or older seem to disagree or rather disagree more often to the statement of decreased quality of trainings/congresses during the pandemic compared to the younger age groups (SMD of 0.701), but it should be considered that only 50% of the youngest age group provided a response to this question.

Study participants working in the public health service tend to become more often involved with infectious diseases for the first time during the COVID-19 pandemic compared to participants not working in this profession (SMD of 0.685). Small differences ( $SMD \leq 0.3$ ) are displayed for the first involvement with infectious diseases between participants working in the research sector or not and participants working in the education sector or not. The work content seems to change more often in educational profession than non-educational profession (SMD of 0.805) and even more in public health service sector compared to participants not working in public health service sector (SMD of 0.957).

Easier access to trainings/congresses was reported more often in participants working in research area compared to non-research area (SMD of 0.755), whereas the difference for participants working in educational profession versus non-educational profession was smaller (SMD of 0.422).

1 **Table 3.** Experiences of employed participants, stratified for gender, age, years of work experience, and profession (n=102).

	Gender		Age in years			Years of work experience			Profession: Research		Profession: Education		Profession: Public health service							
	Male	Female	SMD	≤27	28–<38	≥38	SMD	≤2	2–<10	≥10	SMD	no	yes	SMD	no	yes	SMD	no	yes	SMD
<b>n</b>	21	81		28	48	26		34	51	15		36	66		79	23		73	29	
<b>Infections</b>			0.521				0.402				0.356			0.225			0.331			0.685
agree	4 (21.1)	9 (11.8)		2 (8.0)	8 (17.4)	3 (12.5)		5 (16.7)	6 (12.5)	2 (13.3)		6 (18.2)	7 (11.3)		11 (15.1)	2 (9.1)		5 (7.2)	8 (30.8)	
rather agree	1 (5.3)	8 (10.5)		5 (20.0)	3 (6.5)	1 (4.2)		5 (16.7)	2 (4.2)	2 (13.3)		3 (9.1)	6 (9.7)		8 (11.0)	1 (4.5)		7 (10.1)	2 (7.7)	
rather disagree	4 (21.1)	6 (7.9)		3 (12.0)	4 (8.7)	3 (12.5)		2 (6.7)	6 (12.5)	2 (13.3)		4 (12.1)	6 (9.7)		7 (9.6)	3 (13.6)		9 (13.0)	1 (3.8)	
disagree	10 (52.6)	53 (69.7)		15 (60.0)	31 (67.4)	17 (70.8)		18 (60.0)	34 (70.8)	9 (60.0)		20 (60.6)	43 (69.4)		47 (64.4)	16 (72.7)		48 (69.6)	15 (57.7)	
NA=7																				
<b>Content</b>			0.418				0.570				0.590			0.516			0.805			0.957
agree	8 (40.0)	32 (40.5)		13 (50.0)	16 (34.0)	11 (42.3)		15 (48.4)	20 (39.2)	5 (33.3)		17 (48.6)	23 (35.9)		34 (44.7)	6 (26.1)		21 (29.2)	19 (70.4)	
rather agree	5 (25.0)	21 (26.6)		6 (23.1)	9 (19.1)	11 (42.3)		4 (12.9)	14 (27.5)	7 (46.7)		9 (25.7)	17 (26.6)		14 (18.4)	12 (52.2)		21 (29.2)	5 (18.5)	
rather disagree	1 (5.0)	12 (15.2)		2 (7.7)	10 (21.3)	1 (3.8)		5 (16.1)	6 (11.8)	2 (13.3)		6 (17.1)	7 (10.9)		12 (15.8)	1 (4.3)		12 (16.7)	1 (3.7)	
disagree	6 (30.0)	14 (17.7)		5 (19.2)	12 (25.5)	3 (11.5)		7 (22.6)	11 (21.6)	1 (6.7)		3 (8.6)	17 (26.6)		16 (21.1)	4 (17.4)		18 (25.0)	2 (7.4)	
NA=3																				
<b>Workload</b>			0.516				0.412				0.263			0.715			0.363			0.769
greatly reduced	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
reduced	0 (0.0)	1 (1.3)		0 (0.0)	0 (0.0)	1 (3.8)		0 (0.0)	1 (2.0)	0 (0.0)		0 (0.0)	1 (1.6)		1 (1.4)	0 (0.0)		1 (1.4)	0 (0.0)	
unchanged	6 (28.6)	20 (26.7)		7 (26.9)	14 (31.8)	5 (19.2)		8 (25.8)	15 (30.6)	3 (21.4)		7 (21.2)	19 (30.2)		20 (27.4)	6 (26.1)		22 (31.4)	4 (15.4)	
increased	10 (47.6)	21 (28.0)		10 (38.5)	10 (22.7)	11 (42.3)		10 (32.3)	16 (32.7)	4 (28.6)		6 (18.2)	25 (39.7)		21 (28.8)	10 (43.5)		26 (37.1)	5 (19.2)	
greatly increased	5 (23.8)	33 (44.0)		9 (34.6)	20 (45.5)	9 (34.6)		13 (41.9)	17 (34.7)	7 (50.0)		20 (60.6)	18 (28.6)		31 (42.5)	7 (30.4)		21 (30.0)	17 (65.4)	
NA=6																				
<b>Grants</b>			0.429				0.621				0.901			NaN			0.685			1.318
very burdened	1 (10.0)	5 (17.2)		1 (20.0)	3 (13.6)	2 (16.7)		2 (22.2)	3 (12.5)	1 (20.0)		0 (NaN)	6 (15.4)		2 (8.3)	4 (26.7)		6 (16.2)	0 (0.0)	
burdened	1 (10.0)	4 (13.8)		1 (20.0)	2 (9.1)	2 (16.7)		1 (11.1)	2 (8.3)	2 (40.0)		0 (NaN)	5 (12.8)		2 (8.3)	3 (20.0)		4 (10.8)	1 (50.0)	
less burdened	3 (30.0)	4 (13.8)		0 (0.0)	6 (27.3)	1 (8.3)		0 (0.0)	6 (25.0)	0 (0.0)		0 (NaN)	7 (17.9)		5 (20.8)	2 (13.3)		7 (18.9)	0 (0.0)	
not burdened	5 (50.0)	16 (55.2)		3 (60.0)	11 (50.0)	7 (58.3)		6 (66.7)	13 (54.2)	2 (40.0)		0 (NaN)	21 (53.8)		15 (62.5)	6 (40.0)		20 (54.1)	1 (50.0)	
NA=63																				
<b>Ethics</b>			0.420				0.856				1.276			NaN			0.525			1.268
very burdened	1 (11.1)	1 (4.0)		0 (0.0)	1 (4.5)	1 (10.0)		0 (0.0)	1 (4.5)	1 (20.0)		0 (NaN)	2 (5.9)		0 (0.0)	2 (11.8)		2 (6.2)	0 (0.0)	
burdened	1 (11.1)	3 (12.0)		0 (0.0)	3 (13.6)	1 (10.0)		0 (0.0)	2 (9.1)	2 (40.0)		0 (NaN)	4 (11.8)		2 (11.8)	2 (11.8)		3 (9.4)	1 (50.0)	
less burdened	1 (11.1)	6 (24.0)		0 (0.0)	5 (22.7)	2 (20.0)		1 (16.7)	6 (27.3)	0 (0.0)		0 (NaN)	7 (20.6)		4 (23.5)	3 (17.6)		7 (21.9)	0 (0.0)	
not burdened	6 (66.7)	15 (60.0)		2 (100.0)	13 (59.1)	6 (60.0)		5 (83.3)	13 (59.1)	2 (40.0)		0 (NaN)	21 (61.8)		11 (64.7)	10 (58.8)		20 (62.5)	1 (50.0)	
NA=68																				
<b>Colleagues</b>			0.611				0.586				0.918			NaN			0.404			0.559
very burdened	2 (12.5)	16 (33.3)		8 (44.4)	5 (17.9)	5 (27.8)		7 (35.0)	11 (30.6)	0 (0.0)		0 (NaN)	18 (28.1)		14 (33.3)	4 (18.2)		16 (27.1)	2 (40.0)	
burdened	9 (56.2)	16 (33.3)		6 (33.3)	11 (39.3)	8 (44.4)		6 (30.0)	14 (38.9)	5 (71.4)		0 (NaN)	25 (39.1)		14 (33.3)	11 (50.0)		24 (40.7)	1 (20.0)	
less burdened	3 (18.8)	12 (25.0)		4 (22.2)	7 (25.0)	4 (22.2)		5 (25.0)	7 (19.4)	2 (28.6)		0 (NaN)	15 (23.4)		10 (23.8)	5 (22.7)		14 (23.7)	1 (20.0)	
not burdened	2 (12.5)	4 (8.3)		0 (0.0)	5 (17.9)	1 (5.6)		2 (10.0)	4 (11.1)	0 (0.0)		0 (NaN)	6 (9.4)		4 (9.5)	2 (9.1)		5 (8.5)	1 (20.0)	
NA=38																				
<b>Consortium</b>			0.384				0.737				0.697			NaN			0.514			0.712
very burdened	2 (13.3)	3 (8.3)		1 (12.5)	1 (3.8)	3 (17.6)		1 (8.3)	3 (9.7)	1 (14.3)		0 (NaN)	5 (9.8)		2 (6.7)	3 (14.3)		5 (10.6)	0 (0.0)	

burdened	4 (26.7)	9 (25.0)		3 (37.5)	8 (30.8)	2 (11.8)		4 (33.3)	8 (25.8)	1 (14.3)		0 (NaN)	13 (25.5)		10 (33.3)	3 (14.3)		11 (23.4)	2 (50.0)	
less burdened	6 (40.0)	11 (30.6)		1 (12.5)	8 (30.8)	8 (47.1)		2 (16.7)	10 (32.3)	4 (57.1)		0 (NaN)	17 (33.3)		10 (33.3)	7 (33.3)		16 (34.0)	1 (25.0)	
not burdened	3 (20.0)	13 (36.1)		3 (37.5)	9 (34.6)	4 (23.5)		5 (41.7)	10 (32.3)	1 (14.3)		0 (NaN)	16 (31.4)		8 (26.7)	8 (38.1)		15 (31.9)	1 (25.0)	
NA=51																				
<b>Target group</b>			0.465				0.671				0.485		NaN				0.662			1.268
very burdened	4 (33.3)	7 (19.4)		1 (9.1)	4 (17.4)	6 (42.9)		2 (14.3)	3 (18.8)	6 (35.3)		0 (NaN)	11 (22.9)		5 (16.7)	6 (33.3)		11 (23.9)	0 (0.0)	
burdened	4 (33.3)	13 (36.1)		6 (54.5)	7 (30.4)	4 (28.6)		6 (42.9)	5 (31.2)	5 (29.4)		0 (NaN)	17 (35.4)		13 (43.3)	4 (22.2)		16 (34.8)	1 (50.0)	
less burdened	3 (25.0)	8 (22.2)		2 (18.2)	7 (30.4)	2 (14.3)		3 (21.4)	6 (37.5)	2 (11.8)		0 (NaN)	11 (22.9)		8 (26.7)	3 (16.7)		10 (21.7)	1 (50.0)	
not burdened	1 (8.3)	8 (22.2)		2 (18.2)	5 (21.7)	2 (14.3)		3 (21.4)	2 (12.5)	4 (23.5)		0 (NaN)	9 (18.8)		4 (13.3)	5 (27.8)		9 (19.6)	0 (0.0)	
NA=54																				
<b>Access</b>			0.724				0.068				0.394		0.755				0.422			0.733
agree	6 (31.6)	30 (42.9)		8 (40.0)	18 (41.9)	10 (38.5)		13 (48.1)	18 (38.3)	5 (38.5)		7 (22.6)	29 (50.0)		25 (37.3)	11 (50.0)		30 (46.9)	6 (24.0)	
rather agree	10 (52.6)	20 (28.6)		7 (35.0)	14 (32.6)	9 (34.6)		9 (33.3)	16 (34.0)	4 (30.8)		10 (32.3)	20 (34.5)		22 (32.8)	8 (36.4)		23 (35.9)	7 (28.0)	
rather disagree	3 (15.8)	10 (14.3)		3 (15.0)	6 (14.0)	4 (15.4)		4 (14.8)	5 (10.6)	3 (23.1)		8 (25.8)	5 (8.6)		11 (16.4)	2 (9.1)		7 (10.9)	6 (24.0)	
disagree	0 (0.0)	10 (14.3)		2 (10.0)	5 (11.6)	3 (11.5)		1 (3.7)	8 (17.0)	1 (7.7)		6 (19.4)	4 (6.9)		9 (13.4)	1 (4.5)		4 (6.2)	6 (24.0)	
NA=13																				
<b>Quality</b>			0.234				0.701				0.575		0.750				0.598			0.750
agree	1 (5.9)	7 (12.5)		4 (28.6)	4 (11.1)	0 (0.0)		4 (19.0)	4 (10.5)	0 (0.0)		7 (24.1)	1 (2.3)		8 (14.5)	0 (0.0)		2 (3.9)	6 (27.3)	
rather agree	3 (17.6)	10 (17.9)		3 (21.4)	6 (16.7)	4 (17.4)		3 (14.3)	6 (15.8)	4 (33.3)		6 (20.7)	7 (15.9)		10 (18.2)	3 (16.7)		9 (17.6)	4 (18.2)	
rather disagree	8 (47.1)	24 (42.9)		4 (28.6)	18 (50.0)	10 (43.5)		9 (42.9)	17 (44.7)	4 (33.3)		9 (31.0)	23 (52.3)		23 (41.8)	9 (50.0)		26 (51.0)	6 (27.3)	
disagree	5 (29.4)	15 (26.8)		3 (21.4)	8 (22.2)	9 (39.1)		5 (23.8)	11 (28.9)	4 (33.3)		7 (24.1)	13 (29.5)		14 (25.5)	6 (33.3)		14 (27.5)	6 (27.3)	
NA=29																				
<b>Something else</b>			3.000				1.054				2.279		NaN				0.967			0.926
very burdened	0 (0.0)	7 (77.8)		1 (50.0)	4 (80.0)	2 (50.0)		1 (33.3)	6 (85.7)	0 (0.0)		0 (NaN)	7 (63.6)		5 (71.4)	2 (50.0)		7 (70.0)	0 (0.0)	
burdened	1 (50.0)	2 (22.2)		1 (50.0)	0 (0.0)	2 (50.0)		1 (33.3)	1 (14.3)	1 (100.0)		0 (NaN)	3 (27.3)		1 (14.3)	2 (50.0)		3 (30.0)	0 (0.0)	
less burdened	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
not burdened	1 (50.0)	0 (0.0)		0 (0.0)	1 (20.0)	0 (0.0)		1 (33.3)	0 (0.0)	0 (0.0)		0 (NaN)	1 (9.1)		1 (14.3)	0 (0.0)		0 (0.0)	1 (100.0)	
NA=91																				

2 Legend: "During the COVID-19 pandemic..."

3 Infections: "...I became involved in infectious diseases either professionally or during my studies for the first time."; Content: "...my work content has changed."; Workload: "...how has your average

4 workload changed as a result of the COVID-19 pandemic?"; Grants: "...I had insufficient access to necessary funding/grants."; Ethics: "...I experienced lengthy reviews by the ethic committee."; Colleagues:

5 "...I experienced lack of exchange with colleagues from the own institute/department."; Consortium: "...I had lack of opportunities for cooperation with other (research) institutes."; Target group: "...I had

6 insufficient access to the target group during data collection."; Access: "...access to training of congress participation was easier."; Quality: "...training/congress quality decreased."; Something else: "...I

7 experiences something else that I would like to notice here."

8 NA: not applicable; SMD: standard mean differences

The workload of participants in the public health service seems to be more often increased than the workload of participants not working in the research area (SMD of 0.769). For the profession of education, difference in workload seems smaller (SMD of 0.363). The questions regarding grants/funding, colleagues, collaborations, ethics committees, and target groups applied only to participants working in research. Accordingly, no comparison is displayed. Researcher working additionally in education seem to be more burdened due to insufficient access to grants/funding compared to researchers not working additionally in education (SMD of 0.685).

#### 4. Discussion

Our study shows that the (future) public health workforce in Germany has been burdened due to various aspects during the COVID-19 pandemic, not only related to workload but also due to missing social and professional interaction. This applies to participants who have been studying or employed at that time. Among public health professionals, one can expect particular challenges in retaining work-life-balance during the COVID-19 pandemic [18], because their expertise and workforce was urgently needed [19–21]. However, there were also some aspects where the burden has been perceived quite differently in our study, emphasizing that targeted or tailored approaches are needed. For example, strengthening digital formats both for research and education have either been judged as positive or burdensome. In addition, there have also been serious concerns about quality and validity of research which has been conducted during the COVID-19 pandemic, because study designs had to be adjusted to handle with regulations and restrictions caused by the pandemic and its associated containment measures.

To our knowledge, this is the first study focusing on the impact of the COVID-19 pandemic on workload, work content, and related challenges among the public health workforce in Germany, which includes data on students and young professionals. Previous studies in the context of the COVID-19 pandemic have either focused on specific aspects – particularly related to digital teaching – within medical students or healthcare personnel [22–24] or on mental health issues due to social isolation [1,25]. Although knowledge is available that as an adverse effect of the COVID-19 pandemic education and job training have been disrupted or delayed for many young adults and traditional ways of working encountered serious challenges [26], there has been limited attention on the public health workforce [27,28] in Germany. Previous international studies have already shed some light on exacerbated challenges which have been experienced by the public health workforce, leading to symptoms of posttraumatic stress disorder [29] and burnout [30,31], which may be the results of a shifting focus from normal duties to COVID-19 response activities, higher workload, and job-related threats [29,32]. Therefore, it is imperative to focus much more on the well-being of public health professionals [28,33], which might adversely be impacted due work strains.

The results of our study indicate not only changes in the work content, but also an overall higher workload. The COVID-19 pandemic has led to an increase in the urgency and scope of the work of public health professionals and reduced their capacity to carry out core services [34]. Particularly young professionals with only few years of work experience, who experience such a situation directly at the beginning of their professional life, may be adversely affected. A previous study emphasized that first experiences with such a public health emergency were associated with the intention to leave the job among employees of the public health workforce [27]. Although the public health workforce is an essential part for successfully combating the COVID-19 pandemic [35], one has to acknowledge that there is an urgent need to recruiting and retaining young professionals in this area. For doing so, systematic and organizational changes are needed [32,36] to make the public health workforce an attractive area to be employed in.

Until now, the public health workforce had to operate with minimal resources and was characterized by a “lack of continuing education, shortage of professional staff, low

wages, and a lack of professional organisations to safeguard employment rights” [37]. During the COVID-19 pandemic, young professionals may have experienced a frustrating disconnect between demand and availability of public health infrastructure – consisting of a capable and qualified workforce, up-to-date data and information systems, and agencies capable of assessing and responding to public health needs – on a daily basis [21]. However, the COVID-19 pandemic has led to a public and political focus on these issues. Therefore, it has created a window of opportunity to create change [38]. This might be particularly useful for young professionals, who are a great potential for the field of public health [21].

For attracting these young professionals, digital solutions may serve as valuable tools, because they are flexible and affordable [39] and allow easier communication between various actors. However, our study results show divergent experiences of the public health workforce in this regard: Although external cooperation was accelerated due to the digital communication [40], several respondents – both students and young professionals – were burdened due to a lack of exchange with other persons such as colleagues or lecturers. It has already been described in previous literature that the digital communication during the COVID-19 pandemic led to decreases in synchronous communication and increases in asynchronous communication, which make it harder for employees to acquire and share new information [41]. Especially for young people during their study or early professional life, missing format of exchange and discussion is an aspect that has a negative impact on satisfaction with studies and work and, thus, on their quality of life [42]. Therefore, one needs to acknowledge the opportunities of digitalization which have also been mentioned by our study participants, such as easier access to training courses, but also needs to consider its boundaries to avoid social isolation and overburdening.

A major topic within our analysis have been modifications of research projects. Not only that the scientific rigor might be questioned [43,44], but adjustment of study protocols or time delays in collecting data have burdened the researchers. This emphasizes the need for supporting young investigators, particularly in times of uncertainty, by increasing connectivity in the field of study, intensifying communication with supervisors and colleagues, broadening mentoring opportunities, and increasing flexibility of research and funding programs [45].

#### *4.1. Limitations*

Several limitations need to be considered when interpreting the results. Firstly, we cannot say anything about the representativeness due to the sampling method. We tried to use several distribution lists to gain a large sample size. However, online-based recruiting is based on people’s willingness to participate in research and may, therefore, be biased. Secondly, the timing of questions only provides a snapshot in a dynamic pandemic. We asked for a retrospective assessment which covered the time “during the pandemic”. It might be possible that the respective answers would have been different when focusing on specific time points within the COVID-19 pandemic. Thirdly, we did not use validated instruments for data collection, but tried to assess the most important points which have been described in studies in other target groups and validated these items in a pretest. Fourthly, there are partly very small numbers in the groups for the SMDs which hinder validity.

#### **5. Conclusions**

Overall, the study participants as part of the (future) public health workforce expressed multiple demands that can have an impact on both acquired skills and mental health during the professional qualification phase. The analysis indicates that challenges caused by the COVID-19 pandemic and its associated containment measures received divergent appraisals. This illustrates that specific factors may pose a burden either in

students or on young professionals, but also within these groups – depending on social circumstances and resilience. Therefore, more in-depth analyses are needed for investigating the impact the pandemic will have on the (future) public health workforce in the long run.

**Supplementary Materials:** The following supporting information can be downloaded at: [www.mdpi.com/xxx/s1](http://www.mdpi.com/xxx/s1), Table S1: Experiences of participants with student status for at least four semesters, stratified for gender, age, number of semesters absolved, and graduation status (n=76).

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**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** Data is available from corresponding author upon reasonable request.

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## References

1. Hannemann, J.; Abdalrahman, A.; Erim, Y.; Morawa, E.; Jerg-Bretzke, L.; Beschoner, P.; Geiser, F.; Hiebel, N.; Weidner, K.; Steudte-Schmiedgen, S.; et al. The impact of the COVID-19 pandemic on the mental health of medical staff considering the interplay of pandemic burden and psychosocial resources-A rapid systematic review. *PLoS One* **2022**, *17*, e0264290, doi:10.1371/journal.pone.0264290.
2. WHO. WHO Director-General's opening remarks at the media briefing on COVID19 - March 2020, Geneva, 2020.
3. Werner, A.M.; Tibubos, A.N.; Mülder, L.M.; Reichel, J.L.; Schäfer, M.; Heller, S.; Pfirrmann, D.; Edelmann, D.; Dietz, P.; Rigotti, T.; et al. The impact of lockdown stress and loneliness during the COVID-19 pandemic on mental health among university students in Germany. *Sci. Rep.* **2021**, *11*, 22637, doi:10.1038/s41598-021-02024-5.
4. Pozo-Martin, F.; Weishaar, H.; Cristea, F.; Hanefeld, J.; Bahr, T.; Schaade, L.; El Bcheraoui, C. The impact of non-pharmaceutical interventions on COVID-19 epidemic growth in the 37 OECD member states. *Eur. J. Epidemiol.* **2021**, *36*, 629–640, doi:10.1007/s10654-021-00766-0.
5. Blatt, S.J. *Polarities of experience: Relatedness and self-definition in personality development, psychopathology, and the therapeutic process*; American Psychological Association: Washington, DC, 2008, ISBN 978-1-4338-0314-7.
6. Lekagul, A.; Piancharoen, P.; Chattong, A.; Suradom, C.; Tangcharoensathien, V. Living through the psychological consequences of COVID-19 pandemic: a systematic review of effective mitigating interventions. *BMJ Open* **2022**, *12*, e060804, doi:10.1136/bmjopen-2022-060804.
7. Zeegers Paget, D.; Allebeck, P.; Nagyova, I. COVID-19: What have we learned? What are the public health challenges? *Eur. J. Public Health* **2021**, *31*, iv1-iv2, doi:10.1093/eurpub/ckab150.
8. Rabaan, A.A.; Bakhrebah, M.A.; Mutair, A.A.; Alhumaid, S.; Al-Jishi, J.M.; AlSihati, J.; Albayat, H.; Alsheheri, A.; Aljeldah, M.; Garout, M.; et al. Systematic Review on Pathophysiological Complications in Severe COVID-19 among the Non-Vaccinated and Vaccinated Population. *Vaccines (Basel)* **2022**, *10*, doi:10.3390/vaccines10070985.
9. Maya, S.; Kahn, J.G.; Lin, T.K.; Jacobs, L.M.; Schmidt, L.A.; Burrough, W.B.; Ghasemzadeh, R.; Mousli, L.; Allan, M.; Donovan, M.; et al. Indirect COVID-19 health effects and potential mitigating interventions: Cost-effectiveness framework. *PLoS One* **2022**, *17*, e0271523, doi:10.1371/journal.pone.0271523.
10. Ghahramani, S.; Kasraei, H.; Hayati, R.; Tabrizi, R.; Marzaleh, M.A. Health care workers' mental health in the face of COVID-19: a systematic review and meta-analysis. *Int. J. Psychiatry Clin. Pract.* **2022**, 1–10, doi:10.1080/13651501.2022.2101927.

11. Palmer, J.; Ku, M.; Wang, H.; Crosse, K.; Bennett, A.; Lee, E.; Simmons, A.; Duffy, L.; Montanaro, J.; Bazaid, K. Public health emergency and psychological distress among healthcare workers: a scoping review. *BMC Public Health* **2022**, *22*, 1396, doi:10.1186/s12889-022-13761-1.
12. Koob, C.; Schröpfer, K.; Coenen, M.; Kus, S.; Schmidt, N. Factors influencing study engagement during the COVID-19 pandemic: A cross-sectional study among health and social professions students. *PLoS One* **2021**, *16*, e0255191, doi:10.1371/journal.pone.0255191.
13. Jessup, B.; Hoang, H.; Podubinski, T.; Obamiro, K.; Bourke, L.; Hellwege, B.; Jatrana, S.; Heaney, S.; Farthing, A.; Sheepway, L.; et al. 'I can't go, I can't afford it': Financial concern amongst health students undertaking rural and remote placements during COVID-19. *Aust. J. Rural Health* **2022**, *30*, 238–251, doi:10.1111/ajr.12855.
14. Spagnolo, J.; Gautier, L.; Seppey, M.; D'souza, N.A. Re-thinking global and public health projects during the COVID-19 pandemic context: Considerations and recommendations for early- and not-so-early-career researchers. *Soc. Sci. Humanit. Open* **2020**, *2*, 100075, doi:10.1016/j.ssaho.2020.100075.
15. Spagnolo, J.; Gautier, L.; Champagne, F.; Leduc, N.; Melki, W.; N'Guessan, K.; Charfi, F. Reflecting on knowledge translation strategies from global health research projects in Tunisia and the Republic of Côte d'Ivoire. *Int. J. Public Health* **2020**, *65*, 1559–1570, doi:10.1007/s00038-020-01502-3.
16. Byrom, N. The challenges of lockdown for early-career researchers. *Elife* **2020**, *9*, e59634, doi:10.7554/eLife.59634.
17. López-Vergès, S.; Urbani, B.; Fernández Rivas, D.; Kaur-Ghumaan, S.; Coussens, A.K.; Moronta-Barrios, F.; Bhattarai, S.; Niamir, L.; Siciliano, V.; Molnar, A.; et al. Mitigating losses: how scientific organisations can help address the impact of the COVID-19 pandemic on early-career researchers. *Humanit. Soc. Sci. Commun.* **2021**, *8*, 284, doi:10.1057/s41599-021-00944-1.
18. Malik, A.A.; Crookes, D.M.; Sundaram, M. Being an early career public health professional during the COVID-19 pandemic. *Lancet Reg. Health Am.* **2021**, *4*, 100087, doi:10.1016/j.lana.2021.100087.
19. Hodges, R.; Caperchione, E.; van Helden, J.; Reichard, C.; Sorrentino, D. The Role of Scientific Expertise in COVID-19 Policy-making: Evidence from Four European Countries. *Public Organiz Rev* **2022**, *22*, 249–267, doi:10.1007/s11115-022-00614-z.
20. Czabanowska, K.; Kuhlmann, E. Public health competences through the lens of the COVID-19 pandemic: what matters for health workforce preparedness for global health emergencies. *Int. J. Health Plann. Manage.* **2021**, *36*, 14–19, doi:10.1002/hpm.3131.
21. Wong, B.L.H.; Siepmann, I.; Chen, T.T.; Fisher, S.; Weitzel, T.S.; Nathan, N.L.; Saminarsih, D.S. Rebuilding to shape a better future: the role of young professionals in the public health workforce. *Hum. Resour. Health* **2021**, *19*, 82, doi:10.1186/s12960-021-00627-7.
22. Omlor, A.J.; Schwärzel, L.S.; Bewarder, M.; Casper, M.; Damm, E.; Danziger, G.; Mahfoud, F.; Rentz, K.; Sester, U.; Bals, R.; et al. Comparison of immersive and non-immersive virtual reality videos as substitute for in-hospital teaching during coronavirus lockdown: a survey with graduate medical students in Germany. *Med. Educ. Online* **2022**, *27*, 2101417, doi:10.1080/10872981.2022.2101417.
23. Meyer, A.; Stosch, C.; Klatt, A.R.; Streichert, T. The impact of COVID-19 on medical students' practical skills and hygiene behavior regarding venipuncture: a case control study. *BMC Med. Educ.* **2022**, *22*, 558, doi:10.1186/s12909-022-03601-6.
24. Holzmann-Littig, C.; Zerban, N.L.; Storm, C.; Ulhaas, L.; Pfeiffer, M.; Kotz, A.; Wijnen-Meijer, M.; Keil, S.; Huber, J. One academic year under COVID-19 conditions: two multicenter cross-sectional evaluation studies among medical students in Bavarian medical schools, Germany students' needs, difficulties, and concerns about digital teaching and learning. *BMC Med. Educ.* **2022**, *22*, 450, doi:10.1186/s12909-022-03480-x.
25. Weber, M.; Schulze, L.; Bolzenkötter, T.; Niemeyer, H.; Renneberg, B. Mental Health and Loneliness in University Students During the COVID-19 Pandemic in Germany: A Longitudinal Study. *Front. Psychiatry* **2022**, *13*, 848645, doi:10.3389/fpsy.2022.848645.
26. Samji, H.; Dove, N.; Ames, M.; Barbic, S.; Sones, M.; Leadbeater, B. *Impacts of the COVID-19 Pandemic on the Health and Well-Being of Young Adults in British Columbia*, Vancouver, 2021.
27. Hare Bork, R.; Robins, M.; Schaffer, K.; Leider, J.P.; Castrucci, B.C. Workplace Perceptions and Experiences Related to COVID-19 Response Efforts Among Public Health Workers - Public Health Workforce Interests and Needs Survey, United States, September 2021-January 2022. *MMWR Morb. Mortal. Wkly. Rep.* **2022**, *71*, 920–924, doi:10.15585/mmwr.mm7129a3.

28. Scales, S.E.; Patrick, E.; Stone, K.W.; Kintziger, K.W.; Jagger, M.A.; Horney, J.A. A Qualitative Study of the COVID-19 Response Experiences of Public Health Workers in the United States. *Health Secur.* **2021**, *19*, 573–581, doi:10.1089/hs.2021.0132.
29. Bryant-Geneviev, J.; Rao, C.Y.; Lopes-Cardozo, B.; Kone, A.; Rose, C.; Thomas, I.; Orquiola, D.; Lynfield, R.; Shah, D.; Freeman, L.; et al. Symptoms of Depression, Anxiety, Post-Traumatic Stress Disorder, and Suicidal Ideation Among State, Tribal, Local, and Territorial Public Health Workers During the COVID-19 Pandemic - United States, March-April 2021. *MMWR Morb. Mortal. Wkly. Rep.* **2021**, *70*, 947–952, doi:10.15585/mmwr.mm7026e1.
30. Stone, K.W.; Kintziger, K.W.; Jagger, M.A.; Horney, J.A. Public Health Workforce Burnout in the COVID-19 Response in the U.S. *Int. J. Environ. Res. Public Health* **2021**, *18*, doi:10.3390/ijerph18084369.
31. Ibrahim, F.; Samsudin, E.Z.; Chen, X.W.; Toha, H.R. The Prevalence and Work-Related Factors of Burnout Among Public Health Workforce During the COVID-19 Pandemic. *J. Occup. Environ. Med.* **2022**, *64*, e20-e27, doi:10.1097/JOM.0000000000002428.
32. Zempel, D.J.; Kulik, P.K.G.; Leider, J.P.; Power, L.E. Public Health Workforce Development During and Beyond the COVID-19 Pandemic: Findings From a Qualitative Training Needs Assessment. *J. Public Health Manag. Pract.* **2022**, *28*, S263-S270, doi:10.1097/PHH.0000000000001524.
33. Jackson Preston, P. We must practice what we preach: a framework to promote well-being and sustainable performance in the public health workforce in the United States. *J. Public Health Policy* **2022**, *43*, 140–148, doi:10.1057/s41271-021-00335-5.
34. Kintziger, K.W.; Stone, K.W.; Jagger, M.A.; Horney, J.A. The impact of the COVID-19 response on the provision of other public health services in the U.S.: A cross sectional study. *PLoS One* **2021**, *16*, e0255844, doi:10.1371/journal.pone.0255844.
35. Halverson, P.K.; Yeager, V.A.; Menachemi, N.; Fraser, M.R.; Freeman, L.T. Public Health Officials and COVID-19: Leadership, Politics, and the Pandemic. *J. Public Health Manag. Pract.* **2021**, *27 Suppl 1*, COVID-19 and Public Health: Looking Back, Moving Forward, S11-S13, doi:10.1097/PHH.0000000000001281.
36. Galea, S.; Vaughan, R. Preparing the Public Health Workforce for the Post-COVID-19 Era. *Am. J. Public Health* **2021**, *111*, 350–352, doi:10.2105/AJPH.2020.306110.
37. Treviño-Reyna, G.; Czabanowska, K.; Haque, S.; Plepys, C.M.; Magaña, L.; Middleton, J. Employment outcomes and job satisfaction of international public health professionals: What lessons for public health and COVID-19 pandemic preparedness? Employment outcomes of public health graduates. *Int. J. Health Plann. Manage.* **2021**, *36*, 124–150, doi:10.1002/hpm.3140.
38. Yeager, V.A.; Balio, C.P.; Chudgar, R.B.; Hare Bork, R.; Beitsch, L.M. Estimating Public Health Workforce Efforts Toward Foundational Public Health Services. *J. Public Health Manag. Pract.* **2022**, *28*, 393–398, doi:10.1097/PHH.0000000000001452.
39. Eisenhauer, M.; Crupi, L.; Ray, R.; Mann, T. Tapping into the minds and hearts of the local public health workforce during the COVID-19 pandemic. *Can. J. Public Health* **2022**, doi:10.17269/s41997-022-00664-2.
40. Entschew, E.M. Acceleration through Digital Communication: Theorizing on a Perceived Lack of Time. *Humanist Manag J* **2021**, *6*, 273–287, doi:10.1007/s41463-020-00103-9.
41. Yang, L.; Holtz, D.; Jaffe, S.; Suri, S.; Sinha, S.; Weston, J.; Joyce, C.; Shah, N.; Sherman, K.; Hecht, B.; et al. The effects of remote work on collaboration among information workers. *Nat. Hum. Behav.* **2022**, *6*, 43–54, doi:10.1038/s41562-021-01196-4.
42. Lee, P.S.N.; Leung, L.; Lo, V.; Xiong, C.; Wu, T. Internet Communication Versus Face-to-face Interaction in Quality of Life. *Soc Indic Res* **2011**, *100*, 375–389, doi:10.1007/s11205-010-9618-3.
43. Shyr, Y.; Berry, L.D.; Hsu, C.-Y. Scientific Rigor in the Age of COVID-19. *JAMA Oncol.* **2021**, *7*, 171–172, doi:10.1001/jamaoncol.2020.6639.
44. Spec, A.; Schwartz, I.S. Balancing Scientific Rigor With Urgency in the Coronavirus Disease 2019 Pandemic. *Open Forum Infect. Dis.* **2020**, *7*, ofaa304, doi:10.1093/ofid/ofaa304.
45. Levine, R.L.; Rathmell, W.K. COVID-19 impact on early career investigators: a call for action. *Nat. Rev. Cancer* **2020**, *20*, 357–358, doi:10.1038/s41568-020-0279-5.