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GESUNDHEITLICHE UNGLEICHHEITEN IN DER COVID-19-PANDEMIE: DER ZUSAMMENHANG ZWISCHEN SOZIOÖKONOMISCHEM STATUS UND COVID-19-INFEKTIONEN UND -ERGEBNISSEN

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Die Hilfe bei der Dissertation wurde auf folgende Weise geleistet: HP hat zusammen mit ID das Studienscreening und die Qualitätsbewertung des systematischen Reviews und der Meta-Analyse im Vier-Augen-Prinzip durchgeführt. Bei Meinungsverschiedenheiten wurde TP konsultiert, um einen Kompromiss zu erarbeiten. HPf und UM fungierten als Supervisoren.
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Inhaltsverzeichnis

Abbildungsverzeichnis

Verzeichnis der Tabellen

Abkürzungsverzeichnis

ADI	Gebiet-Deprivationsindex
CVD	Herz-Kreislauf-Erkrankungen
COPD	Chronisch-obstruktive Lungenerkrankung
CI	Konfidenzintervall
COVID-19	Coronavirus-Krankheit 2019
FCoD	Fundamentale Krankheitsursachen
HR	Hazard Ratio
ICU	Intensivpflegestation
IMD	Index der Mehrfachbenachteiligung
MeSH	Medizinische Fachgebiet-Überschriften
OR	Odds Ratio
PRISMA	Bevorzugte Berichtspunkte für systematische Übersichten und Meta-Analysen
RR	Risk Ratio
SARS-CoV-2	Schweres Akutes Respiratorisches Syndrom Coronavirus Typ 2
SDoH	Soziale Determinanten der Gesundheit
SES	Sozioökonomischer Status
SEP	Sozioökonomische Position
SVI	Index der sozialen Verwundbarkeit
TDI	Townsends Deprivationsindex
WHO	Weltgesundheitsorganisation

1 ZUSAMMENFASSUNG

Diese Dissertation untersucht die Rolle sozioökonomischer Faktoren und sozialer Entbehrung (Deprivation) im Verlauf der COVID-19-Pandemie, mit besonderem Fokus auf gesundheitliche Ungleichheiten. Ziel der Arbeit ist es, die Zusammenhänge zwischen dem sozioökonomischen Status (SES) und COVID-19-Infektionsraten sowie der Schwere des Krankheitsverlaufs zu erforschen und zu analysieren, wie Deprivation als spezifischer Indikator für sozioökonomische Benachteiligung das Risiko für schwerwiegende COVID-19-Verläufe beeinflusst.

Im Mittelpunkt dieser Untersuchung stehen zwei zentrale Forschungsfragen: (1) Inwieweit lässt sich ein Zusammenhang zwischen SES und COVID-19 hinsichtlich Schweregrad und Infektionsraten feststellen? (2) In welchem Maße beeinflusst Deprivation als SES-Indikator negative COVID-19-Verläufe wie Hospitalisierungen, Intensivpflege und Todesfälle, und welche Mediatoren dieser Beziehung werden in der aktuellen Literatur identifiziert? Zur Beantwortung dieser Fragen stützt sich die Dissertation auf eine narrative Überprüfung und eine systematische Review mit Meta-Analyse. Die Analyse ist in mehrere Kapitel unterteilt, beginnend mit einer theoretischen Betrachtung der sozialen Determinanten und ihrer Auswirkungen auf Gesundheit. Der empirische Teil folgt, in dem Studienergebnisse zum Zusammenhang zwischen sozialen Faktoren und COVID-19 ausgewertet und kritisch diskutiert werden.

Das theoretische Rahmenmodell dieser Dissertation basiert auf etablierten Modellen der sozialen Determinanten von Gesundheit (Social Determinants of Health, SDoH) sowie der Theorie der fundamentalen Krankheitsursachen (Fundamental Causes of Disease, FCoD). Die SDoH-Theorie verdeutlicht, wie äußere soziale und wirtschaftliche Einflüsse, darunter Einkommen, Bildungsstand und Wohnverhältnisse, das individuelle Risiko und die gesundheitlichen Chancen prägen. Menschen in sozioökonomisch benachteiligten Positionen haben oft schlechtere Zugänge zu Gesundheitsressourcen, ein höheres Vorkommen von gesundheitlichen Belastungen und damit ein erhöhtes Krankheitsrisiko. Die Theorie der fundamentalen Krankheitsursachen ergänzt diesen Ansatz und zeigt auf, dass grundlegende soziale und wirtschaftliche

Ungleichheiten die Ursachen für Gesundheitsunterschiede darstellen und durch die V erlagerung auf unmittelbare Gesundheitsrisiken, wie z.B. individuelle Verhaltensweisen, häufig verdeckt bleiben.

Deprivation wird in dieser Arbeit als ein mehrdimensionales Maß für sozioökonomische Benachteiligung verstanden, das neben materiellen Ressourcen auch soziale und umweltbedingte Einflüsse berücksichtigt. Daher unterscheidet sich der Begriff von SES, da er eine umfassendere Dimension sozialer Benachteiligung beschreibt, die über die finanziellen Aspekte hinausgeht und verschiedene Lebensbedingungen miteinbezieht. Der SES umfasst oft Einkommen, Bildungsgrad und beruflichen Status, während Deprivation zusätzliche Faktoren wie Wohnumgebung und Zugang zu sozialen Dienstleistungen einschließt. Diese differenzierte Betrachtung von SES und Deprivation wird in der Dissertation durchweg berücksichtigt und präzise voneinander abgegrenzt.

Die narrative Überprüfung dieser Dissertation analysiert Studien, die den Zusammenhang zwischen SES und COVID-19-Mortalität bzw. -Infektionsraten beleuchten, um erste Erkenntnisse zu gewinnen. Die systematische Review und Meta-Analyse hingegen verwendet gezielt Studien, die Deprivations-Indizes nutzen, um die Beziehung zwischen sozialer Benachteiligung und negativen COVID-19-V erläufen detailliert zu untersuchen. Diese methodische Zweiteilung ermöglicht es, sowohl frühe Erkenntnisse zum allgemeinen Zusammenhang von SES und COVID-19 zu betrachten als auch eine fundierte Analyse der spezifischen Auswirkungen von Deprivation zu liefern.

Die empirischen Ergebnisse der Dissertation stützen die Hypothese, dass ein niedriger SES und eine hohe Deprivation das Infektionsrisiko und den Verlauf von COVID-19 erheblich negativ beeinflussen. Besonders hervorzuheben sind gesundheitliche Risikofaktoren, die häufig in sozial benachteiligten Bevölkerungsgruppen vorkommen und die Anfälligkeit für schwere Krankheitsverläufe verstärken. Komorbiditäten wie Diabetes, Bluthochdruck und Adipositas, die stark mit einem niedrigen SES korrelieren, tragen dazu bei, dass die betroffenen Personen ein erhöhtes Risiko für schwere COVID-19-Verläufe haben. Die Analyse zeigt auch, dass Menschen mit niedrigem SES häufig in Berufen tätig sind, die ein höheres Infektionsrisiko mit sich bringen, oder in beengten Wohnverhältnissen leben, was die Ausbreitung von SARS-CoV- 2 zusätzlich begünstigt.

Zusammenfassend lässt sich feststellen, dass sozioökonomische Benachteiligungen signifikante Auswirkungen auf die COVID-19-Verläufe haben. Die Arbeit unterstreicht die Bedeutung einer gezielten, sozial gerechten Gesundheitspolitik, die darauf abzielt, soziale Ungleichheiten zu verringern und besonders benachteiligte Bevölkerungsgruppen besser zu schützen. Die Dissertation plädiert dafür, soziale Gesundheitsdeterminanten stärker in die Pandemievorsorge zu integrieren und auf eine gerechtere Verteilung von Gesundheitsressourcen hinzuwirken, um die gesundheitliche Versorgung in Krisenzeiten zu optimieren.

2 INTRODUCTION

The coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus type 2 (SARS-CoV-2) (1), originated in Wuhan, China (2). The virus rapidly escalated into a global pandemic, resulting in over 650 million confirmed infections and 6.6 million deaths worldwide until the end of the reporting period of this dissertation in December 2022 (3).

The challenges presented by COVID-19 are multifaceted, with the disease's transmission through aerosols (4) and its wide variability in severity—ranging from asymptomatic cases to respiratory failure and death (5, 6)—posing significant public health concerns. At the onset of the pandemic, it became evident that the severity of COVID-19 could vary drastically, with the proportion of cases progressing to severe illness ranging widely from as low as 0.1% to over 25% (7).

Early in the pandemic, media and political narratives often suggested that "the virus does not discriminate" (8) and that it was "uniting countries in shared experience" (9). However, emerging research quickly challenged these assertions, revealing that socioeconomically disadvantaged individuals were disproportionately affected, facing higher risks of both contracting SARS-CoV-2 and experiencing fatal outcomes from COVID-19 (10).

Two primary categories of risk factors are associated with COVID-19 mortality. The first includes constitutional factors, such as advanced age, male gender, and hereditary diseases, which have been identified as common among those who succumb to the virus (11). The second category consists of "lifestyle" diseases, such as chronic obstructive pulmonary disease (COPD), type 2 diabetes mellitus, and high blood pressure, which also predict poorer outcomes (12). These lifestyle diseases are strongly correlated with low socioeconomic status (SES) (13-15), suggesting a gradient in COVID-19 mortality across different social strata.

The relationship between social inequality and health is well-established (16). Health inequality refers to systematic differences in health outcomes and access to health opportunities among people occupying unequal positions within society (17). Historical precedents, such as the Spanish flu of 1918 (18) and the H1N1 pandemic of 2009 (19), demonstrate that vulnerable groups often bear a disproportionate burden during pandemics. This underscores the importance of identifying these populations and understanding how SES influences COVID-19 outcomes. Furthermore, higher infection rates in socioeconomically disadvantaged areas can exacerbate the spread of the virus, making the identification of these hotspots crucial for controlling the pandemic (20).

SES is typically measured using indicators such as education, occupation, and income. However, a more nuanced understanding of people's living conditions and social positions can be achieved through the use of multivariate indices, such as deprivation scores. These scores reliably reflect socioeconomic disparities by encompassing various life domains, including employment, health status, crime, and access to local services (21). Despite the growing body of research, there remains a scarcity of systematic reviews and meta-analyses that rigorously examine the relationship between SES and COVID-19 outcomes. Identifying the specific aspects of deprivation that exacerbate health risks is essential for designing targeted health and social interventions, such as educational campaigns and risk reduction strategies.

This dissertation aims to investigate the influence of SES on SARS-CoV-2 infection risks and various COVID-19 outcomes, with a particular focus on the nuanced association between deprivation and adverse outcomes. To guide this investigation, two key research questions were formulated:

1) To what extent is there an association between SES and COVID-19
    A) with regard to disease severity (Q1A)?
    B) with regard to infection rates (Q1B)?
2) To what extent is there a relationship between deprivation as an indicator of SES and adverse COVID-19 outcomes (hospitalization, intensive care admission, death), and what mediators of this relationship are identified in the literature?

The dissertation is structured into three main sections. It begins with a theoretical exploration of the determinants of SES and health inequalities, followed by empirical analyses using current research literature. Central to this analysis is Figure 5, which outlines the logical framework of the study. The second section presents a narrative review of the relationship between social inequalities and variations in disease severity and infection rates, using articles sourced from online platforms between January and November 2020. The third section delves into a systematic review and meta-analysis of the parameters of social disadvantage in relation to COVID-19 outcomes, exploring whether studies account for mediating factors that could inform policy interventions.

The findings align with social science theories on health inequalities, particularly the Social Determinants of Health (SDoH) theory (22) and the Fundamental Causes of Disease (FCoD) theory (23). These theories suggest that underlying social mechanisms contribute to the unequal health status observed in disadvantaged groups. This dissertation also examines unexpected findings, such as the initial peak in infection rates among higher SES groups, offering explanations based on a complex interplay of determinants.

In conclusion, this dissertation highlights the critical relationship between low SES and increased vulnerability to COVID-19, emphasizing the role of deprivation as a significant health risk that must be addressed in pandemic preparedness efforts. It advocates for more nuanced and individualized data collection, a comprehensive understanding of health inequalities, and the identification of intermediaries for targeted public health interventions.

2.1 Theoretical Framework

2.1.1 Historical Background

Examinations of previous communicable diseases have reported health disparities during pan- and epidemics (10). Analysis of the 1918 Spanish influenza showed a relationship between the occurrence of the disease and people's economic status. In their landmark study, Sydenstricker et al. conducted a survey across urban and rural areas of Maryland and observed that lower socioeconomic groups consistently exhibited higher rates of infection and mortality. Importantly, this pattern held true even when controlling for other factors such as ethnicity, sex, and age. As Sydenstricker described, "When the morbidity rate at different ages is compared for persons classified as 'well-to-do' and in 'moderate' circumstances and for persons classified as 'poor' and 'very poor,' it is seen that the higher incidence among members of the poorer households prevailed at all ages". In terms of mortality rate, it was found to be the same in the highest classes, over 33% higher in the class designated as 'poor', and almost three times higher in those classified as 'very poor'" (18).

Mamelund (2006) extended this analysis in his study of Kristiania, Norway, during the Spanish flu. In an examination of individual- and household-level data he described that living in a dwelling with four or more people or living in a designated "poverty area" significantly explained higher mortality. The socioeconomic status was found to be the most important factor explaining "nearly 50% of the variance in pandemic mortality [...]" (24).

These historical findings were mirrored in the more recent 2009 H1N1 pandemic. Lowcock et al. (2012) conducted interviews during two phases of the outbreak in Ontario, Canada. They noted that those with only high school education were more likely to be non-hospitalized, while residents from socioeconomically disadvantaged neighborhoods faced higher hospitalization rates. Additionally, unemployment became an even stronger predictor of hospitalization as the pandemic progressed, highlighting the consistent role of socioeconomic factors in determining health outcomes (19).

2.1.2 Social Inequality and Health

2.1.2.1 Social Position and Social Status

Pierre Bourdieu conceptualizes social position as the first dimension of social space within the structure of society. By visualizing the relationships between individuals as elements within a social space, Bourdieu allows for the theoretical juxtaposition and superimposition of these relationships. According to Bourdieu, a person's social position is shaped by their access to limited resources, which he refers to as capital. He identifies three key elements that determine social position: the volume of capital, the structure of capital, and a temporal element he calls the "social career." These factors act as independent determinants of an individual's place within social space, while the overarching structure of society imposes constraints that shape social reality (25).

Bourdieu distinguishes between four subtypes of capital: economic capital, which can be directly converted into money; cultural capital, which encompasses education, cultural assets, and qualifications; social capital, which is derived from group membership and relationships; and symbolic capital, which corresponds to prestige or status, generated by the other types of capital. Symbolic capital exists in the realm of societal perception and valuation. These forms of capital are not only convertible into one another but also collectively contribute to social mobility and an individual's position within social space. However, Bourdieu emphasizes that it is not merely the accumulation of different types of capital that determines social position, but rather the relationship and interplay among them.

Bourdieu’s framework is relevant to the core theme of this dissertation—health inequalities. Social position, shaped by access to economic, cultural, and social resources, is both a determinant and outcome of health. A person’s social position strongly influences their access to the resources necessary for maintaining good health and obtaining healthcare (26). Thus, social inequalities directly translate into health inequalities, as access to resources plays a crucial role in determining life conditions and health opportunities.

The concepts of social position and social status, while closely related, differ in significant ways. According to the *Dictionary of Sociology*, social position refers to a person’s location within a particular structure of the social system, whereas social status pertains to the value assigned to that position. In Talcott Parsons' structural functionalism, it is assumed that societies, particularly those with a division of labor, assign the most critical social positions to the most qualified individuals. These "most important" positions are those essential for the functioning and survival of society, and as such, they are highly rewarded to incentivize individuals to take on key responsibilities (27).

Over time, the criteria for determining the 'most important' roles in society have evolved. While traditionally, such roles were defined by their necessity for societal survival—such as those in healthcare, education, and public safety—there has been a growing emphasis on positions associated with financial power and economic influence. This shift reflects changes in societal and economic priorities, where the accumulation of capital and financial success often takes precedence over public service. These changes have implications for the organization of social structures and the distribution of resources, which may influence the functioning of society and the valuation of various occupational roles.

The COVID-19 pandemic has highlighted two important phenomena: first, that roles deemed 'systemically important'—such as those in healthcare, logistics, and education—are critical to the functioning of society. Second, it has revealed a disparity between the societal value of these roles and their financial compensation. Despite their essential nature, many of these positions do not receive the highest levels of remuneration, indicating a potential misalignment between the value attributed to certain jobs and their rewards in terms of income and status.

Social status, which is typically measured through indicators such as education, occupational status, and income (26), is closely tied to power and influence within society. Higher-earning individuals or those in prestigious positions tend to have greater access to resources, decision-making power, and social networks, further reinforcing their social standing. This relationship between income, status, and power contributes to the vertical differentiation in social structures, where individuals are positioned hierarchically based on their economic and social capital. These dynamics are fundamental to understanding social inequality, as the occupation of a social position directly influences an individual’s relative standing within the broader social hierarchy, ultimately perpetuating social inequality.

The concept of social status directly contributes to the broader issue of social inequality, as different statuses create stratifications within society. This leads us to explore how inequality manifests both in the distribution of resources and in access to opportunities across different social classes.

2.1.2.2 Social Inequality and Social Class

Social inequality arises when differences in access to resources and opportunities result in unequal living conditions for certain groups. These inequalities manifest when some individuals have greater access to valuable resources, such as education, income, or health, allowing them better opportunities to succeed and improve their quality of life (28).

There are two primary types of social inequality: distributive inequality, which refers to the unequal distribution of resources like money, education, or health, and opportunity inequality, which pertains to unequal chances of attaining these resources. Additionally, social inequality can be analyzed across several dimensions, including education level, job security, occupational status, income, and occupational prestige. These dimensions reflect the relative positions of individuals within society.

Mielck (2005) further distinguishes between horizontal and vertical inequalities. Horizontal inequalities are differences between social groups—based on factors like age, gender, marital status, or nationality—without implying hierarchical superiority. However, these differences can still influence life outcomes. For example, historical and ongoing disparities exist among ethnic groups despite the horizontal nature of these distinctions (26).

In contrast, vertical inequalities create hierarchies within society, dividing individuals into higher and lower positions based on factors such as educational attainment, occupation, and income. People with similar levels of these factors are often grouped into what is commonly referred to as a social class. Although recent theories have critiqued the term "social class" as being too simplistic (25), income remains a key indicator for understanding economic class and its role in social inequality.

Membership in a particular social class significantly influences a person's life chances, including their health. Individuals in higher social classes generally experience better health, longer life expectancy, and greater access to social networks and opportunities. In contrast, those in lower social classes often face restricted opportunities, which not only limits their economic outcomes but also negatively impacts their overall well-being and life satisfaction (29).

2.1.2.3 Poverty

When discussing poverty, the focus often lies on financial poverty, which is the most commonly recognized form. Poverty, in general, is defined as a state in which individuals lack sufficient resources to maintain a minimum standard of living, including basic needs such as food, shelter, and healthcare (30). However, poverty encompasses more than just financial deprivation; it also includes social and material aspects that influence one's quality of life.

Financial poverty is a central aspect of vertical social inequality and can be measured using various indicators. Atkinson et al. (2002), in their work *"Social Indicators: The EU and Social Inclusion,"* describe income levels as useful tools to "provide a measure of the degree to which people face the risk of serious deprivation in terms of their standard of living or to which they fall below a specified minimum level of resources." However, they emphasize that to fully understand the severity of poverty, additional indicators—such as measures of deprivation—are necessary to capture the depth and complexity of poverty (31).

While financial poverty is a common metric for assessing social inequality, it has limitations. Peter Townsend, one of the leading researchers on inequality, argues that the definition of poverty must be closely tied to deprivation (32). Townsend conceptualizes poverty as the lack of command over limited resources, acknowledging that while there are universal needs, their specific expression varies across different societies. According to Townsend, poverty can only be meaningfully measured within the context of the society in which a person or group lives. He suggests two essential steps for objectifying poverty measurement: first, assessing all unequally distributed resources, and second, evaluating the lifestyle of the society. While the first approach involves significant effort, the second opens the door to subjective judgments.

Townsend defines poverty as follows: "Poverty can be defined objectively and applied consistently only in terms of the concept of relative deprivation. […] The term is understood objectively rather than subjectively. Individuals, families, and groups in the population can be said to be in poverty when they lack the resources to obtain the types of diet, participate in the activities and have the living conditions and amenities which are customary, or at least widely encouraged or approved, in the society to which they belong. Their resources are so seriously below those commanded by the average individual or family that they are, in effect, excluded from ordinary living patterns, customs and activities" (32).

2.1.2.4 Deprivation

The OECD Development Assistance Committee confirms that poverty is about various forms of deprivation related to the inability to meet basic human needs. Particularly affected are nutrition, health, education, rights, participation, security, dignity and work (33).

Peter Townsend (2009) defines deprivation as "a state of observable and demonstrable disadvantage relative to the local community or the wider society or nation to which an individual, family, or group belongs." He explains that the term has shifted from focusing solely on the lack of resources to encompassing broader physical, environmental, and social conditions.

Deprivation, in this context, includes the "inability to fulfill expectations" and the "failure to participate in customary family or community activities." Unlike poverty, which typically addresses a general lack of resources, deprivation refers to specific circumstances and distinguishes between actual needs and socially perceived needs. Townsend identifies three forms of deprivation: (a) objective deprivation, (b) normative deprivation, and (c) individual subjective or group deprivation (34).

Townsend further categorizes deprivation into material deprivation (e.g., food, clothing, shelter) and social deprivation (e.g., recreation, education, the right to work). These forms of deprivation can coexist or occur separately, making deprivation a complex phenomenon to observe. He suggests that material deprivation can be objectively measured by assessing a person's ability to participate in the general standard of living. The further a person is from participating in this standard, the greater their degree of deprivation.

In addition to material and social deprivation, other dimensions of deprivation are recognized in the literature. Economic deprivation refers to the lack of financial resources, such as income or employment, which directly impacts a person's ability to access material needs like housing or healthcare. It is closely related to material deprivation but emphasizes the financial aspect of resource access.

Environmental deprivation involves poor or hazardous living conditions, such as exposure to pollution, lack of green spaces, or inadequate infrastructure. Individuals living in deprived environments may face increased health risks due to poor air quality, unsafe water, or overcrowded housing.

Each of these forms of deprivation can interact and reinforce one another, contributing to overall vulnerability. For example, economic deprivation can exacerbate material deprivation, as lack of income limits access to essential goods and services. Likewise, environmental deprivation can intensify social and material deprivation, as individuals in poorer areas may have reduced access to education, healthcare, and safe living conditions. This interrelation highlights the complexity of deprivation as a multidimensional issue, affecting various aspects of life and well-being.

The Indices of Multiple Deprivation (IMD) illustrate how deprivation can be measured across various domains, each reflecting a different facet of societal participation and well-being. These domains, which include income, employment, education, health, crime, housing and services, and the living environment, are combined to provide a comprehensive assessment of deprivation. Each domain assesses multiple components; for example, 'Barriers to Housing and Services' considers factors such as overcrowding, homelessness, housing affordability, and accessibility to essential amenities (35).

Although industrialized countries are generally associated with higher standards of living, significant forms of deprivation persist within them. In particular, health inequalities remain a notable issue, even in affluent societies, despite limited research on the topic (36). In this dissertation, deprivation is used as a core concept to understand poverty and social disadvantage, as health inequalities are also relative in nature and can be measured in wealthier societies.

This research will explore the extent to which the COVID-19 pandemic interacts with social exclusion in affluent contexts.

2.1.2.5 Socioeconomic Status

Socioeconomic status (SES) is a multifaceted measure that encompasses an individual's or family's economic and social position relative to others, based on income, education, and occupation (37, 38). Education influences SES by impacting job opportunities and earnings potential, where higher educational attainment correlates with higher income and occupational prestige. Occupational status, assessed by job roles and income levels, reflects the educational requirements and skills necessary for various positions. Wealth, another key component, includes all financial assets and earnings, influencing the ability to access resources and participate in society fully (39).

SES profoundly affects health outcomes, with higher SES often linked to better access to healthcare, healthier living conditions, and reduced risk of stress-related illnesses. The disparities in SES can lead to significant health inequities, where lower SES is associated with increased exposure to environmental hazards, poorer health behaviors, and less access to effective healthcare. This multifaceted perspective on SES highlights its importance in public health research and policymaking, underscoring the need to address socioeconomic disparities to improve health outcomes across populations.

2.1.2.6 Health Inequalities

Research extensively documents the relationship between social inequality and health, revealing that disparities in health often stem from an individual's social status (16, 23, 40, 41). Health inequalities, also referred to as health inequities, detail these disparities by analyzing the associations, causal chains, and directionality between social conditions and health outcomes.

The term "health inequity" implies a judgment of unfairness, whereas "health inequality" is a neutral descriptor used to outline differences in health across various demographic groups without implying injustice (26).

The World Health Organization (WHO) states, "*Equity* is the absence of avoidable or remediable differences among groups of people, whether those groups are defined socially, economically, demographically, or geographically. Health *inequities*, therefore, involve more than [*health*] *inequality* with respect to health determinants, access to the resources needed to improve and maintain health or health outcomes" (42). Thus, health inequalities highlight structural differences in health status among societal groups, emphasizing that such discrepancies are systematically linked to social determinants of health and are preventable (43). This chapter uses the term "health inequalities" to maintain neutrality in medical sociological findings, while acknowledging the underlying social adversities that drive these disparities.

2.1.2.7 Social Determinants of Health

The World Health Organization defines Social Determinants of Health as "[...] the conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life (44)" and the "fundamental drivers of these conditions" (45). Marmot et al (2007), who developed this concept, described the major pathways in the causal chain from social structure to well-being, morbidity, or mortality as seen in Figure 1. Material factors such as work and social environment operate at both the individual and population levels and contribute directly or indirectly to health outcomes. Factors that have an invariant effect on people's lives include early life experiences, genetic characteristics, and cultural factors.

Figure 2 shows a similar relationship, but in a more abstract and discrete form. SDoH project at three to four levels. The immediate factors that contribute to health outcomes are referred to as upstream determinants, followed by middle and downstream determinants. The analogy to a river is meant to express that the factors of interaction between society and the individual have a directional relationship. Moreover, these factors are causally interdependent, i.e., what happens upstream has consequences further downstream (45). Examples of upstream determinants include social structural phenomena such as working conditions that depend on the labor market, discrimination that is often related to education, and social policies that are reflected in the benefit system. Intermediate determinants include aspects such as socioeconomic position (SEP), gender, ethnicity, and sexuality, which are related to educational attainment, employment status, or living conditions. Downstream determinants include medical endpoints such as heart disease, obesity, or cancer, which may be influenced by behavior and environment (46).

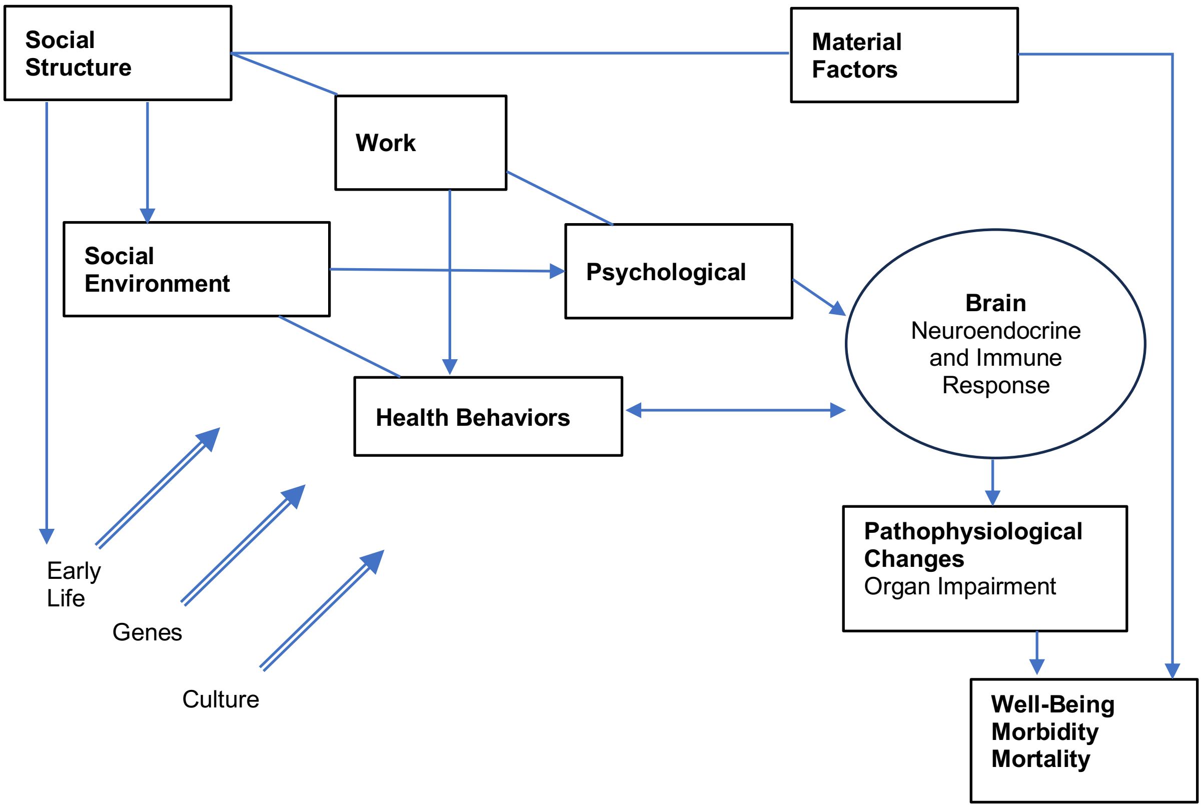

Figure 1: Links Between Social Structure and Health
Based on: *Scoping Paper: Priority Public Health Conditions 2007* (45)

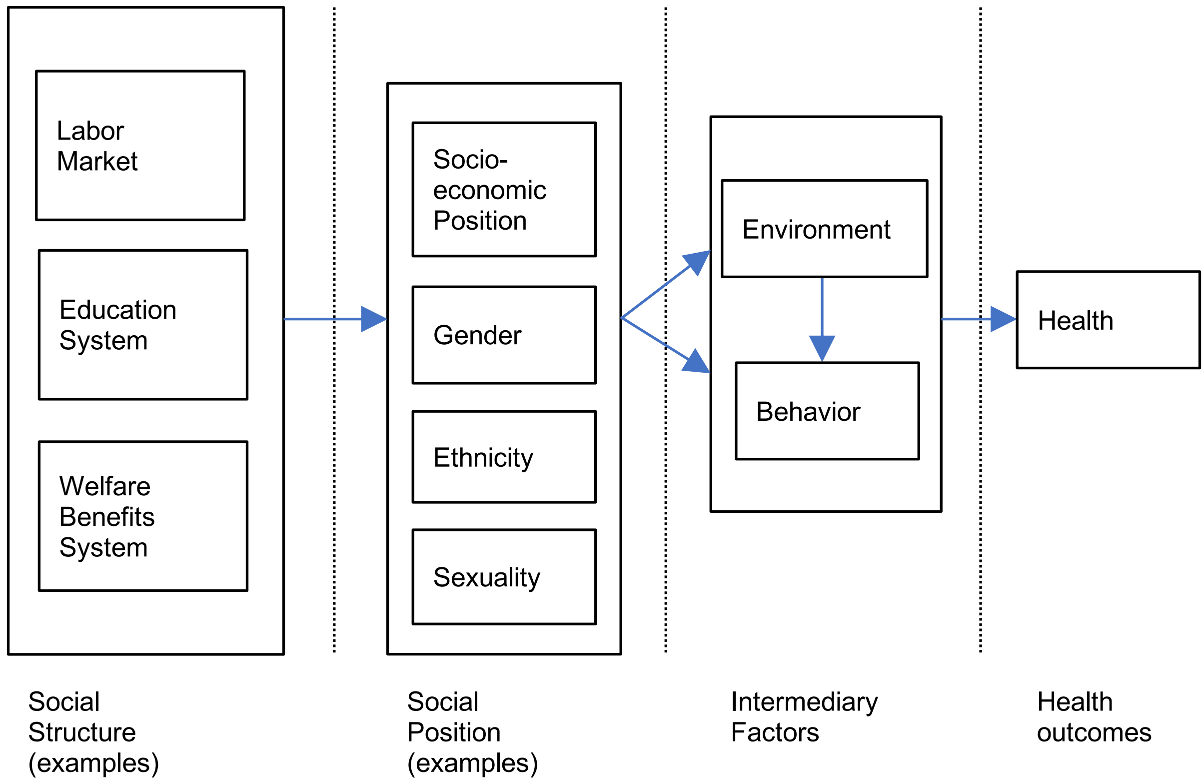

Figure 2: Social Determinants of Health
Based on: *Unequal Lives* (47)

2.1.2.8 Fundamental Causes of Disease

Marmot et al. (2007) highlighted the link between an individual's social structure and health status, examining how layered social status is connected to health inequalities. According to this view, disparities in health reflect and are driven by social and economic inequalities within society (43). Earlier, Link and Phelan (1995) introduced the theory of Fundamental Causes of Disease, which identifies enduring, underlying determinants that persist even as disease patterns evolve. They argued that efforts to reduce health inequalities are often too narrowly focused on immediate risk factors—such as lifestyle choices—without addressing the broader social drivers, like economic and environmental conditions, that shape these behaviors (23). Marmot and Allan (2014) refer to such phenomena as lifestyle drift, which "describes the tendency of public health to focus on individual behaviours, such as smoking [...] but ignore the drivers of these behaviours".

For instance, addressing obesity by reducing stomach size through surgical means does not tackle the broader, systemic issues such as the deregulated food market that predominantly offers high-calorie options. This approach targets an immediate physical manifestation rather than the underlying social and economic drivers of dietary habits. Effective public health strategies should consider the environmental and policy contexts that shape individual behaviors, thus addressing the fundamental causes rather than the symptoms of diseases. Referring to Figure 1 again, such immediate risk factors are too far downstream in the causal chain to address the underlying causes. The risk factors mediate the link between social status and health. Because of inadequate health policies and prevention, these risk factors change, but the link remains, and the root cause will not change (48).

Conversely, health-promoting factors that operate at a fundamental level safeguard against illness, even if new risk factors appear or life circumstances change. Therefore, these health-promoting factors are called "*flexible resources*". Flexible resources can be viewed as protective social factors that increase resilience. The reason for the superior position of people in higher social positions is better access to such resources. Resources may be money, knowledge, or health care. Underlying social causes of disease influence access to these resources, resulting not only in unequal health status but also in unequal health opportunities (43).

According to Graham (2007), author of *Unequal Lives*, access to resources is unequally distributed. For example, advantaged positions have the most resources and are best able to avoid the risks and consequences of disease. She describes the socioeconomic position as one of the Fundamental Causes of Disease because it includes four essential characteristics. First, they affect multiple disease outcomes; second, they affect these outcomes mediated through multiple risk factors; third, they affect access to or deprivation of health resources; and fourth, the association between fundamental cause and health is reproduced through another risk factor (47, 49).

2.1.2.9 Allostatic Load

Wilkinson and Pickett (2017) developed an alternative explanation for the association between social status and illness. According to them, psychosocial stress mediates this relationship. However, what these theories have in common is that the underlying determinant of health inequality is inequality of social position. A recent study by Palmer et al. (2019) attempt to explain why socially disadvantaged people suffer disproportionately from disease and "how social stress 'gets under the skin'". In this study, dysregulations of physiological systems, epigenetic changes, the metabolome and microbiome, and the immune and inflammatory response are used as objects for "plausible physiological explanations of how the body responds to chronic stress created by the [SDoH]" (50, 51).

To describe these effects, McEwen and Stellar (1993) formulated the relationship between stress and the processes leading to disease in their study, “Stress and the Individual Mechanisms Leading to Disease”. Their research led to the development of the concept of allostatic load. Allostatic load is an indicator of individual habits as well as lifelong patterns of behavior that are reflected in it. Physiological examples of allostatic load are an increase in heart rate and blood pressure during physical activity or an increased activity of the immune system during infections (52).

Schulz et al. (2005) on "The importance of chronic stress and social support for the development of physical illnesses" states, that "the same mediators can also harm the body if they are secreted too often, for too long, or too heavily. As a result, the regulatory adjustment turns into allostatic load over time. In the event of inadequate or excessive activation, the stress mediators also cause pathophysiological changes in the cardiovascular system, in glucose and lipid metabolism, in the immune and nervous systems (‘secondary outcome’)" (53).

2.1.2.10 Intersectionality

Socioeconomic status is not the only fundamental cause of disease. Other aspects of identity and social position also have an impact on health. Inequalities in these areas can therefore also cause an unequal distribution of health. Phelan & Link (1995) have already described contextualizing individual risk factors for disease to understand why people are exposed to them and the process that leads to them. This concept reveals that even if certain conditions, such as a sudden increase in wealth, might alleviate some stressors, they do not necessarily change the underlying contexts that contribute to health issues. For example, a low SES person with endogenous depression who inherits a large amount of money now has no financial problems contributing to the illness. However, the context in which the depression arose may not change. The concept of intersectionality is an analytical tool to examine the larger relationships between such frameworks (23).

According to Collins & Bilge (2020), intersectionality can be defined as a concept for examining intersecting power structures that influence social relations in different societies. The categories of race, class, gender, etc. do not operate separately from each other but are interrelated and interdependent, as well as multiply the impact of each of these factors on the individual (54).

According to Hill (2015), research on health inequalities has predominantly focused on SES as a proxy for social inequality. She criticizes the view that SES is a sufficient indicator for disadvantaged populations to identify the causes of their health impairments and health opportunities. She argues for a more complex understanding of identity, social position, and inequality. There should also be a focus on structural and Fundamental Causes of Disease, which, as mentioned in Section 2.2.8, are more upstream factors. In addition to SES, ethnicity and gender are also important factors that affect people's lives and health. She describes intersectionality as the "relationships between different axes of social position and their relevance for health inequalities" (55). In particular, the factors that are "associated with experiences of exclusion or subordination" (56). It is critical to examine the "multiple layers of advantage and disadvantage relevant for health" and to combine vertical with horizontal features of the social position because many of these interact with each other (26).

2.1.3 COVID-19: Transmission, Epidemiology, and Risk Factors

2.1.3.1 General Information on SARS-CoV-2

SARS-CoV-2, identified early in 2020 as the causative agent of COVID-19, is a member of the Coronaviridae family, within the Betacoronavirus subgenus, Sarbecovirus. This virus group is known for its propensity to cross species barriers due to its ability for homologous recombination. SARS-CoV-2 is an enveloped, single-stranded RNA virus, with the largest genome among RNA viruses, encoding nonstructural proteins crucial for RNA replication and structural proteins like the spike (S), envelope (E), membrane (M), and nucleocapsid (N). The spike protein, critical for cell entry, binds to the ACE-2 receptor, predominantly expressed in the respiratory tract, facilitating viral entry via the TMPRSS2 protease. This mechanism explains the virus's effective replication in the upper respiratory system. Histopathological studies reveal the virus's affinity for multiple organs, underscoring its widespread impact across different bodily systems (57).

2.1.3.2 Transmission of COVID-19

The primary mode of SARS-CoV-2 transmission in general populations is through respiratory particles emitted during breathing, coughing, talking, singing, and sneezing. These particles range in size from larger droplets to smaller aerosols, with larger droplets typically falling to the ground quickly, while aerosols can remain airborne and circulate within enclosed spaces. The probability of transmission increases with proximity (within 1-2 meters) to an infected individual and is exacerbated by activities that increase aerosol production, such as shouting or singing. Masks significantly reduce transmission risk by blocking particles of various sizes. The likelihood of aerosol transmission is further heightened in poorly ventilated indoor environments where aerosol particles can accumulate and persist. Factors such as room size, ventilation, temperature, and humidity also play critical roles in the transmission dynamics of the virus (58).

2.1.3.3 Epidemiology of COVID-19

The information for this chapter comes from the Robert Koch Institute's epidemiological profile on COVID-19, which is a compilation of the latest research results (58).

SARS-CoV-2 has demonstrated significant variation through the emergence of distinct viral variants. These variants differ in terms of transmissibility, severity of illness, and, in some cases, the ability to evade immunity. Variants of concern, such as Alpha, Delta, and Omicron, have significantly influenced the spread of the virus and triggered various waves of the pandemic. While some variants are characterized by increased transmissibility and more severe disease, others show a reduced susceptibility to existing vaccines.

Transmission occurs through asymptomatic, pre-symptomatic, and symptomatic individuals, making the control of the pandemic particularly challenging. Asymptomatic and pre-symptomatic carriers can spread the virus before showing symptoms or without ever developing any, contributing to the rapid and global spread of SARS-CoV-2. Infectivity peaks around the time of symptom onset, complicating contact tracing and efforts to control transmission.

The reproduction number (R0) indicates how many people, on average, are infected by a single infected individual. For the original strain of SARS-CoV-2, the estimated R0 ranged from 2.5 to 3. Highly transmissible variants like Delta and Omicron have significantly increased the R0, leading to rapid outbreaks and the need for stricter measures to contain the virus's spread.

Demographic factors play a crucial role in the course of the disease. Older adults and individuals with underlying conditions such as diabetes, hypertension, and cardiovascular diseases are at higher risk of severe outcomes. Men are more likely to experience severe cases compared to women, resulting in higher mortality rates among men. Common symptoms include fever, cough, and difficulty breathing, though the severity of the illness can vary widely. Many individuals experience mild symptoms or remain asymptomatic, while others develop severe respiratory issues that can lead to death.

The case fatality rate, which refers to the ratio of deaths to confirmed cases, initially ranged between 2-3% globally. However, the infection fatality rate, which accounts for all infected individuals, including asymptomatic cases, is estimated to be lower as many mild or asymptomatic cases went undetected. Mortality is particularly high among older adults and those with pre-existing conditions, highlighting the importance of protective measures for these vulnerable groups.

Superspreading events have played a significant role in the epidemiology of COVID-19. These events involve a single person infecting a disproportionately large number of others. Gatherings such as religious events, weddings, or large company meetings have served as hotspots for virus transmission. Poorly ventilated indoor spaces or mass gatherings have significantly contributed to the global spread of the virus (58).

The combination of highly infectious variants, asymptomatic transmission, and superspreading events has made the containment of SARS-CoV-2 a complex global challenge.

2.1.3.4 Pathology of COVID-19

Also, this chapter is based upon information from the epidemiological profile of SARS-CoV-2 by the Robert-Koch Institute (58). COVID-19 presents with a wide spectrum of pathological features, influenced by factors such as age, comorbidities, and viral load. The incubation period, typically ranging between 2 and 14 days (median around 5 days), defines the time from exposure to the onset of symptoms. The serial interval, which is the time between successive cases in a transmission chain, averages around 4 to 5 days, underscoring the rapid spread potential of the virus.

The demographic factors significantly shape the pathology of COVID-19. Older individuals, particularly those over 65 years of age, and patients with underlying conditions such as cardiovascular diseases, diabetes, and chronic respiratory illnesses are at heightened risk for severe disease. Gender also plays a role, with men more frequently experiencing severe outcomes than women. The spectrum of symptoms varies from mild cases, characterized by fever, cough, and fatigue, to severe cases involving pneumonia, acute respiratory distress syndrome (ARDS), multi-organ failure, and death.

The disease often progresses in phases, with an initial viral replication phase followed by an inflammatory phase in more severe cases. Early manifestations typically include fever, dry cough, and fatigue, while more severe symptoms such as dyspnea and hypoxemia may develop later, around 7-10 days after the onset of symptoms. Severe complications can arise, including ARDS, septic shock, thromboembolic events, and acute kidney injury. In addition to respiratory complications, some patients experience gastrointestinal symptoms, neurological manifestations (such as loss of taste and smell), and cardiovascular complications.

COVID-19 is also associated with long-term complications in a subset of patients, commonly referred to as "long COVID" or post-acute sequelae of SARS-CoV-2 infection (PASC). These long-term effects can include persistent fatigue, cognitive dysfunction, respiratory issues, and cardiovascular problems. Even individuals who had mild or asymptomatic infections may experience prolonged symptoms that affect their quality of life.

The duration of infectivity (contagiousness) of SARS-CoV-2 varies based on disease severity. In mild cases, viral shedding may continue for about 10 days after symptom onset, while in severe cases, individuals may remain infectious for up to 20 days. Immunocompromised patients may shed the virus for even longer periods, extending the duration of their contagiousness.

In terms of treatment timelines, prompt identification and supportive care are critical to managing COVID-19. In patients with mild to moderate disease, early interventions focus on symptom management and preventing disease progression. For those with severe disease, treatments may involve oxygen therapy, mechanical ventilation, and corticosteroids to manage inflammation. The timing of interventions is crucial; delays in supportive care can lead to rapid deterioration, particularly in high-risk patients.

The identification of high-risk groups is central to managing COVID-19, as certain populations are more prone to severe outcomes. These groups include the elderly, individuals with underlying medical conditions, and those with compromised immune systems. Early recognition of symptoms and timely interventions are essential to improving outcomes in these vulnerable populations (58).

The pathology of COVID-19 is thus characterized by its variable clinical presentation, the significant impact of demographic factors, and the potential for long-term complications. Understanding the timelines of viral transmission, symptom progression, and treatment is crucial in effectively managing the disease and mitigating its impact on high-risk populations.

2.1.3.5 Risk Factors of a Severe Course of COVID-19

Abstracted from the social inequalities in those affected by COVID-19, there are also strictly medical aspects that create different susceptibility to the disease. Meta-studies and systematic reviews show that certain patients are significantly more likely to suffer from a severe course of the disease than others and are therefore predicted to have a poorer prognosis. Identifying risk factors for severe courses of COVID-19 enables three things: it initiates the social discussion to strive for a change in behavior, it helps clinicians to react more adequately to patient cases, and it insists on changes in health policy. This dissertation takes information from three systematic reviews and meta-analysis, to deduct consequences related to the issue of health inequalities in the COVID-19 pandemic.

In the analyzed population groups of Gold et al., comorbidities were substantially more common among fatal (74 %) versus total cases (41%) (59). The most prevalent chronic comorbidities in severe cases of COVID-19 were obesity and hypertension, followed by diabetes, cardiovascular disease (CVD), respiratory disease, cerebrovascular disease, malignancy, kidney disease, and liver disease (60). Also, smoking was substantially increased in 8.7 % of the patients (61).

2.1.4 Summary of Theoretical Framework

The theoretical framework of this dissertation addresses the complex relationship between socioeconomic status and health outcomes, particularly in the context of the COVID-19 pandemic. Drawing on public health theories and sociological perspectives, the framework highlights the systemic inequalities that contribute to disparate health outcomes across different socioeconomic groups. These inequalities become especially pronounced during health crises, such as pandemics.

This study seeks to explore two main research questions as stated in the Introduction. The first question examines the extent to which an association exists between socioeconomic status (SES) and COVID-19 in terms of disease progression, severity, and infection rates. The second question investigates the relationship between deprivation, as an indicator of SES, and adverse COVID-19 outcomes, such as hospitalization, intensive care admission, and death. Additionally, it aims to identify mediators within the literature that influence this relationship. These questions are grounded in the understanding that health outcomes, particularly during a pandemic, are not randomly distributed but are shaped by broader social and economic structures. Lower SES has long been associated with worse health outcomes due to factors such as reduced access to healthcare, higher prevalence of pre-existing conditions, and increased exposure to health risks. The theoretical framework demonstrates that these factors likely exacerbate the severity and progression of COVID-19.

Several key theoretical considerations have emerged. The social determinants of health (SDoH) provide a framework to understand how external factors such as income, education, and living conditions influence health outcomes. In particular, deprivation serves as a measurable indicator of SES that captures the cumulative disadvantages faced by populations in poverty or near poverty. This deprivation is linked to poor health outcomes, which, in the context of COVID-19, includes higher infection rates, more severe disease progression, and worse clinical outcomes.

The concept of intersectionality further illuminates how SES interacts with other factors such as race, ethnicity, and gender, creating multiple layers of disadvantage. During the pandemic, certain racial and ethnic groups, who are disproportionately represented in lower SES brackets, have experienced higher rates of infection, hospitalization, and mortality. These disparities underscore the importance of addressing both socioeconomic deprivation and intersecting forms of inequality when considering the broader health impact of COVID-19.

Based on the theoretical framework, it is reasonable to hypothesize that SES and deprivation significantly influence COVID-19 outcomes. The empirical part of this dissertation will explore the association between SES and COVID-19 progression, severity, and infection rates, as well as the relationship between deprivation and adverse outcomes such as hospitalization and death. Additionally, it will investigate mediators of these relationships, as identified in the literature, including healthcare access, living conditions, and occupation.

This summary serves to bridge the theoretical and empirical sections, justifying the exploration of SES and deprivation in the empirical analysis. By drawing on the theoretical groundwork laid in the previous chapters, the study aims to provide evidence of how social inequalities have shaped the course and impact of the COVID-19 pandemic.

3 MATERIAL UND METHODEN

In this dissertation, it is important to distinguish between the terms “socioeconomic status” and “deprivation”, as they are not used interchangeably. SES broadly refers to an individual's or group's position within a societal hierarchy based on factors such as income, education, and occupation. Deprivation, on the other hand, is a more complex and multifaceted concept that exists within the broader framework of SES. It reflects a lack of material, social, and environmental resources, and while it often correlates with low income, deprivation encompasses a wider range of factors. These may include the quality of one's living environment, occupational hazards, and access to essential services. Therefore, deprivation is viewed as a comprehensive measure of disadvantage that goes beyond income alone, capturing the cumulative impact of adverse living conditions on health outcomes, particularly in the context of COVID-19. In the narrative review, which was written earlier in the pandemic, SES as a form of social status was used to examine these relationships. However, in the systematic review and meta-analysis, the concept of deprivation was adopted. This was because deprivation offers a more precise way to describe social disadvantage and, given that it was conducted later in the pandemic, we assumed that more studies using deprivation indices would be available. These indices allowed for a more detailed exploration of social inequalities in COVID-19 outcomes.

3.1 Research Methods of the Narrative Review

Research Question and Search Strategy

The primary research question of this narrative review seeks to determine the extent to which an association exists between socioeconomic status and COVID-19 mortality (Q1A) and infection rates (Q1B). To address this, the narrative review included two distinct research strategies.

1. Socioeconomic Status and COVID-19 Deaths: Chapters 4.1.1 and 4.1.2 examine the relationship between COVID-19 and comorbidities (see Figure 5, Pathway P1) and comorbidities and SES (see Figure 5, Pathway P2), respectively. The keywords and Medical Subject Headings (MeSH) terms used for Chapter 4.1.1 were "COVID-19", while for Chapter 4.1.2 the terms were "comorbidities" and "socioeconomic status".
2. Socioeconomic Status and COVID-19 Infections: Chapters 4.1.3 and 4.1.4 examine the relationships between infection-promoting factors and COVID-19 (Figure 5, Pathway P3) and between SES and infection-promoting factors (Figure 5, Pathway P4), respectively. The search terms for Chapter 4.1.3 included "COVID-19" or "SARS-CoV-2" combined with "susceptibility" and "exposure," whereas for Chapter 4.1.4, the terms

used were "socioeconomic status" and proxies for increased susceptibility and exposure.

Core Search of the Narrative Review

The core objective of this review was to identify studies examining the association between SES and COVID-19 mortality or infection rates, represented by Pathways C1 and C2 in Figure 5. The results of this search are discussed in Chapter 4.1.5, with the goal of confirming or refuting the link between SES and adverse COVID-19 outcomes.

Data Sources

The search was limited to studies sourced from PubMed, maintained by the National Center for Biotechnology Information (NCBI), a division of the National Library of Medicine (NLM), and Google Scholar.

Literature Search

To address the research objectives outlined above, a comprehensive search was conducted on the aforementioned platforms, structured around three key elements: "socioeconomic status" and "COVID-19," or "SARS-CoV-2", as well as the specific outcome, i.e., infections, mortality, etc. These terms were linked as necessary conditions using the Boolean operator "AND", as well as "OR" for disjunctive word combinations.

The initial search was performed in April 2020, covering studies dating back to January 2020, and the final update was completed on November 3, 2020. The timeframe for the narrative review stopped earlier because it was conducted at the very beginning of the pandemic. The primary goal at this stage was to quickly obtain an overview of whether health inequalities were evident in the context of COVID-19, specifically in relation to socioeconomic status. This early snapshot was essential for identifying whether a connection between SES and adverse COVID-19 outcomes existed. Once this relationship became evident through initial studies, it laid the groundwork for a more detailed and focused analysis in the subsequent systematic review.

In scoping searches, the association of socioeconomic status and infection rates or mortality were examined in separate chapters. However, it proved beneficial to combine these chapters since infection rate and mortality rate variables are often analyzed together in studies.

Selection of Studies

A detailed overview of the selection process can be seen in Figure 3. The initial screening process adhered to a stringent protocol, beginning with title screening, followed by abstract and full-text screening. For results retrieved from Google Scholar, title screening was conducted before the removal of duplicates, as the platform does not permit bulk downloading of all search results at once.

After the initial review, studies that did not meet the methodological criteria were excluded. For instance, records that did not collect empirical data, as well as reviews and information articles, were excluded. Studies that did not address the SES parameters of education, occupation, and income were subsequently excluded. This exclusion process was essential to ensure the integrity and precision of the analysis. By focusing solely on studies with empirical data, we aimed to base our conclusions on objective, quantifiable evidence rather than speculative or theoretical perspectives. Additionally, narrowing the scope to studies that specifically examined SES parameters such as education, occupation, and income allowed for a more consistent and targeted assessment of socioeconomic disparities. This approach minimized potential confounding factors and ensured that only those studies directly measuring SES factors were included, thereby improving the validity of the conclusions drawn regarding the relationship between SES and COVID-19 outcomes.

Further exclusions were made for studies focusing on secondary effects of SES, such as public transport use, access to care, and health insurance, were excluded from the analysis to ensure that the indicators of socioeconomic status remained as clear and unambiguous as possible. While these secondary effects may also offer valuable insights into the relationship between SES and health outcomes, our aim was to maintain precision by focusing solely on direct SES indicators like income, education, and occupation. This approach reduced the number of variables and potential confounders, allowing for a more targeted investigation of the primary SES factors. By minimizing the inclusion of secondary or indirect variables, we aimed to enhance the clarity and consistency of the findings, ultimately leading to a more robust and precise analysis of the association between SES and COVID-19 outcomes.

Additionally, studies with findings that were too imprecise or abstract, such as the association of median household income with reduced mobility, were excluded. Although findings like "ethnic minorities in Chicago use public transit more" provide information on indices of social position often co-occurring with low SES, they were considered too abstract without demonstrating that low SES is associated with these ethnic minorities under the same circumstances. Such results will be mentioned in the chapter on intersectionality. After the in- and excluding process, studies were categorized into peer-reviewed and preprint studies.

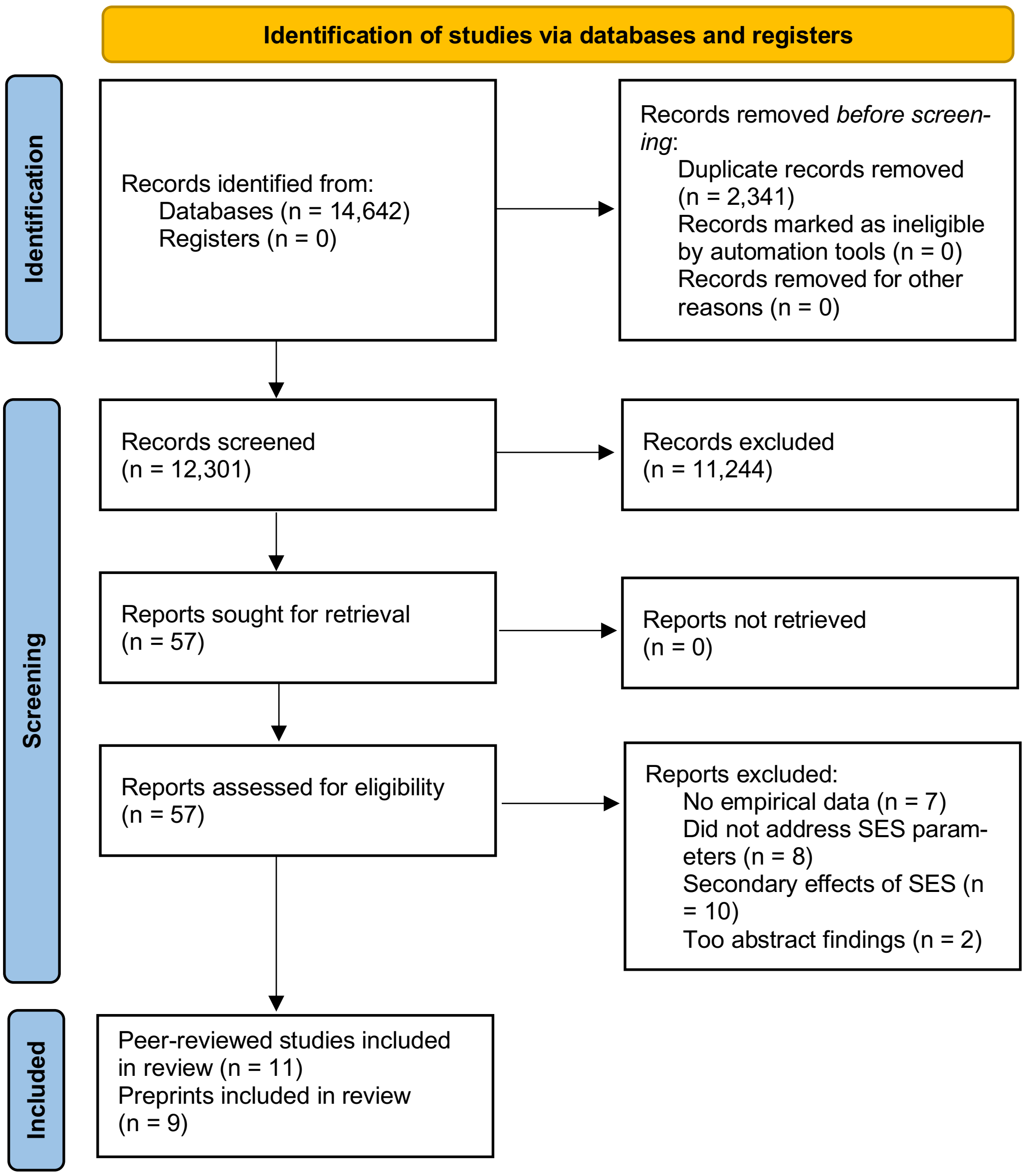

Figure 3: Process of Identifying Articles for Narrative Review

Data Extraction and Analysis

The data extraction protocol followed a strict scheme that recorded the specific data drawn from each study in a data extraction form. This included the country of the study, the indicators of SES, the level at which the data was collected, the population size, and others. The country of the study was important for differentiating the results between developing, emerging and developed countries. The level of data collection as well as the population size ensured comparability between the studies.

The extracted data were analyzed along the flow diagram of Figure 5. Each path of the flowchart corresponded to a single study group that was searched for. The partial results of the search strategy were combined to form the thematic basis of this dissertation. The aim was to examine whether a correlation between social status and COVID-19 severity or infection numbers is conceivable. The synthesis of the search was carried out in a qualitative manner to approach a thematic analysis of the suspected correlation. A narrative summary was created for each theme, highlighting the most significant results, and noting any inconsistencies. In contrast, in the second part of this dissertation, quantitative data were summarized in tables to provide a clear comparison of study results. This synthesis aimed to integrate the diverse findings into a cohesive narrative that elucidates the relationship between SES and COVID-19, providing a comprehensive overview of the current state of research on this topic.

Interpretative Framework

The findings of this narrative review were interpreted through the lens of the social determinants of health framework. This framework posits that socioeconomic factors such as education, income, and occupation significantly influence health outcomes by affecting individuals' access to resources, exposure to health risks, and overall resilience to diseases. In the context of COVID-19, these socioeconomic determinants were examined to understand how they might contribute to disparities in infection rates and disease progression. The interpretation considered both direct effects (e.g., lower SES leading to higher exposure to the virus due to crowded living conditions) and indirect effects (e.g., lower SES limiting access to healthcare resources, thereby worsening disease outcomes). This approach allowed for a comprehensive understanding of how SES impacts COVID-19 outcomes, acknowledging the complex interplay between various social and economic factors.

3.2 Research Methods of the Systematic Review and Meta-Analysis

Research Question

This systematic review and meta-analysis examine whether deprivation, as measured by deprivation indices, is associated with adverse outcomes in COVID-19-infected populations.

Contributors and Publication

The systematic review and meta-analysis served as the basis for a publication, which is currently in the publication process. During this process, the methodology may be revisited and expanded, integrating updated information and approaches aligned with the current understanding of the pandemic. Due to the potential adjustments in methodology, I decided to write this monograph separately from the publication, as it might otherwise diverge too far thematically and exceed the scope of this dissertation. A detailed account of the division of labor, specifying the contributions to the systematic review and meta-analysis, can be found at the beginning of the dissertation, as well as in this methods section.

Data Sources and Study Selection

Henry Peters (HP) and Ibrahim Demirer (ID) identified the key search terms, with HP creating a search strategy consisting of three elements: "COVID-19," "deprivation," and proxies for severe disease progression. These terms were linked using the Boolean operator "AND," while synonyms were connected using "OR." Medical Subject Headings (MeSH) terms were also included. The complete search strategy is presented in Supplementary Table 3 in the Appendix.

Studies were included if they investigated SARS-CoV-2-related outcomes in relation to deprivation. The target population involved individuals with COVID-19, and the outcomes of interest included COVID-19 deaths, intensive care unit (ICU) admissions, and hospitalizations. We prioritized studies that used comprehensive deprivation indices, excluding those that relied on single variables to assess deprivation. Both individual-level and area-level studies were included, as early in the pandemic there was limited individual-level data with strong evidence. Studies that did not meet the criteria for meta-analysis were presented in narrative form.

The initial search covered the period from January 1, 2020, to December 31, 2021, using the following databases: PubMed (National Library of Medicine, NLM), Web of Science, Cochrane Library, Sociological Abstracts, PsycInfo, and the Cochrane COVID-19 Registry. This search period was selected due to the rapid progression and dynamic nature of the pandemic, which introduced unique challenges for data collection and analysis. The early phases of the pandemic were marked by significant uncertainties, and the timeframe was intentionally limited to capture critical data during a period when socioeconomic inequalities were not yet adequately addressed by health policies and interventions.

Additionally, the earlier virus variants were associated with more severe disease courses, while later variants demonstrated increased transmissibility. The limited search period also reflects the fact that, during this time, vaccines had not yet been developed, which could have introduced an additional source of bias in the studies. By focusing on this critical early stage of the pandemic, we aimed to analyze the direct impacts of socioeconomic deprivation on COVID-19 outcomes without the confounding influence of vaccination status.

Two reviewers (HP, ID) independently screened titles, abstracts, and full-text articles based on pre-established eligibility criteria. Any discrepancies were resolved through discussion, and if consensus could not be reached, a third reviewer (TP) was consulted. To account for the evolving pandemic, the search was repeated on May 31, 2022, just before data extraction and analysis. This allowed us to compare early findings with those from a later stage of the pandemic and ensured that we included the most recent research in our systematic review and meta-analysis.

The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, ensuring high methodological quality and transparency. A key limitation was the ongoing lack of detailed individual-level data, even in the later stages of the pandemic, which affected the strength of the available evidence. The search and selection process are illustrated in Figure 4**.** By following this systematic approach, we ensured that the study maintained high standards, while addressing the challenges introduced by the evolving nature of the COVID-19 pandemic and limitations in available data.

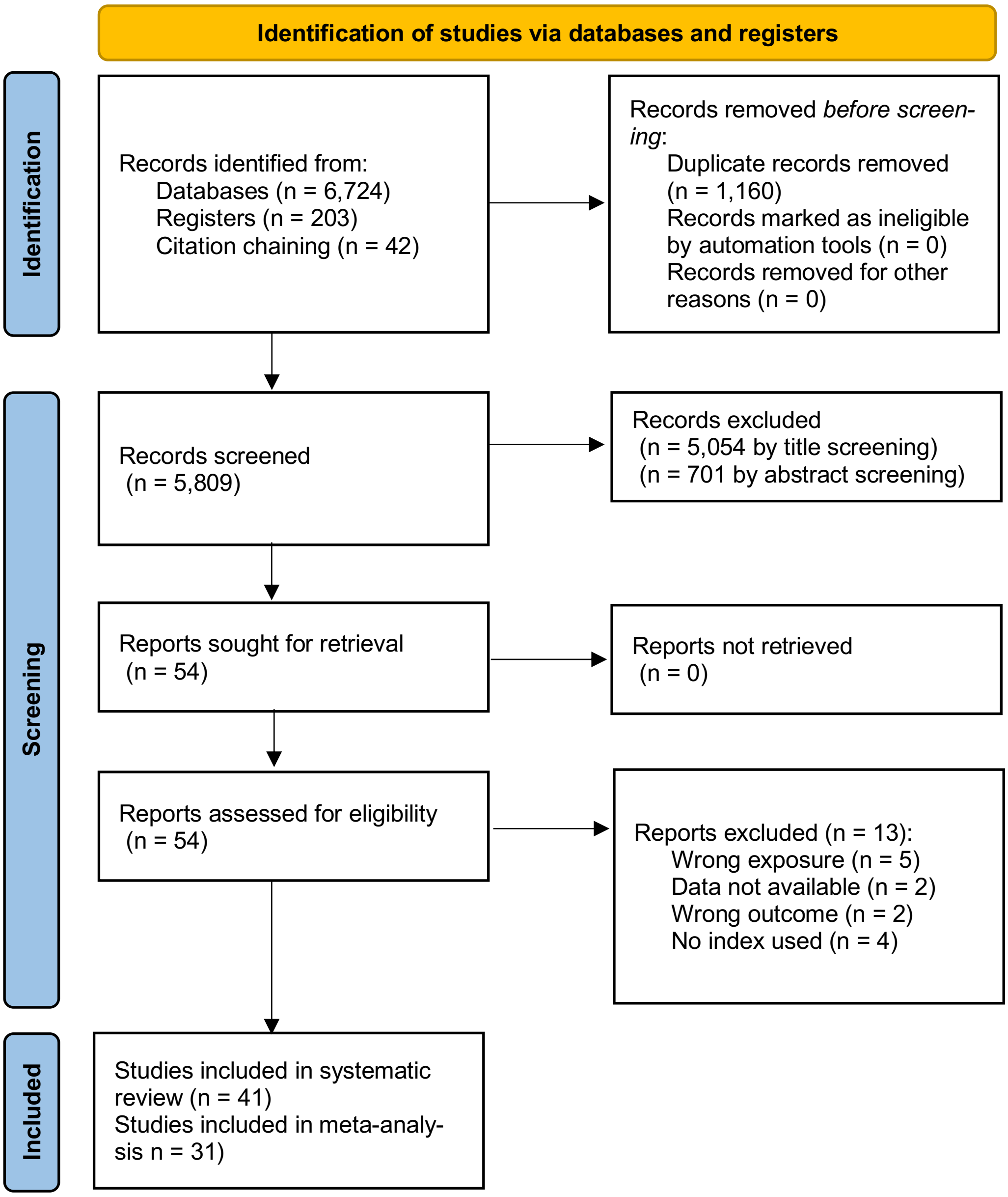

Figure 4: Process of Identifying Articles for Systematic Review and Meta-Analysis

Data Extraction

Data extraction was performed using the same review principle as the study search. First, two reviewers (HP, ID) independently collected information on the study characteristics (author, title, year, DOI, country, design, period, setting, population, exposure measure, outcome measure, results, link) in a four-eyed principle, while disagreement was solved through discussion or a third reviewer (TP). Then, the data of effect estimates, beta coefficients, standard errors, p-values, and confidence intervals (CI) were carefully extracted with the same review method. Further study characteristics and the extracted data can be found in Supplementary Table 1 and Table 2 in the Appendix. All data collection was performed using a data extraction form that the reviewers validated prior to use based on five test studies.

Quality Assessment

Again, two reviewers (HP, ID) performed quality assessment, evaluating the included studies. Disagreements were resolved by discussion or a third person (TP). For cohort and cross-sectional studies, the Joanna Briggs Institute checklists were used (62). They consist of 11 and 8 questions, respectively, on study methods, analyses, and presentation of results. A score below 8 (of 11) or 6 (of 8) meant that studies were excluded. For ecological studies, the same quality assessment tool as for cross-sectional studies was used.

Statistical Analysis

Data analysis was performed using Review Manager 5.4. When deprivation indices were scaled to classify populations (i.e., deciles, quintiles), statistical effect sizes were assessed from the most to the least deprived fraction. Summary effect sizes were presented in forest plots for OR, RR, and HR. For RR, standardized mortality ratio, incidence rate ratio, and mortality rate ratio were subsumed. This was done to ensure comparability because different studies used different effect sizes. When the methods and study characteristics differed substantially, subgroup analysis was performed.

A random-effects model was used in the meta-analyses because we expected high heterogeneity in observational studies. Three tests were applied to assess heterogeneity: Tau^2, Chi^2, and I^2. The I^2 statistic was used to quantify the percentage of total variation across studies that was due to heterogeneity rather than chance, with the standard thresholds applied: values between 0-40% indicated low heterogeneity, 30-60% moderate heterogeneity, 50-90% substantial heterogeneity, and 75-100% high heterogeneity. The Chi^2 test (Cochran's Q-test) was employed to test whether the observed differences between study results were greater than expected by chance, with a p-value of less than 0.10 suggesting significant heterogeneity.

Finally, the Tau^2 statistic was used to measure the absolute variance between studies, providing a more specific estimate of the magnitude of heterogeneity. These standard cut-offs were used to determine whether high heterogeneity was present and to guide further decisions in the meta-analysis.

4 ERGEBNISSE

4.1 Results of the Narrative Review

I investigated whether there is an association between low socioeconomic status and the likelihood of contracting COVID-19 infection or suffering a severe course of the disease. The preliminary investigation of the state of research showed that the association between low SES and poorer health outcomes applies to non-communicable as well as infectious diseases. For example, previous studies elucidated that people with comorbidities have a higher risk of dying from systemic inflammatory diseases (63, 64).

A summary of the theoretical framework of this dissertation is presented in tabular form in Table 1, and in graphical form in Figure 5. Each hypothesis is connected to a premise, which in turn corresponds with a pathway in Figure 5. The first central question is whether a low socioeconomic status is associated with a severe course of COVID-19 (Question 1A, Q1A). The hypothesis to be tested is therefore whether people with comorbidities are more likely to die from COVID-19 (Hypothesis 1, H1). If this proves to be correct, Premise 1 (P1) can be established: People with comorbidities are more likely to die from COVID-19. Next, test whether the second hypothesis (Hypothesis 2, H2) is true, that low SES is associated with increased rates of non-communicable diseases. Premise 2 (P2) can then be established: People with low SES are more likely to have comorbidities associated with a severe course of COVID-19. P1 and P2 lead to one of the main hypotheses (Hypothesis H3), namely: low SES increases the risk of mortality or severity of COVID-19 infection. If this hypothesis appears to be correct, Conclusion 1 (C1) can be drawn from it: People with lower SES are more likely to die from COVID-19 or suffer from a severe course. Hypothesis 3, which results from this theoretical consideration, is supported, or falsified by the current study situation.

Table 1: Central Questions and Hypotheses of the Narrative Review

Q1A	**Is a low socioeconomic status associated with a severe course of COVID-19?**	
H1	People with comorbidities are more likely to die from COVID-19.	→ P1
H2	People with low SES are more likely to have comorbidities associated with severe COVID-19.	→ P2
H3	People with lower SES are more likely to die from COVID-19 or suffer from a severe course.	→ C1
Q1B	**Is a low socioeconomic status associated with higher infection rates of SARS-CoV-2?**	
H4	Higher exposure or susceptibility leads to higher infection rates with SARS-CoV-2.	→ P3
H5	Low SES is associated with factors that cause higher exposure or susceptibility to SARS-CoV-2.	→ P4
H6	Low SES is associated with a higher risk of infection with COVID-19.	→ C2

(→ = leading to)

The same will be checked for the second central question of this dissertation, whether a low SES is associated with a higher risk of infection for COVID-19 (Question 1B, Q1B). For this purpose, factors promoting increased exposure or heightened susceptibility to the virus were investigated. This Hypothesis 4 (H4) would legitimize Premise 3 (P3): A higher exposure/susceptibility leads to higher infection rates with SARS-CoV-2. This is followed by a check to see whether a low SES is associated with factors that cause higher exposure or susceptibility to SARS-CoV-2. This would confirm Hypothesis 5 (H5) and allow Premise 4 (P4). The combination of Premises 3 and 4 establishes the second of the main hypotheses of this Review: Hypothesis H6: Low SES is associated with a higher risk of infection with COVID-19. Finally, the current study situation is also examined for the second main hypothesis of the narrative review. If this is confirmed, Conclusion 2 (C2) can be drawn.

The flow chart of Figure 5 shows the basic model of associations of this dissertation, along which the reviews attempt to work. In general, arrows are typically used to represent causal relationships, which are not definitively established in this type of investigation, given the nature and quality of evidence in a narrative review. Nonetheless, I chose to use arrows to show directionality—such as the suspicion that comorbidities contribute to a more severe course of COVID-19—which is crucial for understanding the relationships under consideration. Moreover, these arrows also highlight the broader implications of this dissertation, as the findings at least suggest the possibility of a causal connection, even if definitive proof is beyond the scope of this type of review.

Figure 5 shows the theoretical framework of this part of the dissertation again in graphic form. The letters „P“ stand for premises and „C“ for conclusion. The premises follow from the assumed hypotheses and in turn serve as the basis for the central hypotheses from which the conclusions are generated. The central hypotheses mark the core of this part of the dissertation and are described by two key questions (Q1A, Q1B).

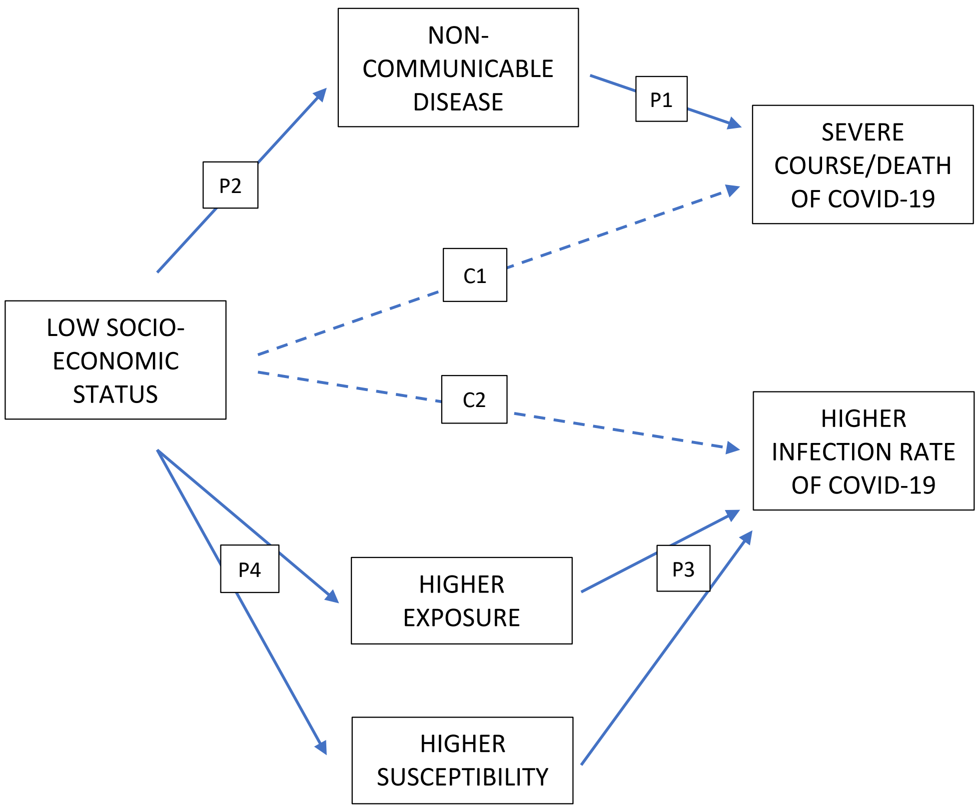

Figure 5: Relationships Between low SES and Unequal Health Outcomes

4.1.1 COVID-19 and Comorbidities

The COVID-19 pandemic does not affect everyone equally (10). Certain risk factors favor the occurrence of a serious infection or death from COVID-19. According to the Robert-Koch institute (2020), risk groups are defined as individuals who are at a higher risk of experiencing a severe course of COVID-19. This understanding of risk factors is informed by both data from previous pandemics and emerging evidence from the ongoing pandemic. The risk of severe illness increases progressively with age, starting from around 50 to 60 years. Particularly in older individuals with pre-existing conditions, the likelihood of a severe course of the disease is significantly elevated compared to those with age alone as a risk factor. Multimorbidity, the presence of multiple underlying health conditions, further heightens the risk of a severe outcome compared to individuals with just one pre-existing condition. Furthermore, individuals with weakened immune systems, whether due to an underlying immunodeficiency or the use of immunosuppressive therapies, are also at an increased risk of severe illness from COVID-19. While younger individuals without pre-existing conditions generally experience milder forms of the illness, severe cases, including hospitalization and death, have been reported across all age groups, particularly with the emergence of new viral variants (65).

Comorbidities

Several chronic illnesses were commonly observed among those who died with COVID-19, and these will be explored in detail in this section. Chronic obstructive pulmonary disease (COPD) has been extensively analyzed in meta-analyses for its impact on COVID-19 outcomes. COPD was associated with a severe course of the disease, with an OR of 2.39 (95% CI: 1.10-5.19) (66), an OR of 5.97, P <0.001 (67) to develop symptoms, and a RR of 4.20, 95% CI: 2.82-6.25 (68). COPD was the strongest predictive comorbidity for severe disease (prevalence odds ratio 6.42, 95% CI 2.44-16.9) and intensive care unit admission (pOR 17.8, 95% CI 6.56-48.2) (69). In the same retrospective cohort study from China, the HR for COPD was 2,681 (CI: 1,424-5,048) to achieve the composite endpoints. The endpoints were admission to an intensive care unit, invasive ventilation, or death (69).

The same applies to hypertension. Hypertension was a feature of severe COVID-19 cases in several studies (66, 70). In a meta-analysis by Espinosa et al. it was the most prevalent comorbidity in COVID-19 deaths (71). Furthermore, it is predictive for severe COVID-19 and intensive care unit admission (69), an independent mortality predictor in older patients (72), one of the most common comorbidities in clinical features of fatal cases (73) and hospitalized patients (74, 75). Two other meta-analysis showed an increased OR to develop COVID-19 when infected with SARS-CoV-2 and have hypertension (67).

Further adversities arise for patients with following comorbidities: diabetes (66, 67), CVD (69, 76), obesity (75, 77), chronic kidney disease (67, 68), cerebrovascular disease (66, 68), malignancy (67, 74) and liver disease (78).

4.1.2 Low SES and Comorbidities Associated with COVID-19

This chapter examines whether there is a connection between low SES and the comorbidities identified in Chapter 4.1.1, and stands for Pathway P2 in Figure 5. The comorbidities associated with severe COVID-19 infection are COPD, hypertension, diabetes, CVD, obesity, chronic kidney disease, cerebrovascular disease, malignancy, and liver disease.

COPD

A review by Sahni et al. (2017) describes the SES and its relation to chronic respiratory disease. They found a lower SES to be linked to several respiratory diseases and disproportionate access to health care. In the setting of COPD, SES has an inverse relationship with COPD prevalence and mortality (79). Another study by Grigsby et al. (2016) analyzed the SES-COPD association among low- and middle-income countries. They found that the odds of having COPD was greater with lower SES (OR = 1.23, 95% CI 1.05-1.43) even after accounting for subject-specific factors and environmental exposures (14). Sommer et al. in their systematic review showed that having low SES and/or living in low- and middle-income countries increased the risk of developing COPD. Furthermore, low SES increased the risk of mortality from lung cancer and COPD (80).

Hypertension

Studies support the connection between hypertension and low, middle, and high SES. In an aging cohort, "being in high as compared with low SES categories was associated with a lower risk of developing hypertension in late life, with HR of 0.87 (95% CI 0.77-0.98) for high neighborhood SES tercile, 0.79 (0.69-0.90) for high individual income, and 0.75 (0.63-0.89)" (81). A meta-analysis by Leng et al. (2015) admitted this by checking on the indicators of income, occupation, and education. They found an overall increased risk of hypertension among the lowest SES for each of the three indicators. "The associations were significant in high-income countries, and the increased risk of hypertension for the lowest categories of all SES indicators was most evident for women, whereas men revealed less consistent associations (82)."

Diabetes

Volaco et al. in their 2018 review point out that cross sectional and prospective studies confirm the relationship between lower SES and obesity or diabetes. "The lower SES is associated to metabolic implications that are linked to insulin resistance and possibly may also interfere with the ability of beta cell to secrete insulin and change the gut microbiota, increasing even more the future risk of developing diabetes." Interestingly, they found the SES to be a mediator between obesity and the development of diabetes. According to literature, reasons for this could be higher stress levels, cortisol levels etc. (83). Further studies report the association between type 2 diabetes and education, income, and occupation, all of which are factors contributing to the SES (84). Evidence on this is saved in meta-analyses reporting on the association between long working hours and diabetes in low SES groups. Results were robust to adjustment for age, sex, obesity, and physical activity, and remained after exclusion of shift workers (15).

Cardiovascular Disease

Researchers of the Prospective Urban Rural Epidemiologic study of 20 low-, middle-, and high-income countries examined the SES and risk of CVD. They found that major cardiovascular events were more common among those with low levels of education (85). The study by Schultz et al. (2018) highlights that SES has a significant impact on cardiovascular health, with biological, behavioral, and psychosocial factors contributing to the link between low SES and cardiovascular disease (CVD). Key SES indicators—income, education, employment, and neighborhood factors—are consistently associated with CVD risk in high-income countries. Disparities in CVD outcomes are further influenced by sex. Interventions for low-SES individuals have mainly targeted traditional CVD risk factors, with promising strategies like structured physical activity and task shifting showing potential. However, integrating SES into CVD risk prediction models remains challenging due to cultural and regional variations. The study calls for more research to understand CVD risk mechanisms in low-SES populations and develop effective interventions (86). Also, risk factors for CVD were positively associated with SES in a cross-sectional study by Kinra et al. (2014). The study found that higher socioeconomic position was positively associated with fat mass index and inversely associated with central-peripheral skinfold ratio and, in boys, fasting triglycerides. However, associations with other cardiovascular risk factors, such as blood pressure and cholesterol, were weak and inconsistent, and did not remain significant after adjusting for factors like age, sex, and adiposity (87).

Obesity

Three meta-analyses and systematic reviews examined the connection of SES and overweight/obesity. "Low [neighborhood SES], compared with high [neighborhood SES], was associated with 31% higher odds of overweight" and "45% higher odds of obesity“ (88). Newton et al. (2017) report that a "consistent association between lower life course SES and obesity among women […] but not among men" (89). Similar findings had Vieira et al. (2019), elucidating the SES throughout life and body mass index. The "BMI mean difference […] was higher among those who remained with low socioeconomic status throughout life when compared with those who maintained a high socioeconomic status". This has been found for women, however, not for men (90).

Other Comorbidities

Chronic kidney disease, cerebrovascular disease, malignancy, and liver disease were associated to a low SES in several studies (91, 92).

4.1.3 COVID-19 and Proxies for Infection-Promoting Factors

This section examines the likelihood of COVID-19 infection and its influencing factors. Initial findings suggest that there are both epidemiological and constitutional differences in the risk of contracting SARS-CoV-2 or developing COVID-19 (9, 10, 46, 93-96). Two main variables determine the likelihood of infection: contact with an infected individual and personal susceptibility to the virus. However, there remains a lack of sufficient data on the correlation between infection risk and specific living and working conditions. Therefore, conclusions in this review are based primarily on current scientific assumptions.

Regarding exposure to SARS-CoV-2, these assumptions are grounded in knowledge about its mode of transmission. Based on available data, certain life circumstances can be identified where individuals are at higher risk of infection. Future research on specific high-risk environments will be crucial for informing policies aimed at promoting equitable health outcomes. Figure 6 illustrates a step-by-step approach to identifying higher risks of infection and death, focusing on the relationship between increased exposure or susceptibility and higher COVID-19 infection rates. This figure can be viewed as a more focused excerpt from Figure 5, which presents a broader overview of how various socioeconomic and health-related factors interact to create unequal health outcomes. While Figure 6 zooms in on specific infection-promoting factors and their transmission pathways, much of the data relies on studies of other infectious diseases. This provides scientific guidance for reducing infection risk based on established knowledge of transmission.

Regarding exposure to SARS-CoV-2, these assumptions are grounded in knowledge about its mode of transmission. Based on available data, certain life circumstances can be identified where individuals are at higher risk of infection. Future research on specific high-risk environments will be crucial for informing policies aimed at promoting equitable health outcomes. Figure 6 illustrates the relationship between COVID-19 and infection-promoting factors, with scientific guidance on reducing infection risk drawn from knowledge of transmission pathways. Much of this data is derived from studies on other infectious diseases.

Similarly, regarding susceptibility to SARS-CoV-2, the research conducted for this dissertation revealed no definitive conclusions on the factors that influence the development of COVID-19. Some risk factors for severe disease progression have already been discussed in Chapter 4.1.1, but other factors, unrelated to lifestyle or environment, may also play a role. Additionally, there are indirect factors, such as work-related stress, that may weaken the immune system and increase vulnerability to SARS-CoV-2. While definitive evidence is lacking, insights from other infectious diseases allow for indirect assumptions about inequalities in susceptibility that may also apply to COVID-19.

Domains of Influencing Factors

Exposure to the virus is regulated by both individual behaviors and conditions that are challenging to escape from or remain unchangeable, such as workplace and living conditions. Susceptibility to the virus is impacted by a range of constitutional and genetic factors, often through mechanisms that have yet to be fully explored. The objective here is to consolidate the available data that either support or challenge the link between exposure and susceptibility to COVID-19. In pursuit of these two factors, specific proxies were identified.

A German scoping review by the Robert-Koch institute (2020) published in the Journal of Health Monitoring examines the international literature on socioeconomic inequalities in relation to COVID-19, revealing significant disparities in infection risks and disease severity, particularly in the US and UK, with a scarcity of individual-level data in other countries like Germany (97). It investigates the correlation between socioeconomic status and COVID-19-related health outcomes by providing an overview of 138 international studies, of which 46 were included in the final analysis. Findings from the US and UK highlight the clear presence of socioeconomic inequalities, with lower-SES populations experiencing higher infection rates and more severe disease courses. In contrast, fewer studies have been conducted in Germany and most other European countries, though the limited available data suggests similar trends. The majority of the reviewed studies are ecological in nature, focusing on population-level data, whereas individual-level studies remain scarce. The authors emphasize the need for more research at the individual level, which would help to better understand the pathways through which socioeconomic factors contribute to disparities in COVID-19 outcomes. Such studies could ultimately inform policies to mitigate the worsening of health inequalities during the pandemic. Some of the fundamental ideas on how these inequalities arise, as outlined in the scoping review, will be explored in greater detail throughout this chapter of the dissertation, expanded upon, and supported by additional studies.

Exposure

As stated in Section 2.3.2 SARS-CoV-2 transmits via three ways: aerosols, droplet infection and contact infection. Certain environments promote transmission and thus place people in different exposure situations. Differences in exposure to the virus create differences in the risk of infection. Living and working conditions mainly determine these differences. Confined living conditions have been shown to lead to a higher risk of contracting influenza viruses (98). Since influenza transmits via comparable modes, these findings can be applied on SARS-CoV-2 transmission risks. Thus, smaller living space could induce higher risk of infection with SARS-CoV-2. In Germany, as in many other countries, there is an unequal distribution of living space to the detriment of the socioeconomically weaker (99). Concluding, the COVID-19 pandemic might affect harder disadvantaged populations, such as minorities, people of low income, Refugees in the asylum seekers' hostels. In addition, financially weaker families usually live together in larger households (100).

Different working conditions also influence the risk of infection. Workers in the so called 'system relevant' jobs must continue working, even if there is a nationwide lockdown. In these jobs mainly people from socioeconomically weaker classes work: "a high share of lower-income workers is employed in industries that are most affected by the pandemic, such as retail sales and food service industries, which require close physical proximity to others" (101). The same people are also more likely to work in social professions such as in care facilities and in the areas of logistics, public transport. In addition, they cannot make use of the generally recommended home office rule. People of lower income are also more dependent on public transport (102), where the risk of infection may be higher than in a car, on a bike, or as a pedestrian.

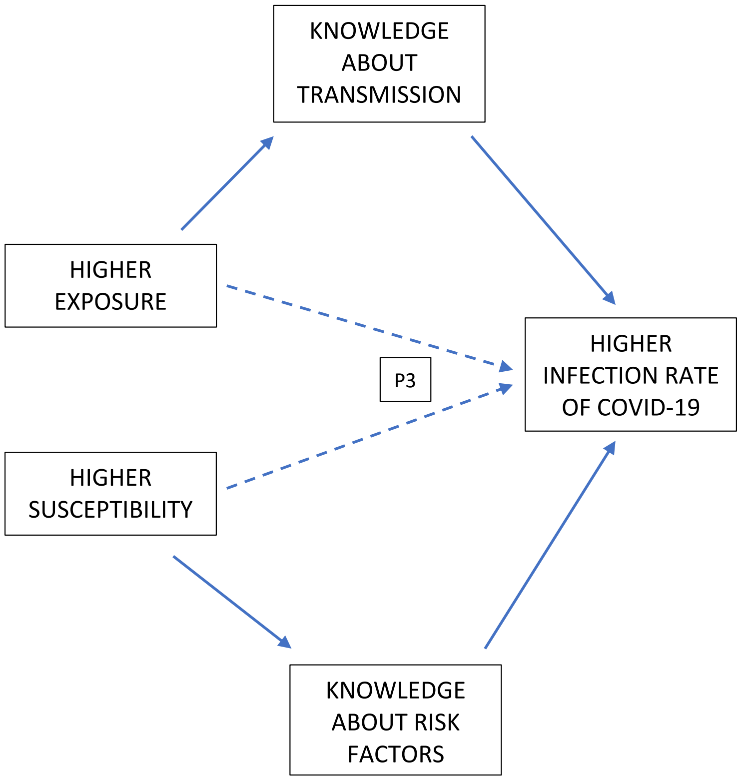

Figure 6: Factors of Higher Infection Rates

Susceptibility

There are also differences in the susceptibility to the virus. That is, the probability that an infected person develops (severe) symptoms of COVID-19. In other respiratory infectious diseases psycho-social factors contributed to the outbreak of symptoms (103). McEwen (1998) introduced protective and damaging effects of stress mediators in the context of allostatic load. There is general agreement that people of lower SES are exposed to higher stress levels (104). Arguing that constantly elevated levels of stress hormones lead to cellular stress and overreacting immune system, people of lower SES therefore are on greater risk to suffer from both chronic disease as well as infection diseases like the common cold (105). Furthermore, studies have shown that higher inflammation profiles occur more often among people of low SES (106). Since a severe course of COVID-19 is associated with elevated pre-existing inflammation levels (107), individuals from lower socioeconomic backgrounds may be at greater risk of experiencing worse outcomes. This aligns with findings discussed later in this review, which demonstrate that SES influences the time to discharge for hospitalized COVID-19 patients. Specifically, lower SES has been independently associated with a 7-day prolonged time to discharge (108). These insights further underscore the broader pattern of socioeconomic disparities highlighted in earlier sections, reinforcing the notion that people from disadvantaged backgrounds face not only higher infection risks but also more severe health consequences and longer recovery times.

Deprivation

Whether and to what extent an infectious disease manifests has been shown to depend on psycho-social factors: for instance, the feeling of social dependency or social disadvantage correlates with manifestation of respiratory diseases (109). A study by the same author on social vulnerabilities to upper respiratory infection illnesses offer psycho-social implications for the susceptibility to COVID-19: "[G]reater social integration was similarly associated with decreased risk of upper respiratory illness" and moreover, "the association of social integration and colds was attributable to decreases in both infection and illness expression among infected participants, allowing for multiple pathways through which integration may influence response to SARS-CoV-2" (110). As we know from Section 2.2.4 about deprivation, the subjective feeling of participation in the general standard of living gives the individual the feeling of integration and belongingness (34). Social deprivation, as in a study by Hawker et al. (2003) was "associated with increased admission rates for all respiratory infection" and "[h]ospital admissions for acute respiratory infection and pneumonia were both significantly associated with deprivation" (111).

Behavior

An individual’s chances of survival are shaped by two main factors: biological makeup and behavior. The biological constitution determines how well a person can withstand various environmental stresses, a capacity often referred to as reaction norms (112). Behavior, on the other hand, serves as the bridge between the individual and their environment, allowing them to interact with and, to some extent, influence their surroundings. While people can modify some environmental factors through their actions, their ability to do so is often limited by external constraints beyond their control.

In the context of socioeconomically driven health disparities, behavior alone is not enough to reduce risks, particularly in situations like the COVID-19 pandemic. For example, individuals who strictly follow preventive measures may still be exposed to the virus due to external pressures, such as work environments that increase exposure. These external factors can force individuals into high-risk situations despite their efforts to avoid them. Additionally, internal factors such as education further restrict a person's ability to respond effectively to health threats. Education shapes one's understanding of health measures and the ability to apply them, thus limiting the impact of individual behavior in preventing infection. As a result, while behavior is an important factor in managing health risks, it is heavily influenced by both external socioeconomic conditions and internal educational inequalities. This interconnectedness between behavior, education, and socioeconomic factors illustrates why people from lower socioeconomic backgrounds often face heightened risks despite their personal efforts.

Health Literacy and Compliance

Studies on health literacy postulate a connection between low SES and health behavior. Authors call health literacy another social determinant of health (113). According to Jansen et al. (2018) there are several potential mechanisms that might cause socioeconomic differences in COVID-19 morbidity and mortality (114). For example, people with a low SES background are more likely to have harmful behaviors such as smoking, poor eating habits, and non-compliance with medication (115, 116). Health literacy describes the ability of the patient to understand and implement medical instructions, package inserts, and patient information (117). The connection to health is well established; health literacy positively influences access and utilization of health care, patient-provider relationship, and self-care (118). Low health literacy is associated with "more hospitalizations; greater use of emergency care; lower receipt of influenza vaccine; poorer ability to demonstrate taking medications appropriately; poorer ability to interpret labels and health messages; and, among elderly persons, poorer overall health status and higher mortality rates" (119).

Health Literacy and COVID-19

Research on inadequate health literacy and COVID-19 found that these people had "poorer understanding of COVID-19 symptoms (49% vs 68%; p < 0.001)", were "less able to identify behaviors to prevent infection (59% vs 72%; p < 0.001)", experienced more difficulties "finding information and understanding government messaging about COVID-19", were "less likely to rate social distancing as important (6.1 vs 6.5; p < 0.001)", and were also more likely to "endorse misinformed beliefs about COVID-19 and vaccinations (in general)" than people with adequate health literacy (120).

In the regard of health literacy and the COVID-19 pandemic another publication by Paakari et al. (2020) describes the *Free Rider-Problem*. These are people that put other personal values over their health, knowing they could harm themselves but chose to have other priorities. However, since COVID-19 is a communicable disease, they do not only harm themselves but others as well. Health literacy could help these people to see the sense of restriction manners and recognize the dangers of their behavior. They suggest that inadequate information and education, and misinformation could be a determinant (121).

A cross-sectional study on coronavirus-related health literacy found 50.1% of their participants to have “problematic” (15.2%) or “inadequate” (34.9%) levels of health literacy on COVID-19. "The participants felt well informed about coronavirus, but 47.8% reported having difficulties judging whether they could trust media information on COVID-19. Confusion about coronavirus information was significantly higher among those who had lower health literacy." These results lead the authors to talk of an *Infodemic*, "a phenomenon that portrays the rapid spread and amplification of vast amounts of valid and invalid information on the internet or through other communication technologies" (122).

Physical Health Behavior

The (physical) health behavior may also play a role in the susceptibility to the virus. Previous research has shown increasing evidence on the efficacy of exercise on the immune system. A meta-analysis by Lee et al. (2014) on effects of exercise on the prevention of respiratory disease found that regular, moderate-intensity exercise may reduce occurrence of the common cold (123). Nieman et al. (2011) examined 1002 adults on upper respiratory tract infection and their perceived physical activity. During the 12-week period of observation, disease was significantly reduced in subjects reporting ≥5 days/week aerobic exercise compared to those who were largely sedentary (≤1 day/week) (124). A more recent review by Nieman et al. (2019) state that "[a]cute exercise is an immune system adjuvant that improves defense activity and metabolic health" and that "[d]ata support a clear inverse relationship between moderate exercise training and illness risk" (125). Another recent review by da Silva et al. (2021) concludes: "The practice of physical activities strengthens the immune system, suggesting a benefit in the response to viral communicable diseases. Thus, regular practice of adequate intensity is suggested as an auxiliary tool in strengthening and preparing the immune system for COVID-19" (112).

4.1.4 Low SES and Proxies for Infection-Promoting Factors

The research results on this topic show that a low SES is associated with disadvantageous living conditions (tight living space, large families, shared accommodation), disadvantageous working conditions (risk of infection at work, on the way to work and no possibility of working from home), negative psycho-social influencing factors (allostatic load, higher illness risk, deprivation), as well as unfavorable behavior (lower compliance, poor health behavior).

A review by Quinn & Kumar (2014) summarized studies on health inequalities and infectious diseases. Referring to the “Special Programme for Research and Training in Tropical Diseases”, "[…] poverty contributes to conditions that cause infectious diseases and also prevent access to health care" and infectious diseases are "a proxy for poverty and disadvantage" (126). Blumenshine et al. (2008) argued that in former diseases like influenza, different exposure may explain respiratory infection disparities as crowding "can increase the likelihood of pathogen transmission" and "[i]n the United States, urban poverty and Hispanic and Asian ethnicity are correlated with domestic crowding". Regarding susceptibility, they state that previous and actual data "indicate that socially disadvantaged groups are likely to be at higher risk for influenza disease, particularly severe disease." The state of their investigations leads them to "[…] explicitly call for action from countries with large subgroups who live in poverty"

(127). Finally, Quinn et al. (2014) developed an empirical approach to measure unequal exposure and susceptibility and found out that during the H1N1 pandemic, "less access to care", "less access to resources" and "social disadvantage" contribute to higher morbidity and mortality from influenza (126).

Exposure: Living and Working Conditions

Although pre-existing comorbidities in deprived populations promote the susceptibility to disease as described earlier, there is research postulating that further factors contribute to infection and disease outcome. Unequal infection rates in New York during the 2009 H1N1 epidemic were to the detriment of poorer people. "We identified a gradient in the odds of hospitalization for 2009 H1N1 influenza by education level among adults" and "[a]n inverse association between odds of hospitalization and neighborhood poverty was also identified among adults and children". However, these differences "could not be entirely explained by access to care and underlying risk factors". They suggest that different rates of exposure and susceptibility may exist because of social mixing and differential vaccination behavior (128).

Household and neighborhood crowding in low-income areas could be a potential mechanism for differential exposure to lower respiratory tract viruses. This was a conclusion by a Brazilian study by Cardoso et al. (2013) on hospital admission of indigenous children. Furthermore, a low stable monthly per capita household income, no income, large number of persons in the household, and indoor exposure to fumes from burning firewood used for cooking were results that lead to higher exposure (129).

Another study on neighborhood SES and influenza hospitalizations among children found that "influenza-associated hospitalization in high-poverty and high-crowding census tracts was at least 3 times greater than that in low-poverty and low-crowding tracts" (130).

According to Quinn & Kumara (2011, 2012), further studies confirm that "employees are often unable to stay home when ill or with a sick child for lack of the ability to work from home or forego wages" and that there are "[s]ocioeconomic disparities in access to paid sick days […] and the ability to stay home from work when ill could lead to differential exposure to virus and, hence, disparities in influenza attack rates" (131, 132).

Scientists report from airborne transmission as a significant route of infection in indoor environments (133). Compared with driving a motor vehicle, the odds of using public transport are higher for members of lower income households and residents of more disadvantaged neighborhoods. Hence, risk of infection is higher for these people (134).

Susceptibility: Psycho-Social and Behavioral Factors

Various studies have shown: stress is more present in lower income groups than in higher ones (135). Stress is seen as an influencing factor for the outbreak of respiratory diseases, and furthermore, there are empirical connections between stress and impaired immune function (136). This can result in a higher susceptibility to viruses. Undernourishment or overeating can also be a behavior-related influencing factor on infection diseases (126, 137). In the same way, a low SES reduces compliance, for example, to take medication or to be vaccinated (138). As we have seen in Section 2.2.9, allostatic load is related to higher susceptibility for infectious diseases. Several studies report that lower SES is consistently related to adverse health effect like the allostatic load (139, 140). Measures for allostatic load in these studies often was the cortisol level. Cortisol, when chronically elevated in blood, decreases the immune function. Hence, risk of infection increases for these people.

Cohen et al. (2008) in their study on "Objective and subjective socioeconomic status and susceptibility to the common cold" examined 193 healthy men and women aged 21-55 years. They were "assessed for subjective (perceived rank) and objective SES, cognitive, affective and social dispositions, and health practices". Health conditions were monitored after them being exposed to a rhinovirus or influenza virus. "Increased subjective SES was associated with decreased risk for developing a cold for both viruses. This association was independent of objective SES and of cognitive, affective and social disposition that might provide alternative spurious (third factor) explanations for the association (109)."

Kilgore et al. (2016) examined the relationship between demographic and socioeconomic factors and medication adherence, i.e., the compliance to take prescribed medication or behave adequately. The medical adherence "was lower for those who resided in an area with higher percent of population below federal poverty level […,] was significantly higher for members who resided in an area with higher home, or higher education level". Thus, they concluded that compliance was "significantly associated with demographic and socioeconomic factors (141)." Marmot et al. (142) pointed out that "in nearly all settings, the lower in a socioeconomic hierarchy a person is ranked, the worse is that person's health". Dorner et al. (2013) analyzed the "impact of different socioeconomic variables on the lifestyle factors, lack of physical activity, diet rich in meat, and smoking, across sex and age groups". They found that lack of physical activity, nutrition rich in meat, and daily smoking is associated with low SES. The strongest predictor of health behavior was profession for men and educational level for women (143).

The described inequalities in exposure and susceptibility make it plausible to assume that socioeconomically disadvantaged people could have an increased risk of contracting SARS-CoV-2 and developing COVID-19 or dying from it.

4.1.5 Low SES and COVID-19 Infections/Deaths

The aim of this section is to synthesize the insights from the previous chapters and to substantiate them empirically. The findings from Chapters 4.1.1 and 4.1.2 provide the foundation for the first of two main hypotheses of the narrative review (Table 1, Hypothesis H3). It has been observed that COVID-19-related deaths are significantly associated with increased comorbidities (Figure 5, Pathway P1). Furthermore, comorbidities are more prevalent among populations with lower SES (Figure 5, Pathway P2). Based on these observations, it is plausible to infer that individuals from socioeconomically disadvantaged backgrounds are disproportionately affected during the pandemic. The first main hypothesis of the narrative review therefore is: “People with low SES are more likely to die from COVID-19” (Table 1, Hypothesis H3, according to Figure 5, Pathway C1). This hypothesis arises from a theoretical framework suggesting that health inequalities are exacerbated during the COVID-19 pandemic due to the intersection of socioeconomic factors and health risks. The empirical data collected supports this deduction, but it is important to note that this conclusion should not yet be considered definitive scientific knowledge. The reasoning thus far remains deductive, meaning it is based on logical inference rather than direct evidence. To transition from theoretical deduction to empirical validation, H3 will be tested for its empirical accuracy to raise Conclusion 1 (C1).

While health inequalities are a significant issue in both developing and industrialized nations, the availability and quality of data are variable. Consequently, this section focuses on data from the United States and the United Kingdom, where there is a higher level of public awareness and available data on these inequalities. This focus allows for a more detailed examination of the relationship between low SES and increased COVID-19 mortality, providing a more robust empirical foundation for the conclusions drawn in this review.

In addition to the first main hypothesis, this chapter deals with the question if "people with low SES are more likely to contract SARS-CoV-2" (Table 1, Hypothesis H6, according to Figure 5, Pathway C2). Likewise, this hypothesis arises from the premises examined in Sections 4.1.3 and 4.1.4 (Figure 5, Pathways P3 and P4, according to Hypotheses H4 and H5). Latter of which answers the question to what degree the SES is associated with a higher exposure and susceptibility to the virus. According to current literature, this hypothesis turned out to be reasonable. Therefore, Premise 4 (P4) can be raised. The former, Premise 3 (P3) also seems to be reasonable: research shows which situations are exactly the ones that promote an infection with SARS-CoV-2 and how people become more susceptible to it. It turned out to be in line with the situations people of low SES often find themselves. Combining these premises, it makes it plausible to assume that a lower SES is associated with higher exposure and susceptibility to SARS-CoV-2. Therefore, it theoretically is plausible, to assume that people of lower SES are in higher risk of infection. This second main hypothesis (H6) is represented by the dotted line of Pathway C2 in Figure 5 and will be checked on its empirical validity in the following chapter. Subsequently, Conclusion 2 (C2) can be raised.

General Results and Study Characteristics

The search revealed 542 results from PubMed, and 14,100 from Google Scholar. After removing duplicates, title, abstract and full-text screening, the systematic search produced a total of 20 studies, comprising 9 peer-reviewed articles and 11 preprints. These studies covered various geographic regions, predominantly the United States and the United Kingdom, and used a diverse range of methodological approaches, including ecological studies, cross-sectional analyses, and retrospective cohort studies. The socioeconomic indicators examined across the studies primarily included income, education, occupation, and indices of deprivation, such as the Social Vulnerability Index and Area Deprivation Index. A consistent theme among the studies was the significant association between lower socioeconomic status and adverse COVID-19 outcomes, including higher infection rates, increased mortality, and prolonged hospitalization. However, some studies revealed nuances, such as differential effects of SES indicators like income and education on racial disparities in COVID-19 mortality. These findings highlight the complex relationship between socioeconomic factors and health outcomes during the pandemic. An overview of the general characteristics of the studies included in the narrative review can be seen in Table 2.

Table 2: Study Characteristics and Main Findings of the Narrative Review

Study	SES Indicator	Country	Setting	Description	Key Results
Abedi et al. (2020)	Income, Poverty level, Education	USA	Ecological study	Analysis of COVID-19 infection and mortality rates with SES and demographic factors.	Counties with higher income had higher infection rates, poverty linked to higher death rates.
Chin et al. (2020)	Poverty	USA	Regional study	Study on poverty and vulnerability to COVID-19 due to comorbidities and reduced access to care.	Poverty associated with increased vulnerability to COVID-19 due to comorbidities and limited care.
Emeruwa et al. (2020)	Income, Building value, Poverty rate	USA	Cross-sectional study	Study on pregnant women and neighborhood SES in relation to COVID-19 infections.	High-income neighborhoods negatively associated with infections, household crowding positively associated.
Hatef et al. (2020)	Area Deprivation Index	USA	Ecological study	Examined Area Deprivation Index and COVID-19 infection rates across states.	Higher ADI neighborhoods had higher infection rates, especially in disadvantaged zip codes.
Hawkins et al. (2020)	Distressed Communities Index	USA	Ecological study	Study on SES and COVID-19 cases/fatalities using the Distressed Communities Index.	Severely distressed counties had higher deaths per 100,000 residents but fewer total deaths.
Khan et al. (2021)	Scottish Index of Multiple Deprivation	Scotland	Hospitalized patients	Study on SES and COVID-19 outcomes in hospitalized patients, focusing on time to discharge.	No significant impact of SES on COVID-19 outcomes except for delayed hospital discharge in low SES group.
Khazanchi et al. (2020)	Social Vulnerability Index	USA	County-level analysis	Study on social vulnerability and COVID-19 cases/deaths using Social Vulnerability Index.	Most vulnerable counties had 1.63-fold greater risk of infection and 1.73-fold greater risk of death.
Lamb et al. (2021)	SES, Mobility	USA	City-level study (NY)	Study on mobility and SES in New York City related to COVID-19 case positivity.	Mobility changes were not a significant mediator between SES and case positivity in NYC.
Liu et al. (2020)	Socioeconomic Deprivation	England	National study	Study on socioeconomic deprivation and COVID-19 case trajectory in England.	Regions with greater socioeconomic deprivation showed a faster rise in COVID-19 cases.
Maroko et al. (2020)	Income, Education	USA	City comparison (NY, Chicago)	Study on SES in New York and Chicago in relation to COVID-19 infection rates.	Low infection rate areas had higher education, income, and more managerial occupations.
McLaren et al. (2021)	Income, Education	USA	County-level study	Investigated racial disparities and COVID-19 deaths in relation to socioeconomic variables like income.	No visible effect of income on racial disparities, but support staff occupations were strongly correlated with mortality.
Mollalo et al. (2020)	Income inequality, Median household income	USA	Spatial modeling	Spatial modeling linking income inequality to COVID-19 incidence rates.	Income inequality positively associated with COVID-19 incidence rates, particularly in nursing professions.
Nayak et al. (2020)	Social Vulnerability Index	USA	Ecological study	Study on social vulnerability and COVID-19 case fatality rates and infection.	Counties with lower SES had 63% higher case fatality rate, robust even after adjusting for age and comorbidities.
Patel et al. (2020)	Townsend Index of Deprivation, Household income	England	National study	Study on racial and socioeconomic deprivation and COVID-19 hospitalization risk in England.	Deprivation and income positively associated with COVID-19 hospitalizations in England.
Prats-Uribe et al. (2020)	Socioeconomic Deprivation	England	National study	Study on socioeconomic deprivation and the risk of developing COVID-19 symptoms in England.	Most deprived areas in England had nearly twice the risk of developing COVID-19 symptoms.
Snyder & Parks (2020)	Poverty, Gini coefficient	USA	Regional study	Study on vulnerability and social determinants of health in relation to COVID-19 infections across counties.	Southeastern US had higher vulnerability to COVID-19 based on social, health, and economic factors.

Takagi et al. (2021)	Unemployment, Poverty	USA	Meta-regression	Meta-regression of socioeconomic characteristics and COVID-19 prevalence/fatality in US cities.	Unemployment and poverty positively associated with COVID-19 prevalence and fatality.
Wanberg et al. (2020)	Income, Education	USA	Retrospective cohort	Study on SES, well-being, and depression during the pandemic.	Income negatively associated with depression, positively associated with life satisfaction and resource mechanisms.
Whittle & Diaz-Artiles (2020)	Median household income	USA	Neighborhood study	Study on socioeconomic predictors of COVID-19 cases in New York City.	Lower median household income associated with higher risk of infection in NYC neighborhoods.
Wiemers et al. (2020)	SES, Poverty	USA	National study	Study on disparities in vulnerability to severe COVID-19 complications.	SES strongly correlated with severe COVID-19 complications, particularly in the Southeast.

Results in Detail

The SES is largely made up of indicators from areas that include occupation, education, and income. Despite more recent findings about the complexity of the SES, income still is the central indicator in this context. Ten of the eleven included studies show an association between parameters of the SES and the increased incidence of COVID-19 infections or deaths.

McLaren et al. (2021) investigated whether racial disparities of the US COVID-19 deaths could be traced back to economic causes. The measurement period was June 2020. They analyzed 3,140 counties on their COVID-19 mortality rate together with economic, demographic, and geographic data at county-level. The data came from the American Community Survey. The economic indices were median household income in each county; the fraction of adults 25 years of age or older without high-school diploma; with high-school diploma but no further education; with *Some College* (including associate degree from community college) but no four-year degree; and with a four-year college degree; and the poverty rate in each county. The authors conducted the study as follows. First, they established the general connection between the SES and the COVID-19 cases. They then took the individual parameters of the SES out of this calculation and looked to see whether the relationship is still significant. "Surprisingly, neither income nor poverty rates have any visible effect on either the minority variables or in themselves. The coefficients on these variables are small and statistically insignificant. The education variables are similar, but with two differences. First, they reduce the magnitude and eliminate the significance of the Hispanic/Latino and Asian variables. Second, they produce negative, sizable, and large coefficients for the share with *Some College*, suggesting that an abundance of people in that educational category lowers deaths. […] African American and First-Nations effects are robust to these controls, but not the other two categories." After accounting for the fraction of workers in the county who can work at home, it appears that this variable has barely any effect on the racial-disparity variables. The coefficients on the work-at-home variable itself are small and insignificant, too. Next, they transformed each bigger share of occupations into a dummy variable to see if they have significant effects on each minority. The effects are strongly significant for African Americans and First Nations shares and mostly insignificant otherwise. Some occupations are strongly correlated with local mortality like "Healthcare Support Occupations, which includes occupations such as Home Health Aides, Nursing Assistants, and Orderlies. […] It is not surprising that the more healthcare professionals there are in a county the more COVID-19 may spread for a great many reasons, but what may be surprising is that only the support staff have a strong correlation with mortality, and not […] the actual doctors and nurses. A similar observation applies to […] Personal Care and Support Occupations, which includes among others barbers, manicurists, and fitness instructors" (144).

Wanberg et al. (2020) conducted a retrospective cohort study of 1,143 adults in the USA on SES and well-being during April to June of the COVID-19 pandemic. They based the study both on the Fundamental Causes of Disease (23) and the theory of conservation of resources (145) which are linked to socioeconomic status. They looked for four resource-based mechanisms underlying the relationship between SES and well-being levels and changes. They operationalized SES as educational attainment as a proxy for human capital and household income as a proxy for material capital. The resource-based mechanisms were: Perceived financial resources, perceived control, interpersonal resources, and COVID-19-related knowledge/news consumption. Depression was a proxy for decreased well-being, life satisfaction a proxy for increased well-being. Occurrence of depression was negatively associated to income. Income was positively associated with life satisfaction during this time. Also, income was positively associated to each of the resource-based mechanisms. Income was positively related to perceived financial resources, perceived control, interpersonal resources, and COVID-related news consumption. Education was positively related to COVID-related knowledge, but COVID-related knowledge was not a significant mediator of the relationships between education and depressive symptoms or life satisfaction. Furthermore, "each of these resources mediated the relationship between income and depressive symptoms and life satisfaction during COVID-19" (146).

Emeruwa et al. (2020) collected data on the inequality of the number of infected pregnant women with regard to the environment and neighborhood. For this cross-sectional study they used demographic and socioeconomic data from the US Census Bureau’s American Community Survey and compared it to real estate data from the New York's department of City Planning. The intervention was to test on SARS-CoV-2 and to compare it to the neighborhood data. Of the 396 patients linked to buildings and neighborhoods in the city, 71 were infected with SARS-CoV-2. The socioeconomic indices included: Number of residential units per building and mean assessed value, median household income, poverty rate, unemployment rate, population density, household membership, and household crowding (percentage of households with >1 person per room). They found the lowest probability of infection in neighborhoods with highly assessed building value. High income neighborhoods were also negatively associated with numbers of infection. There was, in addition, a positive association between the unemployment rate and the number of infections. No significant association, however, was found regarding poverty rate. Results show that neighborhoods with multiple household members have highest probability of infection, and that it was positively associated with number of household members and household crowding. However, no specific association was found between COVID-19 incidence rates and population density (147).

An ecological study by Abedi et al. (2020) conducted an analysis of 369 US counties and published on May 4th of 2020. They examined the association between infection and mortality rate of COVID-19 and demographic, socioeconomic, and mobility variables. Included were the seven most affected states. The examination consisted of an analysis of population characteristics along with COVID-19 infection and mortality rates from USAfacts and the US Census Bureau for COVID-19 cases and county-level demographic data. They collected data on total population, mobility, race, poverty level, median income, education, disability, and rate of the insured population at county-level. Surprisingly, counties with higher income levels had higher infection rates. However, counties with higher poverty rates had higher death rates. As mentioned in previous aspects, mortality was significantly increased for populations of lower SES. This was the case for counties with a higher proportion of African Americans, who were more vulnerable compared to White and other minorities. "Counties with a higher population […] a higher median income […], and a more diverse population (higher percentage of Hispanics, Asians, and Blacks) have a higher rate of infection." However, counties with a smaller population, higher poverty levels, and higher disability have a higher rate of mortality. "Protective factors for the counties are […] a higher education level with a bachelor's degree or higher with an odds ratio ranging from − 0.41 to − 0.03 across the various ethnicities. [Another] protective factor was median income (est. − 0.27, 95% CI − 0.41, − 0.12, q < 0.003). […] Factors significantly associated with higher mortality in the counties analyzed include a higher percentage of people under the poverty level […]. [H]igher income and education, […] and a higher rate of the insured population have a significantly lower than the median death rate. [Finally,] counties with higher death rates have lower median income and higher poverty levels across all the races" (148).

Khazanchi et al. (2020) performed a county-level, cross-sectional analysis on the association of social vulnerability with COVID-19 cases and deaths in the USA. They stratified counties into quartiles using the U.S. Centers for Disease Control's Social Vulnerability Index (SVI). It includes data on aspects of SES, household composition and disability, minority status and language, and housing and transportation of over 612,000 infected people. The most vulnerable counties by SES had a 1.63-fold greater risk of infection and 1.73-fold risk to die from COVID-19. However, "[t]hese trends persisted among urban counties alone. Among rural counties alone […] associations with overall SVI, [and] socioeconomic status […] were no longer significant" (149).

In the US study by Hatef et al. (2020) they conclude, three of the examined states with higher Area Deprivation Index (ADI) have significantly more COVID-19 cases, without adjustments. They conducted an ecological study across seven states in the period of May 3rd to May 30th and collected data at the neighborhood aggregation level. They used ADI data from the American Community Survey, which includes aspects like occupation and educational attainment among the neighborhoods. Two States still have higher Infection rates, when adjustments for underlying demographics were made. "[Z]ip-codes with higher ADI (more disadvantaged neighborhoods) in those states had higher COVID-19 prevalence compared to zip-codes across the country and in the same state with lower ADI (fewer disadvantaged neighborhoods)" (150).

Hawkins et al. (2020) conducted an ecological study on SES and COVID-19 related cases and fatalities. This cohort included 1,089,999 US citizen cases in 3,127 counties. Data was collected at the county level with the indices of Distressed Communities Index which includes metrics of the SES. They found that severely distressed counties had significant fewer deaths in total but higher numbers of deaths per 100,000 citizens. Severely distressed they defined as point values below 75, and they gave points for the extent of metrics like median household income, adults not working, and poverty rate. "In risk-adjusted analysis, the two socioeconomic determinants of health with the strongest association with both higher cases/100,000 and higher fatalities/100,000 were percent of adults without a high school degree (cases: RR 1.10; fatalities: RR 1.08) and proportion of black residents (cases and fatalities: RR 1.03)" (151).

Khan et al. (2021) had similar findings examining the impact of SES on outcome in hospitalized patients with COVID-19 infection. They compared 172 hospitalized coronavirus disease patients, divided in low and high SES group. They used the Scottish index for multiple deprivation to divide patients into the groups. They defined poor outcome as either need for intubation and/or death. No impact of SES on the outcome they found except for time to discharge. People of low SES on average left the hospital 7 days later than those with higher SES (108).

Mollalo et al. (2020) used geographical information system-based spatial modelling to examine COVID-19 incidence rates in the continental US. They support findings that income inequality and median household income being positively associated with COVID-19 incidence rates. Also, they found a positive association between the percentage of workers in the nursing profession and the COVID-19 incidence rate among counties (152).

4.1.6 Preprint Studies on Education, Occupation, and Income

Several studies of this selection examined the influence of education, occupation, and income on the socioeconomic differences in the number of infections, respectively case fatality. Unlike the studies for the main part, they often focused on either infection rates or case fatality. Therefore, a separate view on these variables was possible.

Infection Rates

Maroko et al. (2020) compared ethnical aspects and the SES of New York and Chicago with the infection rates. Areas of low infection rates, so called cold spots, showed typical signs of protecting SDoH. "These neighborhoods tended to be wealthier, have higher educational attainment, higher proportions of non-Hispanic White residents, and more workers in managerial occupations." Hot spots (clusters of high infection rates per ZIP code) tended to have lower rates of college graduates and higher proportions of people of color (153).

Liu et al. (2020) examined the trajectory of COVID-19 infections and local variation in socioeconomic and health disparities in England. They found that "regions with greater socioeconomic deprivation and poorer population health measures showed a faster rise in COVID-19 cases and reached higher peak case levels". Case trajectory over the period of January to May was correlated to "higher multiple deprivation scores ($p<0.001$)" (154).

Nayak et al. (2020) conducted an ecological study on the impact of social vulnerability on COVID-19 incidence and outcomes in the United States. They state that case fatality rates and infection rates were significantly higher in counties with lower SES. The increased SVI per county was associated with 63% higher case fatality rate and robust for age and comorbidities (155).

Takagi et al. (2021) did a meta-regression of COVID-19 prevalence/fatality on socioeconomic characteristics of data from top 50 US large cities. They concluded that COVID-19 prevalence was positively associated to unemployment and poverty. The same occurred to case fatality. Furthermore, they supported the view that COVID-19 prevalence is in inverse relation to educational attainment, as well as computer and internet use (156).

Whittle et al. (2020) did an ecological study of socioeconomic predictors in detection of COVID-19 cases across neighborhoods in New York City. They found the infection rates in an inverse relation to median household income; a decrease of $10,000 income came along with 2.5% higher risk of infection (157).

Snyder et al. (2020) postulate that the pandemic behaves geographically different because of varying vulnerability factors across counties. Vulnerability indicators of this study include, among others, social, health, economic, and environmental factors. They performed this study to examine regional differences across contiguous United States. As stated in Chapter 2.2.7, SDoH explain how structures upstream interact with the health of people. In this study, aspects of SDoH were considered as indicators of vulnerability. Usually, SDoH were considered "factors [,] that determine the health of the individuals within a community" (22, 158). New to this study was, however, the idea that "in the case of the Covid-19 pandemic, the social determinants of health and the social determinants of vulnerability to Covid-19 overlap". They state that "[r]esearch on the social determinants of health has often been separated from research on vulnerability to natural hazards". Methodically, socioeconomic data was collected to analyze the geographic extent of poverty, the SES, and the Gini coefficient in relation to the number of infections. These indicators were used to examine inequalities in four dimensions: ecological, social, health, and economic. While the poverty line describes how many people live in financial deprivation, the Gini coefficient enables a quantitative assessment of how wealth is distributed. Therefore, it is possible to see how different resources are available within the community. Results showed the expected relations: "The health, ecologic, and social vulnerability all show high levels of vulnerability in the Southeastern US. When the[se] four dimensions are aggregated, counties in the Southeast US appear especially vulnerable to Covid-19, while those in the Great Plains and Mountain West appear less vulnerable. […] This suggests that social variables might impact disease" (158).

Case Fatality

Wiemers et al. (2020) highlight significant disparities in COVID-19 vulnerability based on SES and race-ethnicity, using data from the Panel Study of Income Dynamics (PSID). Their findings show that lower-income, less-educated individuals, and non-Hispanic Blacks face a much higher risk of severe COVID-19 complications, largely due to a higher prevalence of preexisting conditions like hypertension and diabetes. Lower-income individuals were found to be 2.7 times more likely to experience severe complications compared to wealthier groups, underscoring the critical need for targeted health interventions during the pandemic (159).

Also, poverty was significantly associated to the inter-county variation of susceptibility. Especially the Southeastern region showed high proportions of at-risk populations. According to Chin et al. (2020), poverty increases the vulnerability to COVID-19 because of multiple accompanying phenomena. For instance, due to its association with comorbidities, decreased access to care, and reduced ability to practice social distancing (160).

Lamb et al. (2021) conducted a study on the relationship between socioeconomic factors, mobility, and COVID-19 case positivity in New York City neighborhoods. They found that socioeconomic markers, such as household size, insurance coverage, and race, explained a significant portion of the variability in COVID-19 positivity rates across different ZIP codes. Lower-income neighborhoods with larger household sizes had higher case positivity rates. Mobility changes initially played a role, as ZIP codes with smaller reductions in mobility had higher positivity rates early in the pandemic. However, mobility did not act as a significant mediator between SES and infection risk, with uninsured rates remaining the strongest predictor of case positivity (161).

In another study, Patel et al. (2020) used the Townsend Deprivation Index (TDI) and household income as measures of socioeconomic status to assess COVID-19 hospitalizations across England. The results indicated that both higher TDI and lower household income were significantly associated with increased hospitalization rates, with Black and Asian individuals at the highest risk. The study, conducted using the UK Biobank cohort, showed an odds ratio of 3.7 (95% CI: 2.5-5.3) for Black participants and 2.2 (95% CI: 1.5-3.2) for Asian participants compared to their White counterparts (162).

Prats-Uribe et al. (2020) conducted a cohort study using data from 415,582 participants from the UK Biobank to assess the relationship between ethnicity, SES, and COVID-19 infection risk. Using multivariable Poisson regression, the study found that individuals from the most deprived socioeconomic quintile had an adjusted relative risk (RR) of 1.93 (95% CI: 1.51-2.46) for testing positive for COVID-19, compared to those from less deprived groups. The study also controlled for factors such as age, sex, comorbidities, smoking, and body mass index (163).

4.2 Results of the Systematic Review and Meta-Analysis

4.2.1 Study Characteristics

For the period ending May 31, 2022, a total of 6,969 articles – 6,724 from searches on databases, 203 articles from registries, and 42 articles by citation chaining – were identified. After removing duplicates and screening titles, abstracts, and full texts in a four-eyed principle, 41 studies were found, 31 of which were included for meta-analysis. Table 3 shows the main characteristics of the publications. Twenty-six studies were conducted in the United Kingdom, nine in the United States, two in Italy, and one each in Hungary, Ireland, France, and Brazil. The setting of the studies varied between community-based and hospital-based. Twenty-seven cohort studies, among others, (162, 164-170), 11 ecological studies, among others, (167, 171-180), and 3 cross-sectional studies (181-183) were included. To see the full list, go to Supplementary Table 1.

Table 3: Study Characteristics and Main Findings of the Systematic Review

Study	Country	Setting	Outcomes	Relevant Findings
Index of Multiple Deprivation				
Bach-Mortensen, 2021	UK	Care homes	COVID-19 deaths	COVID-19-related deaths were more common in the most deprived quartiles compared with the least deprived quartiles.
Baumer, 2020	UK	Hospital	% admitted to ICU	From the least deprived quintile, only 6 patients were admitted to ICU, while 22 patients of the most deprived quintile were admitted to ICU.
Beaney, 2022	UK	Community	Hospital admission and mortality	People living in less deprived areas had lower odds of both admission and mortality compared to those in the most deprived areas.
Bhaskaran, 2021	UK	Community	COVID-19 deaths	Deprivation was more strongly associated with COVID-19 death than non-COVID death.
Brainard, 2021	UK	Community	COVID-19 deaths	Greater deprivation did not correlate with excess case counts but was significantly linked to higher mortality rates after infection.
Bray, 2020	UK	Community	COVID-19 deaths	Weak positive association of median IMD and mortality rate.
Chaudhuri, 2021	UK	Community	COVID-19 deaths	In local authority districts with the highest deprivation quartile, (...) there is a significantly higher age-adjusted COVID-19 mortality compared to respective control populations.
Ferrando-Vivas, 2021	UK	Hospital	COVID-19 deaths	Significant associations for death within 30 days were identified for deprivation.
Gray, 2021	UK	Hospital	In-hospital-mortality	The relationship between deprivation and in-hospital mortality was relatively weak.
Griffith, 2021	UK	Community	COVID-19 deaths	Higher relative deprivation is associated with increased COVID-19 mortality.
Khan, 2021	UK	Hospital	COVID-19 deaths	SES does not influence the outcome in hospitalized patients with COVID-19, however it negatively impacts length of stay.
Kontopantelis, 2021	UK	Community	COVID-19 deaths	The most deprived areas had the highest rates of death attributable to COVID-19 and other indirect deaths. There was also a clear deprivation gradient in excess deaths.
Kontopantelis, 2022	UK	Community	Excess years of life lost	Strong deprivation gradient for years of life lost due to COVID-19.
Navaratnam, 2021	UK	Community	In-hospital-mortality	The number of admissions increased substantially with deprivation. Significant predictors of in-hospital death included greater deprivation.
Singh, 2021	UK	Community	Hospitalization	For death in the community, a significant effect showing an increased mortality rate was only seen in the most deprived quintile.
Soltan, 2021	UK	Hospital	COVID-19 deaths	Patients were more likely to be admitted to ICU if domiciled from the most deprived quintile, compared with patients admitted from all other respective quintiles.
Thompson, 2020	UK	Hospital	COVID-19 deaths	No independent association between death and deprivation level.
Watson, 2021	UK	Hospital	Hospitalization	Socioeconomic deprivation was strongly associated with COVID-19 hospitalization rates.
Williamson, 2020	UK	Community	COVID-19 deaths	COVID-19-related death was associated with deprivation (strong gradient).
Area Deprivation Index				

Adjei-Fremah, 2022	USA	Com-munity	Mortality	ADI has an impact on COVID-19 transmission but not mortality in the District of Columbia.
Barnard, 2021	UK	Com-munity	COVID-19 deaths	Among those aged under 75 years, excess mortality was clearly associated with area deprivation.
Breen, 2021	UK	Com-munity	COVID-19 deaths	Areas with higher social deprivation have a higher COVID-19 mortality rate, but the association is much weaker than between social deprivation and mortality rates more generally.
Eden, 2021	USA	Com-munity	COVID-19 deaths	High deprivation was associated with higher death rates.
Hu, 2021	USA	Hospi-tal	COVID-19 deaths	Patients who lived in the most disadvantaged neighborhood quintile were more likely to die during hospitalization than patients living in the least disadvantaged neighborhoods.
Ingraham, 2021	USA	Hospi-tal	Hospitalization	No statistical difference in hospitalization of White patients of first to fifth ADI quintile, but in other ethnics (Black, Asian, His-panic). Neighborhood-level deprivation was not associated with severe COVID-19.
Walls, 2022	USA	Com-munity	Hospital admission, ICU ad-mission, 30-day-mortality	ADI was associated with adverse COVID-19 outcomes.
Social Deprivation Index				
De Souza, 2020	Brazil	Com-munity	COVID-19 deaths	The mortality rate for most deprived municipalities was 1.2 times higher than the state rate. The CFR was 1.42 times higher in the municipalities with very high social deprivation, when compared with those with low deprivation.
Ossimetha, 2021	USA	Com-munity	COVID-19 deaths	SARS-CoV-2 related deaths were higher for counties with higher social deprivation index levels.
Zhang, 2021	USA	Com-munity	COVID-19 deaths, hospitali-zation	Patients with disadvantaged social conditions had higher risk for hospitalization and mortality.
Italian Deprivation Index				
Di Girolamo, 2020	Italy	Com-munity	COVID-19 deaths	Both overall and COVID-19 age-standardized mortality rates were greater among those living in the most disadvantaged ver-sus most advantaged census blocks, irrespective of the socioeconomic attribute used.
Mateo-Urdiales, 2020	Italy	Com-munity	COVID-19 deaths, hospitali-zation	No differences in case-hospitalization and case-fatality according to deprivation were observed in any period under study.
Townsend Deprivation Index				
Foster, 2022	UK	Com-munity	Mortality, adverse outcomes	Compared with low deprivation, participants in the high deprivation group had higher risk of COVID-19 outcomes across the lifestyle score.
Patel, 2020	UK	Com-munity	Hospitalization	Participants with greater Townsend Deprivation Indices were at substantially higher risk of COVID-19 hospitalization
Woodward, 2021	UK	Com-munity	COVID-19 deaths	Greater social deprivation was associated with greater risk of fatal COVD-19.
French Deprivation Index, French European Deprivation Index				
Beaumont, 2022	France	Hospi-tal	Hospital admission and ad-verse clinical outcome	No association between hospitalization and socioeconomic deprivation and no association between geographical origin or soci-oeconomic deprivation and severity.
Income Deprivation and Health Deprivation and Disability				
Congdon, 2021	UK	Com-munity	COVID-19 deaths	The low impact of income deprivation is counter to preliminary hypothesized expectations, suggesting its effect may be medi-ated by other predictors.
USA National Deprivation Index				

Escobar, 2021	USA	Com-munity	COVID-19 deaths, hospitali-zation	Median NDI among hospitalized patients was slightly higher than among study cohort.
Pobal HP Deprivation Index				
Farrell, 2021	Ireland	Hospi-tal	COVID-19 deaths, ICU-admittance	Deprivation was a strong predictor of mortality.
Utah's Health Improvement Index				
Lewis, 2020	USA	Hospi-tal	Hospitalization	Compared with patients living in very low-deprivation areas, the odds of hospitalization were significantly higher for those resid-ing in low-, average-, high-, or very high- deprivation areas.
Socioeconomic Deprivation Index				
Lone, 2021	UK	Hospi-tal	COVID-19 deaths	Higher proportion of patients admitted to hospital from more deprived areas, mortality was significantly higher in patients from the most deprived quintile, ICUs serving populations with higher levels of deprivation spent a greater amount of time over their baseline ICU bed capacity.
Deprivation Index from Hungarian Census Data				
Oroszi, 2021	Hungary	Com-munity	COVID-19 deaths	The excess death rate increased with deprivation levels.

4.2.2 Deprivation and COVID-19 Outcomes

Data on death due to COVID-19, hospitalizations, and ICU admissions were collected and analyzed with respect to the association with deprivation. The overall result of the studies showed a socioeconomic gradient indicating higher disease severity with increasing deprivation index levels. Thirty-three studies indicated clear associations in this regard. Of these, 27 studies showed that people from socially deprived backgrounds were more likely to die from COVID-19 than people from the least deprived populations (162, 164-171, 174, 176-180, 182-196).

In addition, nine research groups measured higher hospitalization rates for COVID-19 in deprived populations (162, 164-167, 170, 185, 187, 194). Five studies used ICU admission as an indicator of severe outcomes and demonstrated a positive association with high deprivation or ethnic minorities living in deprived areas (165, 166, 187, 188, 197).

Khan et al. (2021) conducted a study in three Scottish hospitals and found that deprivation had no impact on outcomes in hospitalized patients with COVID-19 but had a negative impact on the length of stay. People with a high deprivation index stayed in the hospital an average of 7 days longer until discharge compared with those who were less deprived (108).

Unexpected results found Ingraham et al. (2021). Neighborhood disadvantage was not significantly associated with severe COVID-19. However, differential relations were measured among ethnic groups. While whites were not prone to hospitalization, patients from black, Asian, and Hispanic backgrounds were more likely to require hospital monitoring if they resided in the most deprived quintile of ADI (198).

Congdon et al. (2021) refuted their hypothesis because there was no association between deprivation and COVID-19 deaths. However, they suggest mediation by certain factors. Their regression analysis shows that health deprivation is a mediator in the impact of income level on mortality. The included studies did not reveal any other findings on mediator variables (175).

Three studies showed a weak association. Bray et al. (2020) reported a weak association between deprivation and mortality at the local authority level and Gray et al. (2021) in individuals who died in hospital with COVID-19 (172, 199). Breen et al. (2021) noted that the association was apparent but significantly weaker than the overall excess mortality of people in social deprivation (173). Five studies reported finding no association between deprivation and adverse outcomes (181, 198, 200-202).

4.2.3 Strength of Association

Results from nine studies (177-180, 182-184, 190, 201) were analyzed and found an overall RR of 1.5 (95% CI 1.3-1.7, p < 0.01) for worse outcomes in groups with high deprivation scores compared to those living in low deprivation. Figure 7 shows a forest plot of this analysis. Seventeen studies (108, 162, 164-166, 170, 185-187, 191, 194-196, 198-200, 202) reported an OR for their analysis (Figure 8). They provide an overall OR of 1.3 (95% CI 1.2-1.5, p < 0.01) for unfavorable outcomes in the most deprived groups compared to the least deprived. Seven studies (168-170, 188, 189, 198, 200) that used a hazard ratio (Figure 9) showed the largest statistical effect with an HR of 1.7 (95% 1.2-2.3, p = 0.01).

Study or Subgroup	log[Risk Ratio]	SE	Weight	Risk Ratio IV, Random, 95% CI
Bach-Mortensen 2021	0.1484	0.0757	10.0%	1.16 [1.00, 1.35]
Barnard 2021	0.131	0.009	11.2%	1.14 [1.12, 1.16]
Di Girolamo 2020, men	0.3293	0.0708	10.1%	1.39 [1.21, 1.60]
Di Girolamo 2020, women	0.4383	0.0781	9.9%	1.55 [1.33, 1.81]
Eden 2021	0.1823	0.0262	11.0%	1.20 [1.14, 1.26]
Foster 2022	1.7951	0.1241	8.4%	6.02 [4.72, 7.68]
Griffith 2021	0.1266	0.3036	3.7%	1.13 [0.63, 2.06]
Mateo-Urdiales 2020	-0.0834	0.1042	9.1%	0.92 [0.75, 1.13]
Oroszi 2021, men	0.239	0.0462	10.7%	1.27 [1.16, 1.39]
Oroszi 2021, women	0.2776	0.0486	10.7%	1.32 [1.20, 1.45]
Ossimetha 2021	1.6273	0.2289	5.3%	5.09 [3.25, 7.97]
Total (95% CI)			**100.0%**	**1.51 [1.31, 1.74]**

Heterogeneity: $Tau^2 = 0.05$; $Chi^2 = 258.32$, df = 10 (P < 0.00001); $I^2 = 96\%$
Test for overall effect: Z = 5.76 (P < 0.00001)

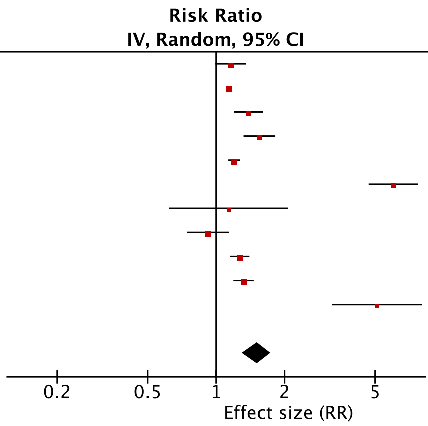

Figure 7: Risk Ratio for Adverse Outcomes in Populations of High vs. Low Deprivation

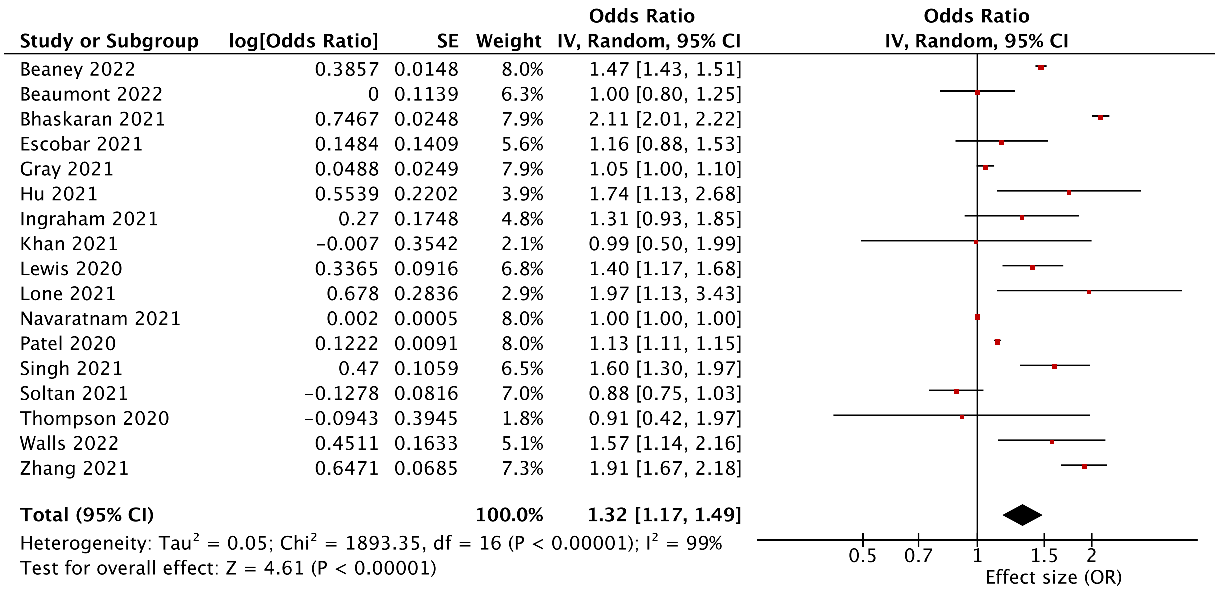

Figure 8: Odds Ratio for Adverse Outcomes in Populations of High vs. Low Deprivation

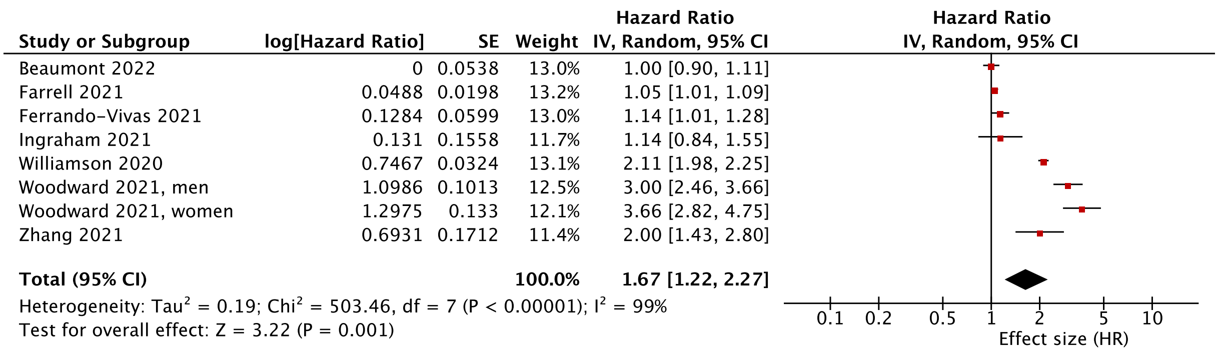

Figure 9: Hazard Ratio for Adverse Outcomes in Populations of High vs. Low Deprivation

4.2.4 Subgroup and Sensitivity Analysis

In the course of this analysis, very high heterogeneity was observed across the included studies. As noted in the methods section, heterogeneity is considered substantial when the I^2 statistic exceeds 50%. The I^2 values reported in Figure 7 (Risk Ratio), Figure 8 (Odds Ratio), and Figure 9 (Hazard Ratio) indicate substantial heterogeneity, with values ranging from 96% to 99%. This significant variability among the studies could not be explained by chance alone, demanding the need for a subgroup and sensitivity analysis.

Because of the heterogeneity in the primary analysis, a subgroup analysis was performed to further assess the sources of variability. The included studies varied in their settings, posing a potential risk of bias. To address this, a statistical effect size for seven studies conducted in a *community setting* was assessed, as shown in Figure 10. The overall odds ratio for these community studies was 1.4 (95% CI: 1.2-1.7), indicating a higher risk of adverse COVID-19 outcomes in populations from more deprived backgrounds. Similarly, the effect size for 10 studies conducted in *hospital settings* was assessed, as shown in Figure 11, with an overall OR of 1.2 (95% CI: 1.0-1.4). These findings suggest that the impact of deprivation on COVID-19 outcomes is slightly stronger in community settings compared to hospital settings.

To further validate the findings, this sensitivity analysis was conducted. By stratifying the studies based on key variables, such as community versus hospital settings, and performing sensitivity tests, the subgroup analysis helped to mitigate the impact of bias and confirm the robustness of the overall findings. This analysis provided a clearer understanding of how socio-economic deprivation influences COVID-19 outcomes, highlighting the importance of setting-specific factors in interpreting the data.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Beaney 2022	0.3857	0.0148	15.5%	1.47 [1.43, 1.51]
Beaumont 2022	0	0.1139	0.0%	1.00 [0.80, 1.25]
Bhaskaran 2021	0.7467	0.0248	15.4%	2.11 [2.01, 2.22]
Escobar 2021	0.1484	0.1409	11.1%	1.16 [0.88, 1.53]
Gray 2021	0.0488	0.0249	0.0%	1.05 [1.00, 1.10]
Hu 2021	0.5539	0.2202	0.0%	1.74 [1.13, 2.68]
Ingraham 2021	0.27	0.1748	0.0%	1.31 [0.93, 1.85]
Khan 2021	−0.007	0.3542	0.0%	0.99 [0.50, 1.99]
Lewis 2020	0.3365	0.0916	0.0%	1.40 [1.17, 1.68]
Lone 2021	0.678	0.2836	0.0%	1.97 [1.13, 3.43]
Navaratnam 2021	0.002	0.0005	15.6%	1.00 [1.00, 1.00]
Patel 2020	0.1222	0.0091	15.5%	1.13 [1.11, 1.15]
Singh 2021	0.47	0.1059	12.7%	1.60 [1.30, 1.97]
Soltan 2021	−0.1278	0.0816	0.0%	0.88 [0.75, 1.03]
Thompson 2020	−0.0943	0.3945	0.0%	0.91 [0.42, 1.97]
Walls 2022	0.4511	0.1633	0.0%	1.57 [1.14, 2.16]
Zhang 2021	0.6471	0.0685	14.2%	1.91 [1.67, 2.18]
Total (95% CI)			**100.0%**	**1.44 [1.21, 1.71]**

Heterogeneity: $Tau^2 = 0.05$; $Chi^2 = 1852.34$, df = 6 ($P < 0.00001$); $I^2 = 100\%$
Test for overall effect: $Z = 4.11$ ($P < 0.0001$)

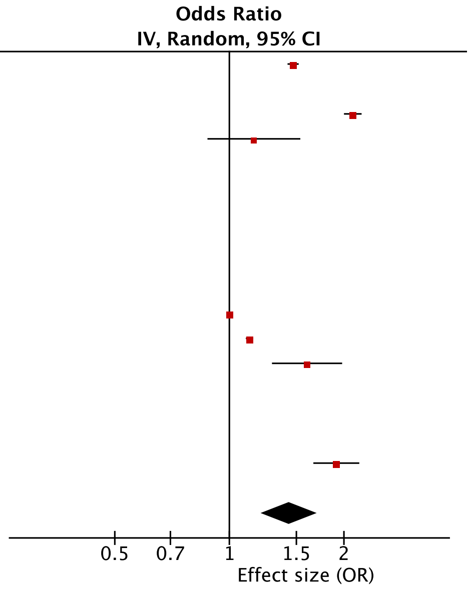

Figure 10: Comparison of Adverse COVID-19 Outcomes Between High and Low Deprivation Populations in Community Settings

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Beaney 2022	0.3857	0.0148	0.0%	1.47 [1.43, 1.51]
Beaumont 2022	0	0.1139	13.2%	1.00 [0.80, 1.25]
Bhaskaran 2021	0.7467	0.0248	0.0%	2.11 [2.01, 2.22]
Escobar 2021	0.1484	0.1409	0.0%	1.16 [0.88, 1.53]
Gray 2021	0.0488	0.0249	18.8%	1.05 [1.00, 1.10]
Hu 2021	0.5539	0.2202	7.1%	1.74 [1.13, 2.68]
Ingraham 2021	0.27	0.1748	9.2%	1.31 [0.93, 1.85]
Khan 2021	−0.007	0.3542	3.5%	0.99 [0.50, 1.99]
Lewis 2020	0.3365	0.0916	14.8%	1.40 [1.17, 1.68]
Lone 2021	0.678	0.2836	5.0%	1.97 [1.13, 3.43]
Navaratnam 2021	0.002	0.0005	0.0%	1.00 [1.00, 1.00]
Patel 2020	0.1222	0.0091	0.0%	1.13 [1.11, 1.15]
Singh 2021	0.47	0.1059	0.0%	1.60 [1.30, 1.97]
Soltan 2021	−0.1278	0.0816	15.5%	0.88 [0.75, 1.03]
Thompson 2020	−0.0943	0.3945	3.0%	0.91 [0.42, 1.97]
Walls 2022	0.4511	0.1633	9.9%	1.57 [1.14, 2.16]
Zhang 2021	0.6471	0.0685	0.0%	1.91 [1.67, 2.18]
Total (95% CI)			**100.0%**	**1.20 [1.03, 1.38]**

Heterogeneity: $Tau^2 = 0.03$; $Chi^2 = 31.84$, df = 9 (P = 0.0002); $I^2 = 72\%$
Test for overall effect: Z = 2.42 (P = 0.02)

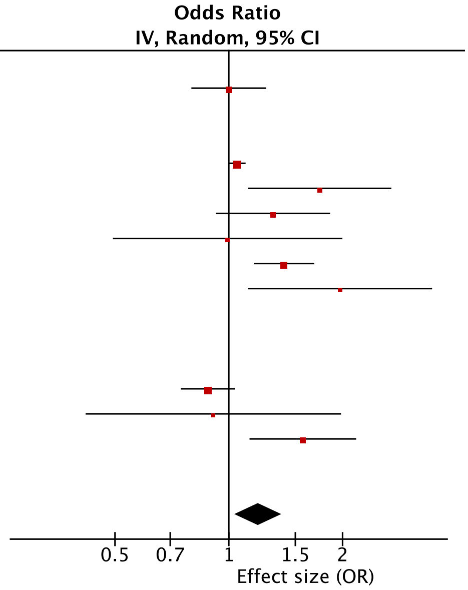

Figure 11: Comparison of Adverse COVID-19 Outcomes Between High and Low Deprivation Populations in Hospital Settings

4.2.5 Quality Assessment

The quality analysis of the included studies was based on the study design using the Joanna Briggs Institute's critical appraisal tools (62). The exact results can be found in Supplementary Table 1 in the Appendix. Overall, the results were positive, with no study that had to be excluded due to poor quality. The quality of cross-sectional and ecological studies was good: 70% used appropriate statistical analyses, measured outcomes validly and reliably, and identified confounding factors. The quality of the cohort studies was satisfactory: 55% met the above points, and 45% of the studies had appropriate ways of handling follow-up.

5 DISKUSSION

5.1 Discussion of the Narrative Review

The objective of this narrative review was to examine the extent to which socioeconomic status is associated with the severity and incidence of COVID-19 infections. The literature suggests a pronounced disparity in health outcomes during the COVID-19 pandemic, with studies from the UK and the USA consistently showing the unequal distribution of infection rates and mortality across different SES groups. Various indicators of SES, such as income, education, and occupation, were used across studies, reflecting the early and diverse stages of data collection during the pandemic. The discussion section of this review aims to consolidate these findings to provide a clearer understanding of how SES impacts COVID-19 outcomes, thereby contributing to the broader discourse on health inequalities exacerbated by the pandemic. The discussion will be proceeded by topic, from the weakest to the strongest argument.

5.1.1 Income, Education, and Occupation

Much of the existing evidence centers on income disparities and their impact on COVID-19 outcomes. Studies have repeatedly demonstrated that individuals with lower income levels faced higher infection rates and worse health outcomes. For example, lower-income groups experienced more significant increases in mental health issues, such as depression, during the pandemic (146). In addition, income was found to be a critical factor influencing life satisfaction, with those earning less suffering a greater decline in life quality as a result of the pandemic's stresses.

Seligman's model of learned helplessness (1972) provides a useful framework to understand these phenomena. The model suggests that repeated exposure to negative experiences—such as financial struggles or job insecurity—can lead individuals to believe they have little control over their situation (203). This sense of helplessness was particularly pronounced in lower-income groups during the pandemic, where limited resources compounded their vulnerability. Resources, which act as mediators between income and well-being, played a significant role in determining individuals' ability to cope with the pandemic, echoing the findings of Wanberg et al. (2020) and supporting Phelan & Link's theory on the fundamental causes of disease (FCoD). The flexibility of resources, including income, allows for better health management even when risk factors change over time (204).

Beyond the context of COVID-19, income has long been established as a determinant of health outcomes. In the Jackson Heart Study, for instance, "John Henryism"—a coping mechanism used to manage prolonged stress, particularly in African American men—was shown to modify the relationship between income and hypertension (205, 206). It is a strategy for coping with prolonged stresses such as social discrimination that lead to an accumulation of physiological adversity (85). This further supports the idea that income disparities have a profound and lasting impact on health, not just in relation to the pandemic but also in other chronic conditions.

When examining COVID-19 specifically, geographic models from the U.S. found that income inequality and occupational status were among the top factors significantly influencing infection rates (158). Similar trends were observed in Germany, where wealthier populations initially had higher infection rates due to increased mobility. However, this trend reversed over time, with lower-income groups experiencing more severe outbreaks (97).

Initially, it may seem contradictory that wealthier individuals exhibited higher infection rates, largely due to greater mobility (e.g., travel or vacations). However, over time, lower-income populations experienced the worst impact of the pandemic's effects, particularly in terms of mortality, due to their more limited access to healthcare and resources (207). Moreover, socioeconomic disparities in health literacy, access to health services, and living conditions—such as overcrowded housing—further contributed to the worsening health outcomes for lower-income groups (208).

In this context, Big Data analyses have shown that human mobility patterns can serve as a proxy for socioeconomic development, as highlighted by Pappalardo et al. (2015). Their study demonstrated how mobility diversity—defined as the range and variety of locations visited—correlates with socioeconomic indicators, such as wealth and education (209). Such studies indicate that mobility diversity, not just the volume of movement, plays a crucial role in understanding how SES impacts exposure to risks, including those associated with pandemics.

In addition, studies have shown that smaller populations with higher poverty rates tend to have a higher case fatality rate, likely due to the difficulty these groups face in accessing necessary resources. Hawkins et al. (2020) found that although distressed communities reported lower absolute case numbers, they had a higher mortality rate per 100,000 inhabitants. This aligns with earlier findings on socioeconomic inequalities and access to healthcare, as explored in Chapter 2.2.6. The reduced availability of healthcare and lower health literacy in these communities exacerbate their vulnerability (151, 207). In contrast, areas with a higher median income were negatively associated with infection risks, reflecting the protective effects of wealth and access to healthcare (147, 148).

The pattern of socioeconomic disparities observed in COVID-19 mirrors what was seen during previous pandemics, such as the H1N1 outbreak in 2009. Lowcock et al. (2012) found that hospitalization during the H1N1 pandemic was associated with several key social determinants of health, including having a high school education or less and living in a neighborhood with high levels of material deprivation (19). Similarly, during COVID-19, populations with higher education levels showed protective factors against the risk of death (148), highlighting the role of education in promoting health literacy and access to healthcare services (146).

These findings confirm the theoretical considerations regarding health behavior and literacy discussed in Section 4.1.3, where higher education and income levels positively influence access to and utilization of healthcare services, ultimately leading to better health outcomes during pandemics. The consistency of these patterns across different pandemics underscores the urgent need to address these social determinants of health in future public health interventions.

Depression and Mental Health

The connection between low income and mental health challenges, particularly depression, became more pronounced during the pandemic. Depression rates rose significantly among low-income groups, who were more likely to face additional stressors such as job loss or the inability to work from home (146). These stressors deepened pre-existing health inequalities, as those with fewer financial resources faced increased difficulties managing both their physical and mental health during the pandemic.

Furthermore, studies show that low-income individuals face heightened mental health challenges, which serve as mediators between SES and physical health outcomes. This lack of financial resources, combined with reduced access to healthcare, left individuals in lower SES groups more vulnerable to both the immediate and long-term effects of the pandemic.

The findings of this narrative review, including those highlighted in the study by Abedi et al. (2020), further demonstrate the role of racial and socioeconomic disparities in shaping COVID-19 outcomes. Abedi et al. found that counties with higher poverty rates and a larger percentage of African American residents had higher COVID-19-related death rates, while wealthier counties experienced lower infection and mortality rates (148). These results align with the general pattern observed in this review, reinforcing the idea that low-income and marginalized communities have faced disproportionately worse outcomes during the pandemic due to underlying social determinants of health.

5.1.2 Vulnerability and Exposure

Many factors of deprivation overlap with those of socioeconomic status. Deprivation refers to the absence or lack of resources and opportunities necessary for individuals to maintain a standard of living that allows for good health and well-being. It encompasses various dimensions, such as economic, environmental, and social factors, that contribute to poor health outcomes. Material deprivation specifically involves the lack of basic physical necessities such as housing, food, and healthcare. In view of the findings from Section 2.2.4, some results can confirm this theory and previous evidence.

Vulnerable communities were at higher risk of infection and case mortality (149). Studies have also shown that a higher deprivation index was associated with more COVID-19 cases. This relationship still existed after adjustment for demographic factors such as age and gender (150). The first-mentioned relationship, however, only applied to the urban districts. At the rural level, the significance was not robust against adjustments. Infectious, statistical, and economic-epidemiological points of view could explain this. Rural districts had fewer total numbers of infections, especially at the beginning of the pandemic, and therefore nominally had fewer deaths (210).

In addition, it is intuitive to assume that the higher the population density, the faster the spread of a virus. This is generally known as density-dependent population-ecological factors (211). As an indicator of high income, a high estimated property value is negatively associated with infection numbers, whereas many household members and household crowding are associated with higher infection numbers (147). These indicators are consistent with infectious aspects as they address two critical aspects of virus transmission. Since living space in Germany is distributed to the detriment of poorer people, more expensive houses mean more space per person (97). This reduces the transmission. The lower density of people per household also reduces the number of people infected by one person. In contrast, the same study showed that there was no specific association between infection rate and population density (147). This result contradicts with other findings on transmission in higher population density (211).

The study by McLaren et al. (2021) showed special results. They found a strong correlation between minorities and COVID-19 deaths but could not prove any significant association between income and poverty on the number of infections. These variables did not influence the increased incidence of COVID-19 cases in minority shares. Education variables showed the same results. One possible reason for this could be the design of the study. In this ecological study, COVID-19 mortality data at the county level was collected from 3,140 counties, together with economic and demographic data of the district. The data on mortality is not broken down by race, so that "[one] cannot tie the socioeconomic status of any one patient to that patient’s health outcome" (144). This is part of a problem economic studies come along with, generally known as the *ecological bias* (2000). However, a great influence of the economic situation on some minorities could be demonstrated here. For African American and First Nation citizen, a racial disparity for COVID-19 deaths persist, even after controlling for education, occupation, and commuting patterns. The authors attribute these results to the use of public transit. Even if the numbers will not give a hint on this, it could also be a good example for the principle of the intersectionality of factors that affect health status (212). As stated in Section 2.2.10, intersectionality examines how power structures depend and intertwine on each other and influence social relations in a diverse society (54). Basically, it points out that certain aspect of the social position like gender, ethnicity, income etc. influence each other and create an impact on the individuum, that is bigger than each of the aspects is on its own.

The findings from this narrative review underscore the crucial role that socioeconomic status plays in shaping unequal health outcomes during pandemics, such as COVID-19. Lower SES is consistently associated with both increased risk of infection and more severe disease outcomes. This relationship can be understood by considering both proximal (behavioral and biological) and distal (social and political) risk factors, as illustrated in Figure 12.

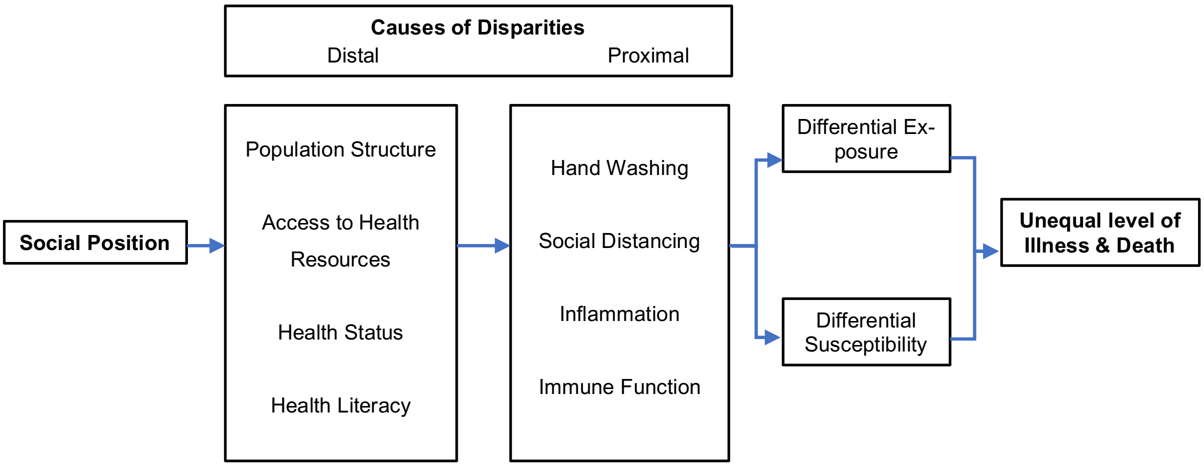

Figure 12: Association of Social Position and Unequal Health
Based on: *Health Inequalities and Infectious Disease Epidemics: A Challenge for Global Health Security* (126)

Proximal factors, such as pre-existing comorbidities and individual health behaviors (e.g., smoking, diet, physical activity), directly impact susceptibility to infection and the severity of outcomes. However, these factors are deeply influenced by distal factors, which include broader social and political conditions such as income inequality, access to healthcare, and living and working environments. The chapter on Exposure: Living and Working Conditions (Section 4.1.4 - Socioeconomic Status and Proxies for Infection-Promoting Factors) provides concrete examples of how these distal factors manifest in disadvantaged populations.

For instance, studies have shown that overcrowded living conditions, which are more prevalent in low-income neighborhoods, increase the likelihood of viral transmission. Cardoso et al. (2013) highlighted that overcrowding in low-income areas contributes to higher rates of respiratory infections, while Yousey-Hindes and Hadler (2011) found that influenza hospitalizations were significantly higher in high-poverty, high-crowding census tracts " (129, 130).

Quinn & Kumara (2011) emphasize that the inability of low-wage workers to stay home when sick, due to a lack of paid sick leave, further exacerbates their risk of exposure (131). These findings align with the broader framework that links distal social determinants to proximal health risks, creating a reinforcing cycle of health inequality. Section 4.1.4 also addresses these points by examining how low SES correlates with infection-promoting factors, such as household crowding and limited access to protective resources, both of which increase exposure and disease severity.

In addition, research on public transport use supports the idea that structural inequalities in access to safe environments contribute to higher exposure and susceptibility. Lower-income individuals are more reliant on public transportation, which exposes them to higher risks of airborne transmission, especially in densely populated urban areas (133, 134). These findings reflect the interconnected nature of proximal and distal factors, where economic deprivation limits individual choices while shaping the environments in which people live and work. This further supports the results presented in Section 4.1.4, which emphasizes that low SES functions as a proxy for heightened exposure risk due to factors like crowding and reliance on public transport.

It is important to note that the concepts of proximal and distal factors should not be confused with the "upstream" and "downstream" determinants of health described by Marmot & Allen (2014). Marmot & Allen use these terms to describe how far or close factors are to health outcomes. In contrast, proximal and distal factors, as depicted in this review, refer to the degree of immediacy in relation to disease risk. Proximal factors are closely linked to the onset of disease, while distal factors, though more removed, play a critical role in shaping these risks through broader social and economic structures (48).

The COVID-19 pandemic has further highlighted these pre-existing inequalities, as it acts as a marker that makes visible the structural inequities already present in society. The metaphor of a fluorescent marker used in this context underscores how the pandemic has brought attention to long-standing fundamental causes of disease that are addressed downstream rather than upstream, focusing on symptoms rather than root causes (49). These inequalities, exacerbated by both the pandemic and the social determinants of health, demonstrate the ongoing failure to tackle the upstream factors that drive poor health outcomes in vulnerable populations.

Summarizing this chapter, the results of this review confirm that social and economic disparities are pivotal in determining the unequal distribution of health risks during pandemics. The interaction between proximal and distal factors helps explain why vulnerable populations experience a disproportionate burden of disease. Specifically, the evidence from Exposure: Living and Working Conditions (Section 4.1.4) illustrates how these factors operate in tandem to exacerbate both exposure risks and adverse outcomes, providing critical insights into the structural drivers of health inequities.

5.1.3 Mediator Variables in the SES-COVID-19 Relationship

Mediator variables are factors that explain the mechanism through which one variable influence another. In the context of socioeconomic status and COVID-19 outcomes, mediator variables help to clarify how SES affects infection risk, disease severity, and recovery. These mediators are particularly relevant in understanding health disparities during the pandemic because they highlight potential intervention points where policies and societal measures can help mitigate adverse outcomes.

The pandemic revealed stark socioeconomic inequalities, and mediator variables offer a lens to dissect these inequalities more precisely. For example, stress-related mechanisms such as allostatic load—a physiological stress response—has been linked to higher inflammation profiles in lower SES populations (106). Elevated inflammation is in turn associated with severe outcomes of COVID-19 (107) suggesting that the chronic stress experienced by socioeconomically disadvantaged individuals may mediate the relationship between SES and COVID-19 severity. Stress-induced biological factors, therefore, present a potential target for intervention, such as providing mental health support or stress-relief programs for at-risk populations.

Moreover, psychosocial factors like perceived control and interpersonal resources also mediate the relationship between SES and well-being during the pandemic (146). Lower income and educational attainment were associated with decreased access to these resources, which in turn were linked to worse mental health outcomes during the pandemic. This underscores the role of psychological and social resources as mediators in the SES-COVID-19 relationship, pointing to possible interventions that improve access to mental health resources or strengthen community networks for low-income groups.

Interestingly, Lamb et al. (2021) found that mobility, often assumed to be a significant mediator between SES and COVID-19 case positivity, did not function as expected in their study of New York City neighborhoods. Mobility changes were not a mediator between ZIP-level SES and case positivity during April 2020, though increased mobility was negatively associated with infection rates in wealthier areas. This unexpected result suggests that wealthier individuals, despite increased mobility, may have better access to protective measures such as social distancing, remote work, or private transportation, reducing their risk of infection (161).

The identification of these mediators—stress and inflammation, psychosocial resources, and mobility—provides critical insight into how the relationship between SES and COVID-19 outcomes unfolds. These factors not only explain why individuals with lower SES face worse outcomes but also offer actionable pathways for reducing these inequalities. Interventions that focus on reducing chronic stress, enhancing psychosocial support, and addressing the structural barriers that limit social distancing for low-income individuals can be pivotal in mitigating the impact of future pandemics.

5.1.4 Preprint Studies - Social Determinants of Health

Regarding SDoH, the research in preprint databases revealed some evidence that confirm the relationship between SES and the incidence of infections. Maroko et al. (2020) differentiated *cold spots* from *hot spots*, which differed in terms of income, education, occupation, and ethnicity (153). This coincides both with the theoretical considerations on SES and infection promoting factors (see Section 4.1.2) and with evidence from previous pandemics (18). Snyder et al. (2020) pointed out the connection between SDoH and social vulnerability (158). Health, ecological and social vulnerabilities were more common in the Southern United States. Wilmers et al. (2020) found similar results, who noted poverty in proportion to the inter-county variation in susceptibility (159). Comorbidities, access to care, and the ability to social distancing were key influencing factors. These results reflect in literature on social vulnerability. As stated by the WHO paper (213) on social vulnerability, it is defined as the potential harm to people and "their capacity to anticipate, cope with, resist and recovery from the impact of a natural hazard".

5.1.5 Preprint Studies - Deprivation

The dimensions of deprivation often overlap with those of socioeconomic status. Liu et al. (2020) demonstrated that regions experiencing higher socioeconomic deprivation exhibited a more rapid increase in the number of COVID-19 cases (154). Similarly, Prats-Uribe et al.

(2020) identified an elevated risk of developing COVID-19 symptoms in deprived areas of England, while Patel et al. (2020) found that household income and the Townsend Deprivation Index (TDI) were significantly associated with COVID-19 hospitalizations (163, 214). These findings are consistent with theoretical expectations regarding deprivation, as outlined in Chapter 2.2.4.

The disadvantages associated with deprivation, which may have previously gone unnoticed, become more evident in the context of a public health crisis. Health inequalities, particularly unequal access to healthcare, increase the likelihood of chronic diseases. The COVID-19 pandemic has exacerbated these existing health disparities, acting as a magnifying glass for the structural inequities in health outcomes. This situation is comparable to the role of a fluorescent marker that highlights pre-existing fundamental causes of disease, which are treated downstream rather than upstream, thereby addressing symptoms rather than the root causes (49). The metaphor of a fluorescent marker is meant to illustrate how the pandemic makes already existing inequalities in health outcomes more visible—similar to how a marker highlights something that was previously unnoticed—without necessarily tackling the underlying issues that give rise to these inequalities.

5.1.6 Preprint Studies - Socioeconomic Status

Lower income, lower SES, unemployment, poverty, and lower education influenced prevalence, case fatality rate and infection rate of COVID-19 as expected (155-157). As stated in Section 4.1.2 and 4.1.5, there already is data on the unequal distribution of COVID-19 infection and unequal health chances when developing symptoms. On explanation could be that this is because underlying factors influencing the possibility of exposure to SARS-CoV-2 come along with low SES. Also, low SES comes along with a physical constitution that promotes a severe course of the disease. In addition, it can be justified in theory by the fact that transmission of viruses is supported by various aspects of a low SES. For example, many household members, worse compliance, and the inability to social distancing.

Lamb et al. (2021) had unexpected findings in New York about the mediator function of mobility. Mobility is not a mediator between the ZIP-SES and the case positivity. However, mobility is negatively associated with the infection rate in these areas (161). The only plausible reason for this connection could be that mobility is a parameter for wealth. As far as this research goes, mobility in the first pandemic phase increased the spread of viruses (215). Wealth, by contrast, is a factor that enables people to protect themselves against the virus through social distancing, etc. (160).

In summary, this narrative review reveals a significant association between SES and COVID-19 outcomes. Lower SES is consistently linked to higher infection rates and greater severity of the disease, influenced by factors such as limited healthcare access, higher exposure risks, and a higher prevalence of comorbidities. These findings underscore the necessity for targeted public health interventions and policies aimed at mitigating these disparities. Addressing SES-related vulnerabilities is crucial for improving health outcomes and ensuring equity in the on-going and future public health responses.

5.1.7 Limitations

Several methodological limitations must be considered when interpreting the findings of this narrative review. First, there is the potential for selection bias, as the review excluded non-English studies and unpublished data, which may have led to the omission of relevant findings from non-English-speaking regions or grey literature. Additionally, the search was limited to studies published between January and November 2020, potentially excluding significant studies published after this period that could offer updated data and insights. Another limitation is the variability in the methodological quality and design of the included studies, which may have affected the reliability and comparability of the results. Furthermore, the heterogeneity in the measures of SES across different studies posed challenges in synthesizing the data, as different definitions and parameters were used to assess SES. The review also did not account for the potential impact of different COVID-19 variants on infection rates and progression severity, which could influence the observed association with SES. Finally, the exclusion of studies using indirect measures of SES, such as access to public transport and health insurance, might have omitted relevant data that could contribute to a more comprehensive understanding of SES-related disparities.

5.1.8 Strengths

This narrative review possesses several strengths that enhance the validity and comprehensiveness of its findings. A key strength is the comprehensive search strategy, which employed multiple databases and a wide range of keywords and MeSH terms, ensuring an exhaustive search of the existing literature. The focused research question provided a targeted approach to examining the association between SES and COVID-19 outcomes, thereby enhancing the review's relevance and impact. The systematic selection process, which included the use of flowcharts for transparency, minimized bias and ensured consistency in the inclusion criteria. Additionally, the use of detailed inclusion and exclusion criteria focused on specific SES parameters such as education, occupation, and income, ensuring that the studies included were directly relevant to the research question and provided a coherent dataset. The narrative synthesis approach, utilizing thematic analysis, allowed for the integration of diverse findings into a comprehensive overview, facilitating a deeper understanding of the complex relationship between SES and COVID-19 outcomes. Furthermore, the inclusion of preprint studies alongside peer-reviewed publications expanded the scope of the review, providing access to the most current research findings, which is particularly critical in the rapidly evolving context of COVID-19 research.

5.2 Discussion of the Systematic Review and Meta-Analysis

This systematic review and meta-analysis aimed to examine socioeconomic disparities during COVID-19 infection. The findings suggest that people from socially deprived backgrounds are at higher risk of experiencing a severe course. Higher levels of deprivation were associated with death, ICU admission, and hospitalization due to COVID-19. Thirty-six of the 41 studies included could demonstrate a socioeconomic gradient in COVID-19 case severity with the population groups of the most deprived areas correlating with the highest numbers of deaths and worst outcomes.

5.2.1 Comparison with Previous Pandemics

The aforementioned is consistent with the results of studies of previous pandemics, such as the 2009 H1N1 outbreak (19) or the 1918 Spanish flu (18), in which structurally weak areas had the highest infection and death rates. Recent systematic reviews also suggest that this relationship is continuing in the current crisis. Khanijahani et al. (2021), and Magesh et al. (2021), postulate that racial/ethnic minority groups and those with low socioeconomic status are more vulnerable to COVID-19 (216, 217). Lord et al. (2021), and Green et al. (2021), examined social determinants of health and found vulnerable groups disproportionately affected by the pandemic (218, 219).

5.2.2 Explanatory Approaches for SES Gradients in COVID-19 Severity

In the following, three explanatory approaches for the results are proposed, ranging from ecological to individual level. Neighborhood deprivation has been shown to be an indicator of higher infection rates and more severe courses (166, 187, 191, 198). This is in line with Rollston et al. (2020), stating that areas with low SES offer fewer opportunities to be physically active, to have good nutrition, which leads to comorbidities and worse health status. Access to health resources is worse, best/early treatment might be reduced due to financial restriction (96).

It is already well established that areas of higher deprivation have higher population densities and therefore favor the reproduction of the virus (220). People of deprived areas are also more likely to use public transport (221), and have more household members (222), hence less chance to implement social distancing and sanitation measures. Evidence from COVID-19 research already shows that there is a connection between neighborhood density and COVID-19 transmission (223).

Another attempt at an explanation for health inequalities in the COVID-19 pandemic is the presence and meaning of comorbidities. Comorbidities and chronic diseases are associated with both deprivation and severe courses of COVID-19. For instance, COPD and hypertension predict worse outcomes of a COVID-19 infection (12). These occur more often in populations with a low SES (13, 14). Therefore, it is reasonable to assume that comorbidities play a mediating role between social deprivation and COVID-19 outcomes. However, only one study, by Bray et al. (2020), suggested that mediators are interposed between variables of deprivation and health. After controlling for overweight and obesity, they found the significance of the association waned (172).

Aside from chronic disease, studies on *health literacy* suggest a connection between deprivation and adverse health behavior. Authors call health literacy another social determinant of health (113), as it is the competency to make appropriate decisions based on health information (224). COVID-19 showed that health literacy is essential to adopt information on SARS-CoV-2, whether it is education about preventative behavior or strategies to stop the spreading of the virus (121). Subsequently, lower health literacy stands in relation to increased numbers of infections (225). Furthermore, people living in deprivation are more likely to have harmful behaviors (115) such as smoking, poor eating habits, and non-compliance with medication (116) which favors severe courses.

5.2.3 Negative Findings and Possible Explanations

In contrast to evidence from current research, three of the 41 included studies (172, 173, 199) showed a weak association and five studies (181, 198, 200-202) showed no association between deprivation and COVID-19 severity. Here some of the negative results were presented to find explanations for them.

Mateo-Urdiales et al. (2021) could not detect any association of deprivation with COVID-19-related mortality. An explanation for this could be the study period: they conducted the measurements before, during, and after the first lockdown in Italy, which describes the period from May to August 2020. They refer to a study that points out that early in the pandemic, primarily adults with high mobility and aged between 18 and 49 were affected (226). Accordingly, none of the counties with higher deprivation levels were severely affected in the first wave. This, however, changed during the pandemic with socioeconomic weaker areas showing higher mortality rates, as seen in the study by Di Girolamo et al. (2020). An ecological study from

Germany shows a similar shift of the transmission patterns. The socioeconomic gradient reversed from the first to the second measurement: while in the first period there were primarily wealthier people who contracted COVID-19, in the second half more deprived people. So, the reason for the negative results could be a too narrow time frame (183, 201, 227).

The second bias that might explain negative results could lie in the individuals' selection. Thompson et al. (2020) found no significant association between deprivation and in-hospital COVID-19 deaths. As our subgroup analysis has shown, the association of deprivation and adverse COVID-19 outcomes is smaller in hospital cohorts (see Figure 10 and Figure 11). Smaller number of patients in this setting correspond to higher standard errors and non-normal distribution of the risk factors for a severe course (202).

5.2.4 Implications for Policy and Public Health

Understanding Social Determinants of Health

The implications of this review are of policy importance for two reasons. Deprivation indices were chosen to capture the relationship between social disadvantage and health in a multifaceted way because it is critical to understand multifactorial and interdependent relationships that affect individual health. On the other hand, modern concepts to reduce health inequality should take into account fundamental causes of disease (23) and social determinants of health (228). They are used to understand how upstream socioeconomic factors such as precarious living conditions and lack of education cause the occurrence of diseases in the downstream causal chain.

Epidemiological Considerations and Broader Impacts

From an epidemiological perspective, it is important to consider health disparities, as areas with higher infection rates will always have relevance to the whole society due to high transmissibility and interconnectivity. In perspective, the results of this review apply to other pandemic impacts. Public protection measures may not be as effective in structurally weak areas (229), and primary data on vaccine procurement and distribution show similar impacts (230).

5.2.5 Limitations

This systematic review and meta-analysis have several limitations that must be considered when interpreting the findings. Firstly, despite including studies from diverse regions, a majority were conducted in Anglo-American countries, potentially limiting the generalizability of the results to other cultural and socioeconomic contexts. All included studies were observational in nature, which restricts the ability to draw causal inferences. The inclusion of cross-sectional and ecological studies, which provide lower levels of evidence compared to cohort studies, further constrains the robustness of the conclusions. Additionally, all studies assessed deprivation at the area level, risking ecological fallacy when transferring regional findings to individual-level implications. The heterogeneity in group sizes and settings—from in-hospital cohorts to nationwide surveys—also adds complexity to the synthesis of results and may influence the observed associations. Furthermore, the review did not account for potential confounding variables such as pre-existing health conditions and access to healthcare, which could significantly impact COVID-19 outcomes. Additionally, potential selection bias exists as non-English studies and unpublished data were excluded, potentially omitting relevant findings from non-English-speaking regions. The timeframe of the studies, often focusing on the initial phases of the pandemic, may not capture the evolving nature of COVID-19 impacts over time.

5.2.6 Strengths

This systematic review and meta-analysis possess several strengths that enhance the credibility and depth of its findings. A key strength is the comprehensive search strategy employed, covering multiple databases, and utilizing a wide array of keywords and MeSH terms to ensure an exhaustive search of the existing literature. The systematic and rigorous selection process, guided by the PRISMA guidelines, minimized bias, and enhanced the reliability of the included studies. The use of deprivation indices to measure SES provided a multifaceted and robust indicator of social disadvantage, allowing for a more nuanced analysis of its impact on COVID-19 outcomes. Additionally, the inclusion of studies from various countries and settings increases the generalizability of the findings. The meta-analysis employed a random-effects model to account for expected heterogeneity in observational studies, providing a more accurate estimate of the association between deprivation and adverse COVID-19 outcomes. Subgroup analyses further refined the findings by exploring differences across various settings and study designs. These methodological rigor and analytical depth contribute to a comprehensive understanding of the socioeconomic disparities in COVID-19 severity and mortality.

5.3 CONCLUSION

This section evaluates the key implications of this thesis, which was divided into two parts. First, a narrative review was conducted to examine whether there is an association between socioeconomic status and COVID-19 infection rates and severity. It also aimed to investigate whether mediating variables could be identified in this relationship. The main hypotheses were that the association between SES and infection rates is mainly determined by exposure and susceptibility, while the association between SES and mortality is mainly determined by chronic diseases.

In the second part, precise search methodology was used to test whether deprivation, a complex indicator of social status, is associated with a severe course of COVID-19. A systematic review with meta-analysis was initiated for this purpose. Eventually, a final statement will be made as to whether this narrative and systematic review and meta-analysis shows that the central hypotheses are supported or refuted by the current state of research.

For this purpose, it is worth taking another look at Figure 5: From the starting point of SES to the end points of higher infection or mortality rates, there are several paths that will be briefly traced here. On the one hand, increased exposure to SARS-CoV-2 represents an increased risk of infection, with a consequent increase in the absolute number of deaths. Second, according to our theoretical considerations, people with low SES are more likely to develop COVID-19 if they become infected and are more likely to suffer a severe course of the disease. In contrast, people with higher SES would be less susceptible.

Several pathways also lead to the other endpoint, mortality. At the center of this pathway are chronic diseases such as diabetes mellitus, hypertension, coronary heart disease, etc. The

self-imposed task was to investigate whether these are more prevalent in lower SES populations and whether they are associated with increased COVID-19 mortality.
In the second section of this dissertation, a specific path of this flowchart was examined. For this purpose, an index was identified that reflects SES in a multifaceted way. The deprivation index was found to be suitable. It was then examined whether greater deprivation was associated with clinical endpoints of adverse COVID-19 outcomes. The endpoints of hospital admission, intensive care unit treatment and death were used as proxies for adverse outcomes.

5.3.1 Conclusion of the Narrative Review

Data on socioeconomic gradients in the COVID-19 pandemic were scarce, especially at the individual level. However, this review supports the notion that health inequalities exist in the current crisis.
The narrative review provides evidence supporting a significant socioeconomic gradient in COVID-19 outcomes, both in terms of disease severity and infection rates. In response to the first leading question (Q1A), findings indicate that individuals with lower socioeconomic status (SES) face a greater risk of severe COVID-19 progression, with higher prevalence rates of comorbidities like COPD, hypertension, and diabetes, all of which increase the likelihood of severe outcomes. These noncommunicable diseases are disproportionately common in low SES populations, compounding the impact of COVID-19 and underscoring that individuals with lower SES may indeed face a higher risk of mortality from the disease.
Regarding the second question (Q1B), the review highlights that living and working conditions associated with low SES significantly elevate the risk of COVID-19 infection. Lower SES groups frequently experience overcrowded living situations and are more often employed in essential roles with limited options for remote work, leading to greater exposure to SARS-CoV-2. Additionally, susceptibility to infection is heightened in these groups due to psychosocial and biological factors such as elevated stress levels and a higher prevalence of inflammatory profiles, both of which may contribute to more frequent and severe health complications.

In conclusion, this review supports the notion that SES is strongly linked to both infection risk and disease severity in COVID-19 outcomes, driven by the complex interplay between environmental exposures, comorbid health conditions, and socioeconomic disparities.

These findings underscore a societal, political, and scientific imperative. A defining characteristic of this pandemic is the powerful influence of individual behavior on societal outcomes. This is primarily due to the high level of aerosol transmission and the variability of disease progression. Western nations have traditionally emphasized individual responsibility in terms of SES and opportunity. However, the demands of managing this pandemic transcend such a focus. Protecting the socioeconomically disadvantaged requires a collective responsibility that transcends self-interest and embraces the well-being of all citizens.

In terms of health legislation, the implications of this review require that socioeconomic disparities in health conditions and opportunities be specifically addressed. Policymakers must prioritize interventions that reduce exposure risks and improve healthcare access for lower SES groups. Furthermore, public health strategies should be inclusive, aiming to mitigate the impact of COVID-19 on vulnerable populations through targeted support and resources.

In conclusion, addressing the socioeconomic determinants of health is crucial for managing the COVID-19 pandemic effectively and equitably. Future research should continue to explore these gradients and inform policies that promote health equity.

5.3.2 Conclusion of the Systematic Review and Meta-Analysis

This part of the dissertation examined the association between socioeconomic status and COVID-19 outcomes through a systematic review and meta-analysis. The study focused on understanding how deprivation, as measured by various indices, impacts the severity and progression of COVID-19, including hospitalization, ICU admission, and mortality rates. The analysis included data from 41 studies, primarily conducted in the UK and USA, which utilized indices like the Index of Multiple Deprivation and the Area Deprivation Index.

In response to the leading question (Q2) on the extent to which deprivation, as a component of socioeconomic status, is associated with adverse COVID-19 outcomes, this systematic review and meta-analysis reveal a significant and consistent link between deprivation and severe

COVID-19 cases, including elevated rates of hospitalization, ICU admission, and mortality. The analysis of 41 studies, primarily from the UK and USA, demonstrates that individuals from deprived backgrounds face markedly higher risks of these severe outcomes, as shown by indices like the Index of Multiple Deprivation and the Area Deprivation Index. These findings support a clear socioeconomic gradient in COVID-19 outcomes, with individuals experiencing greater deprivation bearing the brunt of severe disease progression and complications.

The literature review identified only a few studies that explicitly named mediators in the relationship between deprivation and COVID-19 outcomes. However, comorbidities like COPD, hypertension, and diabetes can be considered as potential influencing factors in this context. These conditions, more prevalent among deprived populations, may exacerbate vulnerability to severe COVID-19 outcomes. Additionally, factors such as crowded living conditions, reliance on public transportation, limited healthcare access, and lower baseline health and health literacy might indirectly contribute to the heightened risk in socioeconomically disadvantaged groups. These elements suggest possible pathways by which deprivation could affect the severity of COVID-19, even if direct mediation effects were not statistically confirmed.

The findings of this dissertation underscore the critical need to address the social determinants of health disparities that have intensified during the COVID-19 pandemic. Reducing these disparities requires a dual focus: improving immediate healthcare access and addressing broader socioeconomic inequalities that contribute to worse health outcomes in disadvantaged populations. A multifaceted approach is essential, encompassing equitable healthcare access, targeted health literacy programs, and supportive social policies in areas like housing, employment, and education.

Policymakers and public health officials should prioritize measures that reduce exposure risks and improve support for lower SES groups, with community-based interventions and cross-sector collaboration forming a coordinated response to health inequalities. In addition, effective public health responses will depend on improved data collection on social determinants and health outcomes, alongside robust evaluations of intervention effectiveness to ensure evidence-based policy development.

Future research should aim to capture the long-term impacts of socioeconomic status on health by exploring individual-level pathways, monitoring these patterns over time, and assessing intervention outcomes. These efforts will provide policymakers with targeted strategies for advancing health equity and creating more resilient healthcare systems in preparation for future public health crises. This dissertation provides a foundation for research and policy efforts focused on achieving health equity by addressing the root causes of health disparities.

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7 ANHANG

Supplementary Table 1) Additional Study Characteristics

Study	Study Design	Study Period	Population	Link	Quality Score
Adjei-Fremah 2022	Cross-sectional	31.03. - 04.07.2020	3,977,544	Link	8/8
Bach-Mortensen 2021	Cross-sectional	10.04. - 21.06.2020	149 residents	Link	8/8
Barnard 2021	Prospective cohort	21.03.2020 - 26.02.2021	569,824 deaths	Link	9/11
Baumer 2020	Prospective cohort	09.03. - 07.05.2020	52 ICU patients	Link	8/11
Beaney 2022	Retrospective cohort	01.10.2020 - 30.04.2021	2,311,282	Link	11/11
Beaumont 2022	Observational cohort	02.03.2020 - 15.04.2020	399 patients	Link	10/11
Bhaskaran 2021	Retrospective cohort	01.02. - 09.11.2020	17,456,515	Link	11/11
Brainard 2021	Ecological study	31.05. - 22.09.2020	1977 infections	Link	6/8
Bray 2020	Ecological study	01.03. - 17.04.2020	310 local authorities	Link	6/8
Breen 2021	Ecological study	01.03. - 31.07.2020	135 districts	Link	6/8
Chaudhuri 2021	Ecological study	01.03. - 17.04.2020	315 LADs	Link	6/8
Congdon 2021	Ecological study	March - July 2020	7,201 MSOAs	Link	6/8
de Souza 2020	Ecological study	26.02. - 06.08.2020	417 municipalities	Link	6/8
Di Girolamo 2020	Cross-sectional	March - April 2020	3,531 deaths	Link	8/8
Eden 2021	Ecological study	Until 09.02.2021	3,102 counties	Link	6/8
Escobar 2021	Retrospective cohort	01.02. - 31.05.2020	3,481,716 patients	Link	10/11
Farrell 2021	Retrospective cohort	13.03. - 01.05.2020	257 patients	Link	10/11
Ferrando-Vivas 2021	Observational cohort	01.03. - 22.06.2020	9,990 patients	Link	10/11
Foster 2022	Prospective cohort	01.03.2020 - 31.03.2021	502,505	Link	10/11
Gray 2021	Retrospective observatio-nal	01.03. - 30.09.2020	28,344 deaths	Link	10/11
Griffith 2021	Ecological study	March - July 2020	7,201 MSOA	Link	8/11
Hu 2021	Retrospective cohort	Feb - Jun 2020	5,999 patients	Link	9/11
Ingraham 2021	Retrospective cohort	04.03. - 19.08.2020	5,577 patients	Link	9/11
Khan 2021	Prospective cohort	April 9, 2020, 30-days	172 patients	Link	10/11
Kontopantelis 2021	Retrospective registry	07.03. - 02.10.2020	62,321 deaths	Link	9/11
Kontopantelis 2022	Retrospective registry	07.03.2020 - 25.12.2020	3,265,937 deaths	Link	9/11
Lewis 2020	Retrospective cohort	03.03. - 09.07.2020	1,781 hospitaliza-tions	Link	9/11
Lone 2021	Cohort study	01.03. - 20.06.2020	735 patients	Link	11/11
Mateo-Urdiales 2020	Retrospective cohort	18.05. - 03.06.2020	38,534,169 citizens	Link	9/11
Navaratnam 2021	Retrospective cohort	01.03. - 31.05.2020	91,541 patients	Link	11/11
Oroszi 2021	Ecological study	22.06.2020 - 24.01.2021	10 districts	Link	10/11
Ossimetha 2021	Ecological study	01.04. - 15.05.2020	2,664 counties	Link	10/11
Patel 2020	Retrospective cohort	Until 02.05.2020	418,794 participants	Link	8/11
Singh 2021	Cohort study	01.03. - 24.05.2020	228,632 adults	Link	9/11
Soltan 2021	Multicentre cohort	01.03. - 31.07.2020	3,671 patients	Link	9/11
Thompson 2020	Retrospective cohort	12.03. - 19.05.2020	470 patients	Link	9/11
Watson 2021	Ecological study	01.02. - 30.09.2020	4,040 patients	Link	9/11
Walls 2022	Retrospective cohort	01.03.2020 - 31.08.2020	12,956 patients	Link	11/11
Williamson 2020	Retrospective cohort	01.02. - 06.05.2020	10,926 deaths	Link	9/11
Woodward 2021	Prospective cohort	01.02. - 01.10.2020	501,865 participants	Link	9/11
Zhang 2021	Retrospective cohort	01.03. - 11.06.2020	23,300 patients	Link	9/11

Supplementary Table 2) Data Extraction Table

Study	Method	Exposure	Outcome	Effect parameter	Scale	Coefficient/value	SE	CI	p-value
Adjei-Fremah, 2022	Correlation and multiple linear regression	Area deprivation index (ADI)	Mortality	Correlation coefficients	N/A	-0.30	N/A	N/A	0.4691
Bach-Mortensen, 2021	Negative binomial regression	Index of multiple deprivation (IMD)	COVID-19 deaths	Incidence rate ratio	1 Least deprived	(Reference)			
					2	0.078	(0.073)		
					3	0.040	(0.067)		
					4 Most deprived	0.149**	(0.075)		** p<0.05
					1	(Reference)			***
					2	0.041	(0.093)		p<0.01
					3	0.071	(0.093)		
					4	0.249***	(0.096)		
					IMD2019Extent raw continuus	0.393***	(0.144)	95% CI 1.00 to 1.34	*** p<0.01
					IMD extent most vs least	IRR: 1.16,			
Barnard, 2021	Quasi-Poisson regression	Area deprivation index (ADI)	Excess mortality	Ratio registered/expected deaths (= standardized mortality rate). Cave: compared are not Quintile 5 to 1 but • 5 to general pop. • 1 to general pop. etc.	People aged <75 years		N/A		N/A
					Quintile I—most deprived	1.25		(1.24, 1.27)	
					Quintile 2	1.22		(1.20, 1.24)	
					Quintile 3	1.19		(1.17, 1.21)	
					Quintile 4	1.16		(1.14, 1.18)	
					Quintile 5— least deprived	1.14		(1.12, 1.16)	
					Among all persons:				
					Quintile I—most deprived	1.24		(1.23, 1.25)	
					Quintile 2	1.22		(1.21, 1.23)	
					Quintile 3	1.21		(1.20, 1.22)	
					Quintile 4	1.2		(1.19, 1.21)	
					Quintile 5— least deprived	1.2		(1.19, 1.21)	
Baumer, 2020	Descriptive statistics	Wales index of multiple deprivation (WIMD)	Number/% of patients admitted to ICU, for each deprivation quintile.	Patients n (%)	Quintile 1 —least	6 (11.5%)	N/A	N/A	N/A
					Quintile 2	7 (13.5%)			
					Quintile 3	11 (21.2%)			
					Quintile 4	5 (9.6%)			
					Quintile 5 —most	22 (42.3%)			
				Rate ratio (calculated): 22/52 / 6/52 = 3.6667	n = 52				
Beaney, 2022	Mixed effects logistic regression	Index of multiple deprivation (IMD)	Case hospitalisation risk (CHR)	Odds ratio	1 (most deprived)	reference	reference	reference	reference
					2	0.93	0.01	0.91 - 0.95	0.54
					3	0.87	0.01	0.85 - 0.89	0.001
					4	0.84	0.01	0.82 - 0.86	0.001
					5	0.82	0.01	0.80 - 0.84	<0.001
					6	0.77	0.01	0.75 - 0.79	<0.001
					7	0.74	0.01	0.72 - 0.76	<0.001
					8	0.73	0.01	0.71 - 0.75	<0.001

			and case fa- tality risk (CFR)		9 10 (least deprived) 1 (most deprived) 2 3 4 5 6 7 8 9 10 (least deprived)	0.71 0.68 reference 0.94 0.89 0.86 0.80 0.79 0.75 0.72 0.71 0.70	0.01 0.01 reference 0.02 0.02 0.02 0.02 0.02 0.02 0.02 0.02 0.02	0.69 - 0.73 0.66 - 0.70 reference 0.90-0.98 0.85-0.93 0.83-0.90 0.77-0.84 0.75-0.82 0.72-0.79 0.69-0.75 0.68-0.75 0.67-0.74	<0.001 <0.001 reference 0.005 <0.001 <0.001 <0.001 <0.001 <0.001 <0.001 <0.001 <0.001
Beaumont, 2022	Logistic regression and Cox proportional hazards models	French Deprivation Index (FDEP), French European Depriation Index (French EDI)	Hospitalization, risk of mechanical ventilation	Odds ratio (hospitalization) Hazard ratio (risk of mechanical ventilation)	N/A	FDEP: 1.0 French EDI: 1.0 FDEP: 1.0 French EDI: 1.0	N/A	0.8 - 1.1 0.9 - 1.0 0.9 - 1.1 0.9 - 1.0	0.5757 0.7691 0.9514 0.5063
Bhaskaran, 2021	Multinomial logistic regression	Index of multiple deprivation (IMD)	COVID-19 deaths	1. Age-sex adjusted Odds Ratio (95% CI) for associations between individual-level factors and COVID-19/non-COVID deaths. 2. Fully adjusted Odds Ratio for associations between individual-level factors and COVID-19/non-COVID deaths (controlling for all other factors considered)	1 (least deprived) 2 3 4 5 (most deprived) 1 (least deprived) 2 3 4 5 (most deprived)	1.00 (ref) 1.17 1.37 1.77 2.11 1.00 (ref) 1.13 1.25 1.53 1.71	N/A	 (1.11-1.23) (1.30-1.44) (1.68-1.86) (2.01-2.22) (1.07-1.19) (1.19-1.32) (1.46-1.61) (1.62-1.80)	N/A
Brainard, 2021	Besag-York-Mollié (BYM) model with a Poisson error structure to model spatial dependencies, structural equation modeling (SEM)	Index of multiple deprivation (IMD)	COVID-19 deaths	Relative risk	N/A	−0.331	N/A	95%CI:−0.506 to −0.160	N/A
Bray, 2020	Correlation and multiple linear regression	Mean IMD	COVID-19 deaths	Mortality rate explained by mean IMD (linear regression)	N/A	Univariate: 0.885 Multivariate: -0.139	N/A	N/A	0.000 0.343

				Correlation of mean IMD score and C19 deaths		r=0.2			
Breen, 2021	Statistical method summary unavailable	Office of National Statistics' (ONS) indices of an area's relative deprivation	COVID-19 deaths	Correlation of average Deprivation score and C19 mortality	N/A	–0.09	0.06	N/A	N/A
Chaudhuri, 2021	Spatial autoregressive regression	Index of multiple deprivation (IMD)	COVID-19 deaths	Mortality rate explained by IMD (linear regression) Secondary analysis: spatial regression	Quartile dummy 1 Quartile dummy 2 Quartile dummy 3 Quartile dummy 4 Not of interest, b/c ethnicity is a variable	– -2.108 5.977 16.270	N/A	– (-16.570 to 12.353) (-7.203 to 19.156) (2.355 to 30.185)	 p=0.774 p=0.373 p= 0.022
Congdon, 2021	Negative binomial regression	Income Deprivation (ID) and Health Deprivation and Disability (HDD)	COVID-19 deaths	Standardized mortality ratios Regression coefficient, implied relative risk	Income deprivation, Health deprivation: Decile 1 Decile 2 Decile 3 Decile 4 Decile 5 Decile 6 Decile 7 Decile 8 Decile 9 Decile 10 All Neighborhoods Health deprivation (...) 0.153, 1.085	 0.60, 0.81 0.76, 0.83 0.84, 0.83 0.83, 0.88 0.90, 0.90 1.03, 0.99 1.18, 1.04 1.28, 1.14 1.42, 1.33 1.71, 1.51 1.00, 1.00	N/A	N/A	N/A
De Souza, 2020	Spatial analysis; Moran Local Bivariate statistic	Social deprivation index (SDI)	COVID-19 deaths	Mortality rate/100,000 in 40 most vulnerable municipalities of Bahia vs. Total MR of Bahia (417 municipalities) Mortality rate ratio Case fatality rate % (...)	N/A	12.7 vs. 10.85 1.2	N/A	N/A	N/A

Di Girolamo, 2020	Quasi-Poisson regression	Italian deprivation index	COVID-19 deaths	Mortality rate ratio, age-standardized Mortality rate ratio (...)	Males: 1 least 2 3 4 5 most Females: 1 least 2 3 4 5 most	 1 1.10 1.03 1.21 1.39 1 0.97 0.96 1 .18 1.55	N/A	 (0.95;1.26) (0.89;1.18) (1.05;1.39) (1.21;1.59) (0.81;1.16) (0.80;1.15) (1.00;1.40) (1.33;1.82)	p-value likelihood ratio test: <0.001
Eden, 2021	Negative binomial regression	Broadstreet area deprivation index	COVID-19 deaths	Risk ratio	N/A	1.20	N/A	1.14-1.27	N/A
Escobar, 2021	Descriptive and nongeographic statistical analyses	National deprivation index (NDI)	Hospitalization Death (ever) Death in hospital	Odds ratio	N/A	1.07 1.08 1.16	N/A	(0.97 to 1.18) (0.87 to 1.36) (0.88 to 1.52)	N/A
Farrell, 2021	Multivariable regression	Pobal HP Deprivation Index	COVID-19 deaths, ICU admittance	Age-adjusted hazard ratio Age-adjusted hazard ratio	N/A	1.05 0.97	N/A	(1.01, 1.09) (0.94, 1.01)	p = 0.012 0.196
Ferrando-Vivas, 2021	Cox proportional hazards modeling	Multiple deprivation indice of each country included England, Wales, Northern Ireland	Death within 30 days	Hazard ratio	1 (least deprived) 2 3 4 5 (most deprived)	 1.017 1.006 1.063 1.137	N/A	 (0.901-1.149) (0.897-1.128) (0.951-1.188) (1.011-1.279)	 0.785 0.371 0.829 0.026
Foster, 2022	Quasi-Poisson regression	Townsend deprivation index	COVID-19 mortality Composite outcome of severe COVID-19—defined as COVID-19 admission to hospital or death from COVID-19	Risk ratio	1: least deprived 2 3 4 5: most deprived 1: least deprived 2 3 4 5: most deprived	1 (reference) 1.22 5.09 2.41 9.60 1 (reference) 1.32 5.17 2.31 6.02	N/A	 (0.96–1.57) (1.39–25.20) (1.93–3.02) (4.70–21.44) (1.18–1.49) (2.46–12.01) (2.12–2.53) (4.72–7.71)	N/A

Gray, 2021	Multilevel logistic regression	Index of multiple deprivation (IMD)	In-hospital mortality	Odds ratio	5 (least deprived) 4 3 2 1 (most deprived) 5 (least deprived) 4 3 2 1 (most deprived)	1 (reference) 1.03 1.07 1.05 1.05 1 (reference) 0.96 1.05 1.01 1.08	N/A	 (0.97 to 1.09) (1.01 to 1.13) (0.99 to 1.11) (1.00 to 1.12) (0.83 to 1.10) (0.92 to 1.21) (0.88 to 1.15) (0.94 to 1.23)	N/A
Griffith, 2021	Quasi-Poisson regression	Index of multiple deprivation (IMD)	COVID-19 deaths	Mortality rate ratio	N/A	 1.097 1.168 1.197 1.210 1.135	N/A	2,5%/97,5% CI 0.631-1.822 0.861-1.519 0.904-1.613 0.777-2.098 0.626-2.291	N/A
Hu, 2021	Multivariable logistic regression	Area deprivation index (ADI)	COVID-19 deaths	Odds ratio	ADI national rank: quintile First (1—20) least disadvantaged Second (21—40) Third (41-60) Fourth (61-80) Fifth (81-100)	 1 [Reference] 0.99 1.37 1.21 1.74	N/A	 (0.65-1.49) (0.92-2.04) (0.78-1.88) (1.13-2.67)	N/A
Ingraham, 2021	Logistic and competing-risk regression models	Area deprivation index (ADI)	Hospitalization	Odds ratio Hazard ratio	First: 0-20% Second: 21-40% Third: 41-60% Fourth: 61-80% Fifth: 81-100% First: 0-20% Second: 21-40% Third: 41-60% Fourth: 61-80% Fifth: 81-100%	 0.83 0.87 0.88 1.31 0.85 0.88 0.87 1.14	N/A	 0.65-1.07 0.67-1.13 0.65-1.19 0.93-1.85 0.69-1.04 0.71-1.1 0.67-1.13 0.84—1.54	 0.2 0.3 0.4 0.1 0.12 0.26 0.29 0.39
Khan, 2021	Descriptive statistics	Scottish index of multiple deprivation (SIMD)	Poor outcome; defined as either need for intubation and/or death.	Odds ratio	More deprived vs. Less deprived	0.993	N/A	(0.496, 1.988)	.985
Kontopantelis, 2021	Negative binomial regression	Multiple deprivation indices of each country included England, Wales	COVID-19 deaths or other respiratory	Mortality rates of direct, indirect, and total excess deaths per 100,000 population,	1 (least deprived) 2 3	68 74 75	N/A	(67,69) (73,74) (74,75)	N/A

				weeks 11 to 40 (7 Mar 2020 to 2 Oct 2020).	4 5 (most deprived)	80 90		(79,81) (89,91)	
Kontopantelis, 2022	Negative binomial regressions	Index of multiple deprivation (IMD)	Years of life lost (YLL)	N/A	1 (least deprived) 2 3 4 5 (most deprived)	92,782 109,690 117,466 144,521 181,298	N/A	(90,595, 94,968) (106,955, 112,424) (115,136, 119,797) (141,710, 147,333) (177,509, 185,086)	N/A
Lewis, 2020	Binary logistic regression	Utah's Health Improvement Index (HII)	Hospitalization	Odds ratio	Very low (least deprived) Low Average High Very high (most deprived)	Referent 1.14 1.39 1.16 1.40	N/A	 (0.94-1.38) (1.15-1.69) (0.96-1.41) (1.17-1.68)	N/A
Lone, 2021	Multivariable logistic regression	Socioeconomic deprivation index	COVID-19 deaths, 30-day-mortality	Odds ratio univariable Odds ratio multivariable	1 = Most deprived 2 3 4 5 = Least deprived 1 = Most deprived 2 3 4 5 = Least deprived	1 (ref) 0.93 0.92 0.88 1.44 1 (ref) 1.01 1.07 1.03 1.97	N/A	 (0.53,1.65) (0.53,1.62) (0.52,1.49) (0.87,2.39) (0.55,1.86) (0.59,1.94) (0.58,1.80) (1.13,3.41)	 p=0.811 p=0.783 p=0.628 p=0.157 p=0.981 p=0.823 p=0.930 p=0.016
Mateo-Urdiales, 2020	Multilevel negative binomial regression models	Italian deprivation index	COVID-19 deaths (Incidence of death, also available: Case-hospitalizations, CFR)	Incidence rate ratio	Pre-lockdown Q1 (least deprived) Q2 Q3 Q4 Q5 (most deprived) Lockdown Q1 (least deprived) Q2 Q3 Q4 Q5 (most deprived) Post-Lockdown Q1 (least deprived) Q2 Q3	 Ref 0.96 1.01 1.06 0.92 Ref 0.94 0.94 0.94 0.95 Ref 0.94 1.26	N/A	 [0.82-1.12] [0.86-1.17] [0.90-1.24] [0.75-1.13] [0.86-1.02] [0.86-1.02] [0.86-1.02] [0.85-1.07] [0.71-1.25] [0.96-1.66]	N/A

					Q4 Q5 (most deprived)	1.20 1.02		[0.90-1.59] [0.73-1.41]	
Navaratnam, 2021	Multilevel logistic regression	Index of multiple deprivation (IMD)	In-hospital mortality	Odds ratio	N/A	1·002	N/A	[1·001–1·003]	N/A
Oroszi, 2021	Bayesian smoothed indirectly standardised ratios	Deprivation Index using data from the Hungarian Central Statistical Office (Census 2011) and the Hungarian Tax and Financial Control Administration (2011)	COVID-19 deaths	Standardized mortality rate	Males: I. Least deprived II. III. IV. V. Most deprived Females: I. Least deprived II. III. IV. V. Most deprived	 0.73 0.96 1.05 1.11 1.32 0.69 0.93 1.05 1.18 1.27	N/A	 (0.68-0.79) (0.91-1.00) (1.00-1.09) (1.05-1.17) (1.20-1.44) (0.64-0.75) (0.88-0.97) (1.00-1.09) (1.12-1.25) (1.16-1.39)	N/A
				Relative case fatality rate	Males: I. Least deprived II. III. IV. V. Most deprived Females: I. Least deprived II. III. IV. V. Most deprived	 0.85 0.99 0.99 1.05 1.27 0.82 0.95 0.99 1.11 1.32		 (0.79-0.91) (0.94-1.03) (0.95-1.04) (0.99-1.11) (1.16-1.39) (0.76-0.89) (0.90-0.99) (0.95-1.04) (1.05-1.17) (1.20-1.44)	
Ossimetha, 2021	Locally weighted scatterplot smoothing	Social deprivation index (SDI)	COVID-19 deaths	Mortality rate ratio	Low (ref) Medium High	 1.63 5.09	N/A	 (0.20 to 3.06) (3.25 to 6.94)	 .03 <.001
Patel, 2020	Descriptive statistics	Townsend Deprivation Index	Hospitalization	Odds ratio	N/A	Unadjusted: 1.13	N/A	(1.1-1.16)	<0.001
Singh, 2021	Descriptive statistics	Index of multiple deprivation (IMD)	Hospitalization	Odds ratio	IMD category Q2 (16.5-27.7) IMD category Q3 (27.8-39.0) IMD category Q4 (39.3—45.7) IMD category Q5 (45.7-71.8)	1.8 1.7 1.6 ns	N/A	(1.4 to 2.2) (1.4 to 2.1) (1.3 to 2) ns	p<0.001 p<0.001 p<0.001 p=0.517
Soltan, 2021	Logistic and multivariate regression analyses	Index of multiple deprivation (IMD)	COVID-19 deaths	Odds ratio	N/A	0.88	N/A	0.75-1.04	0.126

Thompson, 2020	Logistic regression model	Index of multiple deprivation (IMD)	COVID-19 deaths	Odds ratio	5 (least deprived) 4 3 2 1 (most deprived)	1.00 0.80 0.95 1.30 0.91	N/A	 (0.33-1.92) (0.38-2.38) (0.58-2.90) (0.42-1.95)	0.56
Walls, 2022	Multinomial regression models	Area deprivation index (ADI)	30-day ICU admission 30-day all-cause mortality	Odds ratio	(ref = Q1) Q2 Q3 Q4 Q5 (ref = Q1) Q2 Q3 Q4 Q5	 1.33 1.43 1.54 1.57 1.16 1.23 1.18 1.33	N/A	 (0.96–1.85) (1.04–1.98)* (1.13–2.11)** (1.14–2.16)** (0.94–1.42) (1.00–1.51) (0.97–1.44) (1.09–1.63)**	*p<.05; **p<.01; ***p < .001
Watson, 2021	Geospatial statistical model	Index of multiple deprivation (IMD)	Hospitalization	Hospitalization rates	Increase (less deprived) in IMD decile (linear) April 1 May 1 June 1	 0.93 0.91 0.89	N/A	 (0.91,0.95) (0.90, 0.92) (0.88, 0.90)	N/A
Williamson, 2020	Descriptive statistics	Index of multiple deprivation (IMD)	COVID-19 deaths	Hazard ratio, age-sex-adjusted	1 (least deprived) 2 3 4 5 (most deprived)	1.00 (ref) 1.16 1.31 1.69 2.11	N/A	(ref) (1.08-1.23) (1.23-1.40) (1.59-1.79) (1.98-2.25)	N/A
Woodward, 2021	Descriptive statistics	Townsend Deprivation Index	COVID-19 deaths	Hazard ratio age-ethnicity adjusted	Women: 1st Least disadvantaged 2nd 3rd 4th 5th Most disadvantaged Men: 1st Least disadvantaged 2nd 3rd 4th 5th Most disadvantaged	 Ref 1.34 1.55 2.98 3.66 Ref 1.32 1.45 2.10 3.00	N/A	 Ref (0.96 to 1.87) (1.07 to 2.24) (2.23 to 3.98) (2.82 to 4.75) Ref (1.06 to 1.66) (1.12 to 1.89) (1.65 to 2.67) (2.46 to 3.66)	N/A
Zhang, 2021	Logistic regressions and Cox proportional-hazards models	Social deprivation index (SDI)	COVID-19 deaths (HR), Hospitalization (OR)	Hazard ratio (C19 deaths) Odds ratio (Hospitalization)	Quintile 1 —least Quintile 2 Quintile 3 Quintile 4 Quintile 5 —most Quintile 1 —least Quintile 2	 1.61 1.27 1.80 2.00 1.43	N/A	 (1.07, 2.42)* (0.87, 1.84)* (1.27, 2.54)* (1.43, 2.80)* (1.20, 1.71) *	 *q-value < 0.05.

					Quintile 3 Quintile 4 Quintile 5 —most	1.25 1.70 1.91		(1.07, 1.45) * (1.48, 1.97) * (1.67, 2.18) *	

Supplementary Table 3) Search Syntax

Database	**Syntax**	**Filters**
PubMed	((Socioeconomic status[Title/Abstract]) OR (Socio-economic status[Title/Abstract])) OR (Socioeconomic status[Title/Abstract])) OR (Socio-economic status[Title/Abstract])) OR (Income[Title/Abstract])) OR (Poverty[Title/Abstract])) OR (Neighborhood Deprivation[Title/Abstract])) OR (Neighborhood Disadvantage[Title/Abstract])) OR (Overcrowded Household[Title/Abstract])) OR (Education[Title/Abstract])) OR (Occupation[Title/Abstract])) OR (Employment[Title/Abstract])) OR (Class, Social[Title/Abstract])) OR (Classes, Social[Title/Abstract])) OR (Social Classes[Title/Abstract])) OR (Socioeconomic Status[Title/Abstract])) OR (Status, Socioeconomic[Title/Abstract])) OR (Factor, Socioeconomic[Title/Abstract])) OR (Socioeconomic Factor[Title/Abstract])) OR (Factors, Socioeconomic[Title/Abstract])) OR (Standard of Living[Title/Abstract])) OR (Living Standard[Title/Abstract])) OR (Living Standards[Title/Abstract])) OR (Social Inequality[Title/Abstract])) OR (Inequalities, Social[Title/Abstract])) OR (Inequality, Social[Title/Abstract])) OR (Social Inequalities[Title/Abstract])) OR (Social Inequity[Title/Abstract])) OR (Social Inequities[Title/Abstract])) OR (Social Vulnerability[Title/Abstract])) OR (Social Deprivation[Title/Abstract])) OR (Material Deprivation[Title/Abstract])) OR (Deprivation[Title/Abstract])) OR (Health Determinants[Title/Abstract])) OR (Social Determinants of Health[Title/Abstract])) OR (Social Determinants[Title/Abstract])) OR (Health Inequality[Title/Abstract])) OR (Health Inequalities[Title/Abstract])) OR (Health Inequity[Title/Abstract])) OR (Health Inequities[Title/Abstract])) **AND** (((((((((((((((((((((((((((COVID 19[Title/Abstract]) OR (COVID-19[Title/Abstract])) (Virus Disease[Title/Abstract])) OR (COVID 19 Virus Disease[Title/Abstract])) OR (COVID-19 Virus Diseases[Title/Abstract])) OR (COVID-19 Virus Infection[Title/Abstract])) OR (COVID 19 Virus Infection[Title/Abstract])) OR (COVID-19 Virus Infections[Title/Abstract])) OR (2019-nCoV Infection[Title/Abstract])) OR (2019 nCoV Infection[Title/Abstract])) OR (2019-nCoV Infections[Title/Abstract])) OR (Coronavirus Disease-19[Title/Abstract])) OR (Coronavirus Disease 19[Title/Abstract])) OR (2019 Novel Coronavirus Disease[Title/Abstract])) OR (2019 Novel Coronavirus Infection[Title/Abstract])) OR (2019-nCoV Disease[Title/Abstract])) OR (2019 nCoV Disease[Title/Abstract])) OR (2019-nCoV Diseases[Title/Abstract])) OR (COVID19[Title/Abstract])) OR (Coronavirus Disease 2019[Title/Abstract])) OR (SARS Coronavirus 2 Infection[Title/Abstract])) OR (SARS-CoV-2 Infection[Title/Abstract])) OR (SARS CoV 2 Infection[Title/Abstract])) OR (SARS- CoV-2 Infections[Title/Abstract])) OR (COVID-19 Pandemic[Title/Abstract])) OR (COVID 19 Pandemic[Title/Abstract])) OR (COVID-19 Pandemics[Title/Abstract])) **AND** ((((((((((((((((((((((((Mortality[Title/Abstract])) OR (Mortalities[Title/Abstract])) OR (Case Fatality Rate[Title/Abstract])) OR (Case Fatality Rates[Title/Abstract])) OR (Crude Death Rate[Title/Abstract])) OR (Crude Death Rates[Title/Abstract])) OR (Crude Mortality Rate[Title/Abstract])) OR (Crude Mortality Rates[Title/Abstract])) OR (Death Rate[Title/Abstract])) OR (Death Rates[Title/Abstract])) OR (Mortality Rate[Title/Abstract])) OR (Mortality Rates[Title/Abstract])) OR (Excess Mortality[Title/Abstract])) OR (Excess Mortalities[Title/Abstract])) OR (Mortality Determinants[Title/Abstract])) OR (Differential Mortality[Title/Abstract])) OR (Differential Mortalities[Title/Abstract])) OR (Fatal Outcome[Title/Abstract])) OR (Fatal Outcomes[Title/Abstract])) OR (Hospitalization[Title/Abstract])) OR (Hospitalizations[Title/Abstract])) OR (Disease Severity[Title/Abstract])) OR (Adverse Outcome[Title/Abstract])) OR (Adverse Outcomes[Title/Abstract]))	Years: 2020/2021
Web of Science	((TI=(Socioeconomic status OR Socio-economic status OR Socioeconomic status OR Socio-economic status OR Income OR Poverty OR Neighborhood Deprivation OR Neighborhood Disadvantage OR Overcrowded Household OR Education OR Occupation OR Employment OR Class, Social OR Classes, Social OR Social Classes OR Socioeconomic Status OR Status, Socioeconomic OR Factor, Socioeconomic OR Socioeconomic Factor OR Factors, Socioeconomic OR Standard of Living OR Living Standard OR Living Standards OR Social Inequality OR Inequalities, Social OR Inequality, Social OR Social Inequalities OR Social Inequity OR Social Inequities OR Social Vulnerability OR Social Deprivation OR Material Deprivation OR Deprivation OR Health Determinants OR Social Determinants of Health OR Social Determinants OR Health Inequality OR Health Inequalities OR Health Inequity OR Health Inequities)) OR (AB=(Socioeconomic status OR Socio-economic status OR Socioeconomic status OR Socio-economic status OR Income OR Poverty OR Neighborhood Deprivation OR Neighborhood Disadvantage OR Overcrowded Household OR Education OR Occupation OR Employment OR Class, Social OR Classes, Social OR Social Classes OR Socioeconomic Status OR Status, Socioeconomic OR Factor, Socioeconomic OR Socioeconomic Factor OR Factors, Socioeconomic OR Standard of Living OR Living Standard OR Living Standards OR Social Inequality OR Inequalities, Social OR Inequality, Social OR Social Inequalities OR Social Inequity OR Social Inequities OR Social Vulnerability OR Social Deprivation OR Material Deprivation OR Deprivation OR Health Determinants OR Social Determinants of Health OR Social Determinants OR Health Inequality OR Health Inequalities OR Health Inequity OR Health Inequities))) **AND** ((TI=(COVID 19 OR COVID-19 Virus Disease OR COVID 19 Virus Disease OR COVID-19 Virus Diseases OR COVID-19 Virus Infection OR COVID 19 Virus Infection OR COVID-19 Virus Infections OR 2019-nCoV Infection OR 2019 nCoV Infection OR 2019-nCoV Infections OR Coronavirus Disease-19 OR Coronavirus Disease 19 OR 2019 Novel Coronavirus Disease OR 2019 Novel Coronavirus Infection OR 2019-nCoV Disease OR 2019 nCoV Disease OR 2019-nCoV Diseases OR COVID19 OR Coronavirus Disease 2019 OR SARS Coronavirus 2 Infection OR SARS-CoV-2 Infection OR SARS CoV 2 Infection OR SARS-CoV-2 Infections OR COVID-19 Pandemic OR COVID 19 Pandemic OR COVID-19 Pandemics)) OR (AB=(COVID 19 OR COVID-19 Virus Disease OR COVID 19 Virus Disease OR COVID-19 Virus Diseases OR COVID-19 Virus Infection OR COVID 19 Virus Infection OR COVID-19 Virus Infections OR 2019-nCoV Infection OR 2019 nCoV Infection OR 2019-nCoV Infections OR Coronavirus Disease-19 OR Coronavirus Disease 19 OR 2019 Novel Coronavirus Disease OR 2019 Novel Coronavirus Infection OR 2019-nCoV Disease OR 2019 nCoV Disease OR 2019-nCoV Diseases OR COVID19 OR Coronavirus Disease 2019 OR SARS Coronavirus 2 Infection OR SARS-CoV-2 Infection OR SARS CoV 2 Infection OR SARS- CoV-2 Infections OR COVID-19 Pandemic OR COVID 19 Pandemic OR COVID-19 Pandemics))) **AND**	Years: 2020/2021

	((TI=(Mortality OR Mortalities OR Case Fatality Rate OR Case Fatality Rates OR Crude Death Rate OR Crude Death Rates OR Crude Mortality Rate OR Crude Mortality Rates OR Death Rate OR Death Rates OR Mortality Rate OR Mortality Rates OR Excess Mortality OR Excess Mortalities OR Mortality Determinants OR Differential Mortality OR Differential Mortalities OR Fatal Outcome OR Fatal Outcomes OR Hospitalization OR Hospitalizations OR Disease Severity OR Adverse Outcome OR Adverse Outcomes)) OR (AB=(Mortality OR Mortalities OR Case Fatality Rate OR Case Fatality Rates OR Crude Death Rate OR Crude Death Rates OR Crude Mortality Rate OR Crude Mortality Rates OR Death Rate OR Death Rates OR Mortality Rate OR Mortality Rates OR Excess Mortality OR Excess Mortalities OR Mortality Determinants OR Differential Mortality OR Differential Mortalities OR Fatal Outcome OR Fatal Outcomes OR Hospitalization OR Hospitalizations OR Disease Severity OR Adverse Outcome OR Adverse Outcomes)))	
Cochrane Library	**Search 1**: Socioeconomic status OR Socio-economic status OR Socioeconomic status OR Socio-economic status OR Income OR Poverty OR Neighborhood Deprivation OR Neighborhood Disadvantage OR Overcrowded Household OR Education OR Occupation OR Employment OR Class, Social OR Classes, Social OR Social Classes OR Socioeconomic Status OR Status, Socioeconomic OR Factor, Socioeconomic OR Socioeconomic Factor OR Factors, Socioeconomic OR Standard of Living OR Living Standard OR Living Standards OR Social Inequality OR Inequalities, Social OR Inequality, Social OR Social Inequalities OR Social Inequity OR Social Inequities OR Social Vulnerability OR Social Deprivation OR Material Deprivation OR Deprivation OR Health Determinants OR Social Determinants of Health OR Social Determinants OR Health Inequality OR Health Inequalities OR Health Inequity OR Health Inequities **Search 2**: "COVID 19" OR "COVID-19 Virus Disease" OR "COVID 19 Virus Disease" OR "COVID-19 Virus Diseases" OR "COVID-19 Virus Infection" OR "COVID 19 Virus Infection" OR "COVID-19 Virus Infections" OR "2019-nCoV Infection" OR "2019 nCoV Infection" OR "2019-nCoV Infections" OR "Coronavirus Disease-19" OR "Coronavirus Disease 19" OR "2019 Novel Coronavirus Disease" OR "2019 Novel Coronavirus Infection" OR "2019-nCoV Disease" OR "2019 nCoV Disease" OR "2019-nCoV Diseases" OR "COVID19" OR "Coronavirus Disease 2019" OR "SARS Coronavirus 2 Infection" OR "SARS-CoV-2 Infection" OR "SARS CoV 2 Infection" OR "SARS-CoV-2 Infections" OR "COVID-19 Pandemic" OR "COVID 19 Pandemic" OR "COVID-19 Pandemics" **Search 3**: Mortality OR Mortalities OR Case Fatality Rate OR Case Fatality Rates OR Crude Death Rate OR Crude Death Rates OR Crude Mortality Rate OR Crude Mortality Rates OR Death Rate OR Death Rates OR Mortality Rate OR Mortality Rates OR Excess Mortality OR Excess Mortalities OR Mortality Determinants OR Differential Mortality OR Differential Mortalities OR Fatal Outcome OR Fatal Outcomes OR Hospitalization OR Hospitalizations OR Disease Severity OR Adverse Outcome OR Adverse Outcomes **1# AND 2# AND 3#**	Abstract, Title, Keywords Trials only
Cochrane - Covid-19 Registry		SES, Mortality, Years: 2020, 2021
Sociological Abstracts	AB,TI(Socioeconomic status OR Socio-economic status OR Socioeconomic status OR Socio-economic status OR Income OR Poverty OR Neighborhood Deprivation OR Neighborhood Disadvantage OR Overcrowded Household OR Education OR Occupation OR Employment OR Class, Social OR Classes, Social OR Social Classes OR Socioeconomic Status OR Status, Socioeconomic OR Factor, Socioeconomic OR Socioeconomic Factor OR Factors, Socioeconomic OR Standard of Living OR Living Standard OR Living Standards OR Social Inequality OR Inequalities, Social OR Inequality, Social OR Social Inequalities OR Social Inequity OR Social Inequities OR Social Vulnerability OR Social Deprivation OR Material Deprivation OR Deprivation OR Health Determinants OR Social Determinants of Health OR Social Determinants OR Health Inequality OR Health Inequalities OR Health Inequity OR Health Inequities) **AND** AB,TI(COVID 19 OR COVID-19 Virus Disease OR COVID 19 Virus Disease OR COVID-19 Virus Diseases OR COVID-19 Virus Infection OR COVID 19 Virus Infection OR COVID- 19 Virus Infections OR 2019-nCoV Infection OR 2019 nCoV Infection OR 2019-nCoV Infections OR Coronavirus Disease-19 OR Coronavirus Disease 19 OR 2019 Novel Coronavirus Disease OR 2019 Novel Coronavirus Infection OR 2019-nCoV Disease OR 2019 nCoV Disease OR 2019-nCoV Diseases OR COVID19 OR Coronavirus Disease 2019 OR SARS Coronavirus 2 Infection OR SARS-CoV-2 Infection OR SARS CoV 2 Infection OR SARS-CoV-2 Infections OR COVID-19 Pandemic OR COVID 19 Pandemic OR COVID-19 Pandemics) **AND** AB,TI(Mortality OR Mortalities OR Case Fatality Rate OR Case Fatality Rates OR Crude Death Rate OR Crude Death Rates OR Crude Mortality Rate OR Crude Mortality Rates OR Death Rate OR Death Rates OR Mortality Rate OR Mortality Rates OR Excess Mortality OR Excess Mortalities OR Mortality Determinants OR Differential Mortality OR Differential Mortalities OR Fatal Outcome OR Fatal Outcomes OR Hospitalization OR Hospitalizations OR Disease Severity OR Adverse Outcome OR Adverse Outcomes)	Years: 2020, 2021
PsycInfo	**Search 1: Fields: Title** (Socioeconomic status OR Socio-economic status OR Socioeconomic status OR Socio-economic status OR Income OR Poverty OR Neighborhood Deprivation OR Neighborhood Disadvantage OR Overcrowded Household OR Education OR Occupation OR Employment OR Class, Social OR Classes, Social OR Social Classes OR Socioeconomic Status OR Status, Socioeconomic OR Factor, Socioeconomic OR Socioeconomic Factor OR Factors, Socioeconomic OR Standard of Living OR Living Standard OR Living Standards OR Social Inequality OR Inequalities, Social OR Inequality, Social OR Social Inequalities OR Social Inequity OR Social Inequities OR Social Vulnerability OR Social Deprivation OR Material Deprivation OR Deprivation OR Health Determinants OR Social Determinants of Health OR Social Determinants OR Health Inequality OR Health Inequalities OR Health Inequity OR Health Inequities) **AND** (COVID 19 OR COVID-19 Virus Disease OR COVID 19 Virus Disease OR COVID-19 Virus Diseases OR COVID-19 Virus Infection OR COVID 19 Virus Infection OR COVID-19 Virus Infections OR 2019-nCoV Infection OR 2019 nCoV Infection OR 2019-nCoV Infections OR Coronavirus Disease-19 OR Coronavirus Disease 19 OR 2019 Novel Coronavirus Disease OR 2019	-

	Novel Coronavirus Infection OR 2019-nCoV Disease OR 2019 nCoV Disease OR 2019-nCoV Diseases OR COVID19 OR Coronavirus Disease 2019 OR SARS Coronavirus 2 Infection OR SARS-CoV-2 Infection OR SARS CoV 2 Infection OR SARS-CoV-2 Infections OR COVID-19 Pandemic OR COVID 19 Pandemic OR COVID-19 Pandemics) **AND** (Mortality OR Mortalities OR Case Fatality Rate OR Case Fatality Rates OR Crude Death Rate OR Crude Death Rates OR Crude Mortality Rate OR Crude Mortality Rates OR Death Rate OR Death Rates OR Mortality Rate OR Mortality Rates OR Excess Mortality OR Excess Mortalities OR Mortality Determinants OR Differential Mortality OR Differential Mortalities OR Fatal Outcome OR Fatal Outcomes OR Hospitalization OR Hospitalizations OR Disease Severity OR Adverse Outcome OR Adverse Outcomes) **Search 2: Fields: Abstract** (Socioeconomic status OR Socio-economic status OR Socioeconomic status OR Socio-economic status OR Income OR Poverty OR Neighborhood Deprivation OR Neighborhood Disadvantage OR Overcrowded Household OR Education OR Occupation OR Employment OR Class, Social OR Classes, Social OR Social Classes OR Socioeconomic Status OR Status, Socioeconomic OR Factor, Socioeconomic OR Socioeconomic Factor OR Factors, Socioeconomic OR Standard of Living OR Living Standard OR Living Standards OR Social Inequality OR Inequalities, Social OR Inequality, Social OR Social Inequalities OR Social Inequity OR Social Inequities OR Social Vulnerability OR Social Deprivation OR Material Deprivation OR Deprivation OR Health Determinants OR Social Determinants of Health OR Social Determinants OR Health Inequality OR Health Inequalities OR Health Inequity OR Health Inequities) **AND** (COVID 19 OR COVID-19 Virus Disease OR COVID 19 Virus Disease OR COVID-19 Virus Diseases OR COVID-19 Virus Infection OR COVID 19 Virus Infection OR COVID-19 Virus Infections OR 2019-nCoV Infection OR 2019 nCoV Infection OR 2019-nCoV Infections OR Coronavirus Disease-19 OR Coronavirus Disease 19 OR 2019 Novel Coronavirus Disease OR 2019 Novel Coronavirus Infection OR 2019-nCoV Disease OR 2019 nCoV Disease OR 2019-nCoV Diseases OR COVID19 OR Coronavirus Disease 2019 OR SARS Coronavirus 2 Infection OR SARS-CoV-2 Infection OR SARS CoV 2 Infection OR SARS-CoV-2 Infections OR COVID-19 Pandemic OR COVID 19 Pandemic OR COVID-19 Pandemics) **AND** (Mortality OR Mortalities OR Case Fatality Rate OR Case Fatality Rates OR Crude Death Rate OR Crude Death Rates OR Crude Mortality Rate OR Crude Mortality Rates OR Death Rate OR Death Rates OR Mortality Rate OR Mortality Rates OR Excess Mortality OR Excess Mortalities OR Mortality Determinants OR Differential Mortality OR Differential Mortalities OR Fatal Outcome OR Fatal Outcomes OR Hospitalization OR Hospitalizations OR Disease Severity OR Adverse Outcome OR Adverse Outcomes) **Search 3: S1 OR S2**	

8 PRE-PUBLICATION OF RESULTS

No results were published in advance.