Universität Bern
Wirtschafts- und Sozialwissenschaftliche Fakultät
Insititut für Soziologie

Empirische Untersuchungen zu aktuellen gesellschaftlichen Herausforderungen aus den Bereichen öffentliche Gesundheit, Klimawandel und Verkehr

Inauguraldissertation

zur Erlangung der Würde eines Doctor rerum socialium an der Wirtschafts- und Sozialwissenschaftlichen Fakultät der Universität Bern

vorgelegt von

Fabienne Anastasia Wöhner

aus Selb in Deutschland

August 2023

Erstgutachter: Prof. Dr. Axel Franzen
Zweitgutachter: Prof. Dr. Roger Berger

Die Fakultät hat diese Arbeit am 02. November 2023 auf Antrag der beiden Gutachter Prof. Dr. Axel Franzen und Prof. Dr. Roger Berger als Dissertation angenommen, ohne damit zu den darin ausgesprochenen Auffassungen Stellung nehmen zu wollen.

Inhaltsverzeichnis

Abstract

Diese Dissertation beinhaltet vier empirische Studien zu ausgewählten aktuellen gesellschaftlichen Herausforderungen aus den Bereichen öffentliche Gesundheit, Klimawandel und Verkehr. Alle Untersuchungen beziehen sich auf die Schweiz. Thematisch lässt sich diese Arbeit in zwei Teile gliedern. Der eine Teil der Dissertation behandelt das Social-Distancing-Verhalten während der Coronapandemie. Im Rahmen dessen wurde die Frage gestellt, unter welchen Bedingungen junge Erwachsene dem Social-Distancing-Appell Folge leisteten und so viel wie möglich zu Hause blieben. Die Ergebnisse von zwei aufeinander aufbauenden Studien zeigen, dass insbesondere Personen, deren Umfeld sich selbst an den Social-Distancing-Appell hält, einen eigenen Beitrag zum Kollektivgut „Virusverbreitung stoppen“ leisten. Ausserdem befolgen Individuen, welche andere Schutzmassnahmen (wie die Schliessungen von Restaurants, Hochschulen und Freizeiteinrichtungen) befürworten, stärker den Social-Distancing-Appell. Mithilfe von zwei Panelanalysen wird gezeigt, dass der Zusammenhang zwischen der Einstellung bezüglich der Schutzmassnahmen und dem Social-Distancing-Verhalten kausal interpretiert werden kann. Der andere Teil der Arbeit behandelt das Mobilitätsverhalten von Erwerbstätigen und besteht aus zwei zusammenhängenden wissenschaftlichen Artikeln. In der ersten Publikation wird untersucht, ob die Flexibilisierung des Arbeitsmarktes in Form von Home-Office-Arbeit und Gleitzeit, dazu beitragen kann, die Verkehrsnachfrage zu reduzieren. Damit soll eingeschätzt werden, ob die Veränderungen der Arbeitswelt zur Abmilderung des Klimawandels beitragen könnten. Die wichtigste Erkenntnis ist, dass die Home-Office Nutzung bisher nicht mit einer Reduktion der Gesamtverkehrsnachfrage beziehungsweise des Strassenverkehrs verbunden ist, weil es einen Reboundeffekt gibt: Home-Office-Arbeitende pendeln zwar weniger, aber reinvestieren die gesparte Zeit in anderweitige Mobilitätszwecke, wie beispielsweise Einkaufen oder Freizeit. Ein Nutzen für die Umwelt in Form von weniger Treibhausgasemissionen durch Home-Office-Arbeit ist folglich nicht gegeben. In der zweiten Mobilitätsstudie wird der Zusammenhang von flexiblen Arbeitsformen und der aktiven Mobilität (also Laufen und Radfahren) analysiert. Hier zeigen sich zwei zentrale Befunde. Erstens ist Gleitzeitarbeit (genauer gesagt die Kernarbeitszeit) mit häufigeren und längeren Fusswegen verbunden. Zweitens könnten Telearbeit und Gleitzeit zur öffentlichen Gesundheit beitragen, denn sie erhöhen die Wahrscheinlichkeit, ein gesundheitsförderndes Ausmass an aktiver Mobilität (30+ Minuten pro Tag) zu erreichen.

Finanzierung
Ein Teil dieser Dissertation wurde vom Schweizerischen Nationalfonds (SNF) unter der Projektnummer 188866 gefördert. Der SNF hatte keinen inhaltlichen Einfluss auf die Erstellung dieser Arbeit.

1 Einführung

1.1 Aktuelle gesellschaftliche Herausforderungen

Aktuell finden verschiedene globale Ereignisse und Entwicklungen statt, welche die Gesellschaft mit neuen Herausforderungen konfrontieren. Die vorliegende Dissertation beschäftigt sich mit verschiedenen gegenwärtigen gesellschaftlichen Problematiken in Bezug auf die öffentliche Gesundheit, den Klimawandel und den Verkehr. Mithilfe von vier in der Schweiz durchgeführten Studien zielt diese Arbeit darauf ab, einen sozialwissenschaftlichen Beitrag zum besseren Verständnis im Umgang mit diesen Herausforderungen zu leisten.

Eines der einschneidendsten Ereignisse in den letzten Jahren war die weltweite Corona-Pandemie. Zu Beginn des Jahres 2020 begann sich eine neue Infektionskrankheit – das COVID-19-Virus – rasend schnell auf der gesamten Welt zu verbreiten. Bereits nach wenigen Wochen hat die Weltgesundheitsorganisation (WHO) deswegen eine gesundheitliche internationale Notlage ausgerufen und nur wenig später, am 11. März 2020, von einer weltweiten Pandemie gesprochen (WHO 2020a, WHO 2021). Am 16. März 2020 wurde auch in der Schweiz die Situation zur „ausserordentlichen Lage“ erklärt (Schweizerische Eidgenossenschaft 2020b). Die Krankheit stellte eine ungewohnte Bedrohung für die (weltweite) öffentliche Gesundheit dar. Um dem Coronavirus zu begegnen, wurde international mit Hochdruck nach Möglichkeiten zur Behandlung der Krankheit geforscht und mit der Entwicklung von Impfstoffen begonnen. Da dies jedoch Zeit benötigt, basierte das Krisenmanagement vor allem zu Beginn der Pandemie auf vielfältigen Schutzmassnassnahmen, die kurzerhand implementiert wurden. Diese hatten zum Ziel, die Verbreitung des Virus so gut wie möglich einzudämmen, besonders gefährdete Personen zu schützen und die gesundheitsrelevanten Kapazitäten der Schweiz zu schonen, um die gesundheitliche Versorgung sicherzustellen (Schweizerische Eidgenossenschaft 2020a). Somit wurden in der Schweiz im Frühjahr 2020 verschiedenste Massnahmen angeordnet. Diese umfassten unter anderem die Schliessung von Restaurants, Bars, Freizeiteinrichtungen sowie von Geschäften ausserhalb der täglichen Grundversorgung, Fernunterricht an Schulen und Hochschulen, Home-Office-Arbeit, Veranstaltungsgebote und Quarantäneauflagen (Schweizerische Eidgenossenschaft 2020a und 2020b). Diese Massnahmen reduzierten das gesellschaftliche Zusammenleben auf ein systemrelevantes Minimum und waren auch als Shutdown beziehungsweise Lockdown bekannt. Darüber hinaus wurden vom Bundesamt für Gesundheit verschiedene Kampagnen unter dem Titel „So schützen wir uns“ lanciert, welche an weitere krankheitsverhindernde Verhaltensweisen appellierten (siehe Bundesamt für Gesundheit 2020-2022). Hierzu zählte unter anderem Abstand halten, Hände waschen, Lüften und das Vermeiden

von Kontakten mit Personen ausserhalb des eigenen Haushalts (Social-Distancing). Um die Verbreitung des Virus bis zur Fertigstellung und Verteilung der Impfstoffe zu hemmen, war es erforderlich, dass die meisten Menschen diese Verhaltensnormen einhielten. Dies war gesellschaftlich gesehen eine Herausforderung, denn die Massnahmen brachten mitunter deutliche Einschränkungen für die Bevölkerung mit sich und das konsequente Umsetzen der Verhaltensregeln war zumindest teilweise freiwillig. So gab es beispielsweise in der Schweiz – anderes als in einigen Nachbarländern – keine Ausgangssperren. Folglich ist die Verordnung von Schutzmassnahmen und Handlungsnormen seitens der Politik von der tatsächlichen Kooperationsbereitschaft der Bevölkerung zu unterscheiden. Dies ist insbesondere dann der Fall, wenn eine Krankheit – so wie das Coronavirus – nicht für alle Menschen gleich bedrohlich ist. Inwiefern die verschiedenen Schutzmassnahmen tatsächlich mitgetragen werden, ist demnach eine empirische Frage. Im Rahmen der Dissertation wird der Fokus auf die Social-Distancing Massnahme gelegt und untersucht unter welchen Bedingungen die persönlichen Kontakte mit Personen ausserhalb des eigenen Haushalts während der Coronapandemie eingeschränkt wurden.

Im Mai 2023 hat die Weltgesundheitsorganisation die gesundheitliche internationale Notlage für beendet erklärt (WHO 2023). Obwohl der weltweite Gesundheitsnotstand fast drei Jahre anhielt, befindet sich die Gesellschaft nun wieder auf dem Weg zur Normalität. Anders sieht es jedoch mit einer weiteren gesellschaftlichen Herausforderung aus, welche die Welt seit längerer Zeit beschäftigt und voraussichtlich auch in den nächsten Jahrzehnten nicht für beendet erklärt werden kann. Die Rede ist vom voranschreitenden Klimawandel. Bereits jetzt manifestieren sich die Konsequenzen der globalen Erderwärmung deutlich – beispielsweise in Form von vermehrten Extremwetterereignissen, dem Rückgang der Biodiversität, häufigeren Ernteausfällen und der Zunahme von Vektor-Krankheiten (IPCC 2023). Essenziell ist der Umstand, dass die aktuelle Erderwärmung nicht natürlich ist, sondern hauptsächlich durch die Treibhausgasemissionen der Menschen vorangetrieben wird (IPCC 2023). Um eine drohende Klimakrise zu verhindern und die Auswirkungen des anthropogenen Klimawandels möglichst zu begrenzen, wurde 2015 das Übereinkommen von Paris verabschiedet (UNFCCC 2015). Dieses internationale Abkommen hat das Ziel, die durch die Industrialisierung induzierte globale Erderwärmung bis zum Ende des 21. Jahrhunderts auf höchstens 2 Grad Celsius, und besser noch 1.5 Grad Celsius, zu drosseln. Jedoch wird angenommen, dass bereits ab einer Erderwärmung von über 1 Grad Celsius kritische und irreversible Konsequenzen für Mensch und Natur drohen und diese immer drastischer werden je weiter globale Durchschnittstemperatur ansteigt (McKay et al. 2022). Das ist besonders deswegen besorgniserregend, weil für den Zeitraum 2011-2020 bereits eine durchschnittliche Erderwärmung von 1.1 Grad Celsius im Vergleich zu 1850-1900 dokumentiert wurde

(IPCC 2023). Aufgrund dessen sollte das im Pariser Klimaabkommen angestrebte Ziel von höchstens 1.5 Grad Celsius Erderwärmung dringend weiterverfolgt werden (McKay et al. 2022). Zusammenfassend ist es vonnöten, die anthropogenen Treibhausgasemissionen zu reduzieren. Darüber hinaus ist es wichtig, so schnell wie möglich zu agieren und die Reduktionsbemühungen alsbald zu verstärken, um irreversible negative Langzeit-Konsequenzen aufgrund späteren Handelns zu verhindern (Iyer et al. 2022). Im Rahmen des Pariser Klimaabkommens hat die Schweiz 2021 ihre langfristige Klimastrategie verabschiedet, mit der die Treibhausgasemissionen bis 2030 halbiert und bis 2050 auf „Netto-Null“ reduziert werden sollen (Der Bundesrat 2021). Die Erreichung dieses Ziels erfordert unter anderem deutliche Verhaltensveränderungen seitens der Bevölkerung. Dies liegt darin begründet, dass sich der Grossteil der ausgestossenen Emissionen schlussendlich auf den Konsum und Verbrauch von Haushalten zurückführen lässt (Hertwich und Peters 2009, Ivanova et al. 2015). Es sind aber auch das alltägliche Verhalten und die kulturellen Normen, die im Zusammenhang mit dem Energieverbrauch und Konsum einen entscheidenden Einfluss auf die Einsparung von Emissionen besitzen (IPCC 2014, Ivanova et al. 2020). Die Forschung zur Erreichung der Klimaziele sollte demnach nicht nur technologische Möglichkeiten und Entwicklungen fokussieren (wie beispielsweise Geoengineering), sondern auch explizit die Nachfragerseite mit einbeziehen (Creutzig et al. 2018, Ivanova et al. 2020). Als Bereiche mit erheblichem Einsparpotenzial der Nachfrageseite – also der Endverbraucher – werden insbesondere Wohnen und Gebäude, Ernährung sowie Transport identifiziert (z.B. Dubois et al. 2019, Hertwich and Peters 2009, Ivanova et al. 2020). Gerade der letzte Bereich ist bedeutsam. So wird auch in der Schweiz der grösste Teil der Emissionen – rund 30% – durch Transport und Verkehr verursacht (Bundesamt für Umwelt BAFU 2023). Massnahmen wie der Wechsel auf umweltfreundlichere Autos (beispielsweise von Benzinmotoren auf Elektro-Antriebe) bieten zwar Potenzial für Emissionsreduktionen (Creutzig et al. 2015, Ivanova et al. 2020), aber deren Implementation kann langwierig sein. Darüber hinaus adressieren solche Massnahmen nur ein Element eines umfassenderen Problems. Denn nicht nur aus ökologischer Sicht besteht Veränderungsbedarf bezüglich des Mobilitätsverhaltens. Auch das Verkehrsaufkommen selbst fordert die Gesellschaft heraus.

In den letzten Jahrzehnten hat die Mobilität im Allgemeinen und insbesondere der motorisierte private Individualverkehr immer weiter zugenommen und es wird davon ausgegangen, dass durch das Wirtschafts- und Bevölkerungswachstum das Verkehrsaufkommen noch weiter ansteigen wird (Bundesamt für Raumentwicklung ARE 2022). Im Jahr 2019 gab es allein auf den Schweizer Nationalstrassen rund 30000 Staustunden, welche zu 89% auf eine Überlastung des Strassenverkehrsnetzes zurückzuführen sind (Bundesamt für Strassen ASTRA 2019). Während der beiden

Pandemiejahre wurden dort wie zu erwarten weniger Staustunden verzeichnet, wobei bereits im Jahr 2021 nur noch 6.7% weniger Staustunden als vor der Pandemie (2019) registriert wurden (Bundesamt für Strassen ASTRA 2021). Obwohl 2022 die Anzahl an gefahrenen Kilometern auf den Schweizer Nationalstrassen noch nicht wieder gänzlich auf das Niveau von vor der Pandemie zurückgekehrt ist, wurden sogar mehr Staustunden (rund 35000) als noch 2019 erfasst, was darauf hindeutet, dass die Nationalstrassen an ihre Kapazitätsgrenzen stossen (Bundesamt für Strassen 2022). Die Staus verursachen immense volkswirtschaftliche Kosten durch Zeitverluste und ziehen weitere Folgekosten für Umwelt, Klima, Energie und durch Unfälle nach sich, welche sich im Jahr 2015 insgesamt auf rund 1888 Millionen CHF beliefen (Keller 2019). Insgesamt zieht der Strassenverkehr vielfältige negative Externalitäten nach sich zu denen unter anderem Treibhausgasemissionen, Umweltzerstörung, Unfälle, Luftverschmutzung und Lärm zählen, wobei diese sowohl für die Umwelt als auch die Gesundheit nachteilig sein können (Fernandes et al. 2019, Santos et al. 2010). Folgerichtig sind Reduktionen des Verkehrs, insbesondere des stark emittierenden Autoverkehrs, sowohl für die Erreichung der Klimaziele als auch für ein gesundes gesellschaftliches Zusammenleben notwendig. Im Folgenden wird deswegen eine fortlaufende Entwicklung untersucht, die auf natürliche Weise, das heisst ohne aktive interventionspolitische Massnahme, einen Rückgang in der Verkehrsnachfrage mit sich bringen könnte: der Einsatz von Telearbeit (Home-Office) im Berufsalltag. Bereits seit den 1970er Jahren wurde der Einsatz von Telearbeit als eine vielversprechende Möglichkeit diskutiert, die dazu beitragen könnte, den Verkehr zu reduzieren (z.B. Mokhtarian 1991). Die Idee dahinter ist, dass aufgrund von Telearbeit auf Pendelfahrten verzichtet werden kann, was den Verkehr insgesamt und während den Stosszeiten entlasten könnte. Home-Office wird auch heutzutage immer noch als mögliche Massnahme vorgeschlagen, welche die Notwendigkeit für Fahrten verringern könnte und damit Emissionssparpotential besitzt (z.B. Creutzig et al. 2018, Ivanova et al. 2020). Auch in der Langfristigen Klimastrategie der Schweiz wird Telearbeit als Möglichkeit, den Energieverbrauch zu senken, genannt (Der Bundesrat 2021). Der Ansatz scheint lohnend, denn es gibt in der Schweiz rund 3.6 Millionen Pendlerinnen und Pendler, von denen rund die Hälfte mit dem Auto zum Arbeitsplatz fährt. Inwieweit diese Überlegung zur Telearbeit tatsächlich zutrifft oder ob der sogenannte Reboundeffekt auftritt, bei dem gesparte Pendelfahrten mit anderen Fahrten kompensiert werden (z.B. Salomon 1986, Hook et al. 2020), ist wieder eine empirisch zu klärende Frage. Zudem zeigt sich, dass die Verkehrsüberlastung besonders oft unter der Woche von Montag bis Freitag am Morgen zwischen 7 und 8 Uhr und am frühen Abend zwischen 17 und 18 Uhr auftritt (Bundesamt für Statistik 2021, Bundesamt für Statistik und Bundesamt für Raumentwicklung ARE 2023). Pendlerinnen und Pendler sind besonders von dem Problem betroffen und

gleichzeitig auch für dieses mitverantwortlich (Bundesamt für Statistik 2021, Bundesamt für Statistik und Bundesamt für Raumentwicklung ARE 2023). Neben der Möglichkeit von Home-Office-Arbeit könnte diesbezüglich auch Gleitzeitarbeit helfen, die Verkehrsspitzen (auch Rushhour genannt) abzumildern. Unter Gleitzeit wird in dieser Dissertation im Allgemeinen die Möglichkeit, teilweise oder vollständig über Beginn und Ende der eigenen Arbeitszeit zu entscheiden, verstanden. Gemäss der „Schweizerischen Verkehrsperspektiven 2050“ wird erwartet, dass neuere Arbeitsformen wie das Home-Office einen komplexen Einfluss auf die Mobilität haben werden, die beispielsweise zeitliche Verkehrsverlagerungen, Abmilderungen der Verkehrsspitzen sowie Änderungen der Verkehrsmittelwahl ergeben könnten (Bundesamt für Raumentwicklung ARE 2022). Weil das Thema immer wieder von den relevanten Entscheidungsträgern aufgegriffen wird (z.B. in der Langfristigen Klimastrategie der Schweiz oder in den Verkehrsperspektiven 2050), sind Erkenntnisse aus empirischen verhaltensbasierten Untersuchungen für die zukünftige Planung substanziell. Aus den dargelegten Gründen ergibt sich daher ein weiteres Anliegen dieser Dissertation: Es soll ein empirisch fundierter Beitrag zur Einschätzung des Potenzials der Flexibilisierung des Arbeitsmarktes (in Form von Home-Office-Arbeit und Gleitzeit) für Verkehrsreduktionen und -entlastungen in der Schweiz bereitgestellt werden.

Es wurde bereits erläutert, dass das steigende Verkehrsaufkommen und die Überlastung der Nationalstrassen zu immensen Kosten in der Schweiz führen. Darüber hinaus erzeugen auch ausserplanmässige Ereignisse wie das Auftreten des Coronavirus immense finanzielle und soziale Herausforderungen. So verursachte COVID-19 in der Schweiz direkte Kosten für den Bund in Höhe von knapp 5 Milliarden Franken (Bundesrat 2023, Tabelle 17). Doch nicht nur akute Gesundheitskrisen wie die Coronapandemie bedeuten für die Gesellschaft eine Belastung. Auch die Präsenz von langfristigen nicht-übertragbaren Krankheiten (auch NCD für non-communable diseases) ist gesamtgesellschaftlich gesehen eine Herausforderung. Dieser begegnet die Schweiz aktuell mit der „Nationalen Strategie zur Prävention nichtübertragbarer Krankheiten“ (auch NCD-Strategie genannt), welche mehr Krankheitsprävention und eine bessere Begleitung von Erkrankten anstrebt (Bundesamt für Gesundheit BAG, Schweizerische Konferenz der kantonalen Gesundheitsdirektorinnen und -direktoren GDK 2016). Dabei fokussiert die Schweizer NCD-Strategie die folgenden fünf Krankheiten: Herz-Kreislauf-Erkrankungen, Diabetes, Krebs sowie Atemwegs- und muskuloskelettale Erkrankungen. Diese chronischen Krankheiten führen nicht nur zu negativen Folgen für die Betroffenen selbst, sondern auch zu immensen Kosten für die Gesellschaft. In der Schweiz betrugen die Behandlungskosten der fünf fokussierten nicht-übertragbaren Krankheiten im Jahr 2011 rund 25.6 Milliarden Franken (Wieser et al. 2014) und machten damit knapp 40% der gesamten Gesundheitskosten aus (Bundesamt für Gesundheit BAG, Schweizerische Konferenz der kantonalen

Gesundheitsdirektorinnen und -direktoren GDK). Werden zusätzlich die indirekten Kosten, wie Produktivitätsverluste von Erkrankten und Angehörigen, berücksichtigt, erhöhen sich die volkswirtschaftlichen Kosten schätzungsweise um weitere 15.4 bis 29.5 Milliarden Franken (Wieser et al. 2014, Bundesamt für Gesundheit BAG, Schweizerische Konferenz der kantonalen Gesundheitsdirektorinnen und -direktoren GDK 2016). Ein entscheidender Aspekt ist hierbei, dass diese Krankheiten häufig von schädlichen Lebensstilen (wie ungesunde Ernährung, Alkohol oder Rauchen) und körperlicher Inaktivität begünstigt werden (Bundesamt für Gesundheit BAG, Schweizerische Konferenz der kantonalen Gesundheitsdirektorinnen und -direktoren GDK 2016, WHO 2010). Ebenfalls ist Übergewicht ein Problem in der Schweiz, das neben anderen Faktoren ebenfalls mit ungesunden Lebensstilen und mangelnder Bewegung zusammenhäng (Matthes et al. 2020). Im Jahr 2012 waren 42,2% der Schweizer Bevölkerung übergewichtig (Schneider und Venetz 2014). Die volkswirtschaftlichen Kosten von Übergewicht, den damit einhergehenden Folgeerkrankungen sowie von Produktivitätsverlusten beliefen sich 2012 auf rund 8 Milliarden Franken (Schneider und Venetz 2014). Im Bestreben nicht-übertragbare Krankheiten und Übergewicht zu reduzieren, empfiehlt die WHO 150-300 Minuten moderate körperliche Aktivität pro Woche (WHO 2010).

Das Anliegen der letzten Forschungsarbeit im Rahmen dieser Dissertation ist, die beiden Aspekte Gesundheit und Mobilität zusammen zu bringen. Neben dem motorisierten Individualverkehr und dem öffentlichen Transport sind auch aktive Fortbewegungsmethoden (active travel) Teil der alltäglichen Mobilität. Damit ist die Bewegung von einem Ort zum anderen aus eigener Kraft gemeint (Cook et al. 2022), beispielsweise das Zurücklegen von Wegen zu Fuss oder mit dem Fahrrad. Die aktiven Fortbewegungsmethoden sind im Vergleich zum privaten motorisierten Verkehr und den öffentlichen Verkehrsmitteln am umweltfreundlichsten, weswegen diese Art der Wegbewältigung auch für das Erreichen der Klimaziele von Nutzen ist. Wie zuvor dargelegt, ist mangelnde körperliche Aktivität nachteilig für die Gesundheit, wohingegen genügend Bewegung gesundheitliche Vorteile mit sich bringt. Durch die Nutzung von aktiven Fortbewegungsmethoden für bestimmte Wegstrecken könnte genügend Bewegung praktisch nebenbei im Alltag erreicht werden. Es wäre demnach vorteilhaft für die Individuen selbst und der öffentlichen Gesundheit zuträglich, wenn sich möglichst viele Personen ausreichend aktiv fortbewegen würden (z.B. Merom et al. 2010, Mueller et al. 2015, Saunders et al. 2013). Zusätzlich dazu kann Mobilität auch einen nutzenstiftenden Selbstzweck haben und dies gilt auch für die aktive Mobilität, beispielsweise wenn Personen Spazierengehen, um spazieren zu gehen (Mokhtarian und Salomon 2001, Mokhtarian et al. 2001). Zusammenfassend könnte der Anstieg von aktiven Fortbewegungsmethoden dazu beitragen, die Treibhausgasemissionen zu senken und gleichzeitig die öffentliche Ge-

sundheit zu verbessern (Woodcook et al. 2007). Ein Handlungsfeld der Nationalen NCD-Strategie ist, Rahmenbedingungen zu schaffen, die ein gesundheitsförderliches Verhalten unterstützen (Bundesamt für Gesundheit BAG, Schweizerische Konferenz der kantonalen Gesundheitsdirektorinnen und -direktoren GDK 2016). Eine mögliche Rahmenbedingung, um mehr aktive Fortbewegung in den Alltag zu integrieren, ergibt sich wie auch bei dem vorherigen Forschungsanliegen aus der Transformation der Arbeitswelt. Durch die zunehmende Flexibilisierung des Arbeitsmarktes, insbesondere durch Telearbeit und Gleitzeit, wird die zeitliche und räumliche Tagesstruktur, die sonst durch die Erwerbsarbeit stark vorgegeben ist, gelockert. Dies könnte es beispielsweise erleichtern, Spaziergänge als Pausen in den Arbeitsalltag zu integrieren. Wie zuvor diskutiert, könnte Home-Office-Arbeit zudem auch Pendelfahrten reduzieren. Der diesbezüglich angesprochene potenzielle Reboundeffekt, muss sich nicht zwingenderweise in anderen Autofahrten manifestieren. Die gesparte Zeit könnte auch in langsamere aktive Fortbewegungsmethoden reinvestiert werden (Elldér 2022), doch ob dies tatsächlich zutrifft, muss wiederum empirisch überprüft werden. Laut der „Schweizerischen Verkehrsperspektiven 2050“ wird erwartet, dass sich Home-Office-Arbeit weiter durchsetzen wird und dass die Bedeutung der aktiven Mobilität insgesamt zunehmen wird (Bundesamt für Statistik 2020). Aktuelle Erkenntnisse zum Zusammenhang zwischen den beiden Aspekten könnten daher möglicherweise gewinnbringend für zukünftige Mobilitätsprognosen eingesetzt werden. Demzufolge ist das letzte Forschungsanliegen dieser Dissertation herauszufinden, ob die Flexibilisierung der Arbeitswelt einen Beitrag zu mehr aktiver Fortbewegung im Alltag leisten kann.

Zusammenfassend lässt sich festhalten, dass es aktuell vielfältige gesellschaftliche Herausforderungen in den Bereichen öffentliche Gesundheit, Umwelt und Verkehr gibt. Im Umgang mit diesen wird die individuelle Mitarbeit der Bevölkerung benötigt. So müssten beispielsweise möglichst viele Personen verordneten Schutzmassnahmen befolgen, um eine Pandemie im Zaum zu halten oder weniger Autofahren, um den Klimawandel zu bremsen. Wie die Menschen letztendlich auf verordnete Massnahmen oder gesellschaftliche Entwicklungen reagieren, ist jedoch unsicher. Die vorliegende Dissertation zielt deswegen darauf ab, empirisch-fundierte Beiträge zum besseren Verständnis des Verhaltens der Bevölkerung im Hinblick auf ausgewählte Problembereiche zu leisten.

1.2 Überblick über die Dissertation

Insgesamt beseht die Dissertation aus vier Publikationen in englischsprachigen Fachzeitschriften, die empirische Erkenntnisse zum Verhalten der Bevölkerung im Kontext verschiedener aktueller gesellschaftlicher Herausforderungen liefern. Thematisch lässt sich die Arbeit in zwei Teile untergliedern, wobei der erste die Einhaltung von Schutzmassnahmen während der Coronapandemie adressiert und der zweite die Mobilität von Erwerbstätigen behandelt. Jeder der beiden Abschnitte besteht aus zwei zusammenhängenden wissenschaftlichen Publikationen.

Der eine Teil der Dissertation beschäftigt sich mit den Einstellungen und dem Verhalten von jungen Erwachsenen bezüglich der COVID-19-Schutzmassnahmen. Es sollte mit diesen Forschungsbeiträgen schnell auf die neue Situation reagiert werden, indem aktuelle Daten zur Risikoeinschätzung der neuartigen Krankheit und dem Umgang mit den verordneten Massnahmen generiert werden. Hierzu wurden zwei Publikationen in Ko-Autorenschaft mit Axel Franzen erstellt. Der erste Artikel mit dem Titel „Coronavirus risk perception and compliance with social distancing measures in a sample of young adults: Evidence from Switzerland“ hatte zum Ziel, die wichtigsten Einflussfaktoren für das Einhalten des Social-Distancing-Appells zu identifizieren (Franzen und Wöhner 2021a). Die zweite Publikation lautet „Fatigue during the COVID-19 pandemic: Evidence of social distancing adherence from a panel study of young adults in Switzerland“ (Franzen und Wöhner 2021b). Dieser Artikel beinhaltet eine Panelfortführung der ersten Untersuchung, beschäftigt sich mit der Pandemiemüdigkeit und adressiert einige offen gebliebene Aspekte aus der ersten Studie.

Der andere Teil der Dissertation enthält zwei Forschungsarbeiten, die im Rahmen eines vom Schweizerischen Nationalfonds (SNF) geförderten Projekts entstanden sind (Projektnummer: 188866). Das SNF-Projekt hatte den Titel „Mobilität in der Schweiz: Potenziale der Digitalisierung des Arbeitsmarkts für Umwelt und Wirtschaft“ und lief vom 01.01.2020 bis zum 28.02.2023. Das Ziel des Projekts war, die Auswirkungen der Digitalisierung des Arbeitsmarktes auf den Verkehr und das Mobilitätsverhalten zu analysieren. Dabei lag das Hauptaugenmerk auf der Frage, ob flexible Arbeitsformen wie Home-Office und Gleitzeit, die sich durch die Digitalisierung des Arbeitsmarktes immer weiter durchsetzen, zur Verkehrsreduktion und -entlastung beitragen können. Die Ergebnisse wurden in einer Publikation veröffentlicht, die in Alleinautorenschaft angefertigt wurde und den folgenden Titel trägt: „Work flexibly, travel less? The impact of telework and flextime on mobility behavior in Switzerland“ (Wöhner 2022). Ein weiteres Anliegen des Projekts war, zu prüfen, ob flexibel arbeitende Personen vermehrt nachhaltigere Verkehrsmittel nutzen. Diesbezüglich wurde eine zweite Publikation in Alleinautorenschaft entwi-

ckelt. Die Arbeit heisst „Work flexibly, travel more healthily? How telework and flextime affect active travel in Switzerland“ und fokussiert die Nutzung von aktiven Fortbewegungsmethoden von Erwerbstätigen (Wöhner 2023).

Eine Übersicht über die vier Artikel sowie deren bibliographische Angaben findet sich in Tabelle 1. Alle vier Forschungsarbeiten wurden in der Schweiz durchgeführt. Im Hinblick auf die Coronapandemie eignete sich die Schweiz für Untersuchungen zum Schutzverhalten, weil die dortigen Massnahmen vermehrt auf die Eigenverantwortung der Personen setzten und weniger stark gesetzlich forciert und strafrechtlich geahndet wurden als beispielsweise in vielen Nachbarländern. Bezüglich der Mobilitätsforschung bot sich die Forschung in der Schweiz aus mehreren Gründen an. Erstens hat das Land eine gut ausgebaute öffentliche Verkehrsinfrastruktur, die eine Alternative zu Autofahrten darstellt. Zweitens haben in praktisch alle Haushalte einen Breitband-Internetzugang (96% im Jahr 2019 und 99% Im Jahr 2021) (Bundesamt für Statistik 2023) – was eine wichtige Voraussetzung für Home-Office-Arbeit in vielen Berufen ist. Drittens ist der tertiäre Sektor, der grösstenteils Dienstleistungen beinhaltet, und in welchem flexible Arbeitsformen oft gut einsetzbar ist, der grösste Wirtschaftssektor in der Schweiz (Bundesamt für Statistik 2022). Schliesslich ist bereits eine ideale Datengrundlage vorhanden, die genutzt werden kann, um die Forschungsfragen zu klären. Letzteres deutet einen Unterschied zwischen den beiden Hauptthemen der Arbeit an. Die Befunde zum Mobilitätsverhalten wurden auf Basis von Sekundärdatenanalysen einer schweizweiten Mobilitätsstudie gewonnen. Dabei handelt es sich um den Mikrozensus Mobilität und Verkehr, welcher vom Bundesamt für Statistik und dem Bundesamt für Raumentwicklung herausgegeben wird. Demgegenüber wurden die Daten für die Untersuchung des Social-Distancing-Verhaltens in der Schweiz selbst erhoben. Beide Datenquellen beruhen auf Individualdaten, für welche die Befragten Auskunft über ihre Verhaltensweisen und Lebenssituation gaben, und sind geeignet, um die Forschungsfragen zu beantworten.

Der Rest der Dissertation ist in drei weitere Abschnitte gegliedert. Im zweiten Kapitel werden die beiden COVID-19-Studien zum Social-Distancing-Verhalten beschrieben und präsentiert. Das darauffolgende Kapitel der Arbeit stellt die beiden Mobilitätsstudien, welche die Auswirkungen von flexiblen Arbeitsformen auf das tägliche Verkehrsverhalten untersuchen, vor. Zum Abschluss wird ein kurzes Fazit gezogen.

Tabelle 1: Übersicht über die vier publizierten Artikel der Dissertation

1	Titel	**Coronavirus risk perception and compliance with social distancing measures in a sample of young adults: Evidence from Switzerland**
	Autoren	Axel Franzen und Fabienne Wöhner
	Veröffentlichungsdatum	19. Februar 2021
	Zeitschrift	PLoS ONE 16(2): e0247447
	Journal Impact Factor	3.75 (2021)
	DOI	https://doi.org/10.1371/journal.pone.0247447
2	Titel	**Fatigue during the COVID-19 pandemic: Evidence of social distancing adherence from a panel study of young adults in Switzerland**
	Autoren	Axel Franzen und Fabienne Wöhner
	Veröffentlichungsdatum	10. Dezember 2021
	Zeitschrift	PLoS ONE 16(12): e0261276
	Journal Impact Factor	3.75 (2021)
	DOI	https://doi.org/10.1371/journal.pone.0261276
3	Titel	**Work flexibly, travel less? The impact of telework and flextime on mobility behavior in Switzerland**
	Autorin	Fabienne Wöhner
	Veröffentlichungsdatum	25. Juni 2022
	Zeitschrift	Journal of Transport Geography 102: 103390
	Journal Impact Factor	6.1 (2022)
	DOI	https://doi.org/10.1016/j.jtrangeo.2022.103390
4	Titel	**Work flexibly, travel more healthily? How telework and flextime affect active travel in Switzerland**
	Autorin	Fabienne Wöhner
	Veröffentlichungsdatum	30 Juni 2023
	Zeitschrift	Transportation Research Part A: Policy and Practice 174: 103748
	Journal Impact Factor	6.4 (2022)
	DOI	https://doi.org/10.1016/j.tra.2023.103748

Hinweis: Der Journal Impact Factor stammt jeweils aus den „Journal Citation Reports“ von 2021 bzw. 2022, welche von Clarivate ermittelt und veröffentlicht wurden (https://jcr.clarivate.com/jcr/home, zuletzt abgerufen am 07.07.2023).

2 Wer bleibt zum Wohle der anderen in Coronazeiten zu Hause?

In diesem Kapitel werden die beiden Untersuchungen zum Social-Distancing vorgestellt. Im Anschluss an die Zusammenfassung der Studien werden die daraus resultierten Publikationen (Franzen und Wöhner 2021a, Franzen und Wöhner 2021b) abgedruckt.

2.1 Zusammenfassung

Da das COVID-19-Virus eine neue Infektionskrankheit war, gab es zu Beginn der Pandemie weder eine darauf abgestimmte Behandlungsmethode noch eine schützende Impfung. Das Hauptziel der Corona-Schutzmassnahmen war demnach, die besonders verletzlichen Personen vor einer Ansteckung zu schützen und dazu beizutragen, die Gesundheits-Infrastruktur nicht zu überlasten (Schweizerische Eidgenossenschaft 2020a). Eine der wichtigsten Massnahmen war in diesem Zusammenhang das Social-Distancing. Neben dem Abstandhalten bei unbedingt nötigen persönlichen Interaktionen, wie beispielsweise beim Einkaufen oder einem Arztbesuch, zählte dazu insbesondere der Appell, weitestgehend zu Hause zu bleiben. Im Frühjahr 2020 wurden die Schulen und Hochschulen auf Fernlehre umgestellt, es sollte wo immer möglich aus dem Home-Office gearbeitet werden und auf Treffen mit anderen zu Freizeitzwecken verzichtet werden. Hierzu hat das Bundesamt für Gesundheit im Rahmen der „So schützen wir uns“-Kampagne ab dem 16. März 2020 auf Plakaten appelliert: „Der Bundesrat und die Schweiz brauchen Sie. BLEIBEN SIE JETZT ZU HAUSE. RETTEN SIE LEBEN.“ (Bundesamt für Gesundheit 2020-2022).

Jedoch wurde bereits recht früh davon ausgegangen, dass das mit der Krankheit einhergehende Risiko ungleich in der Gesellschaft verteilt ist. Während das Coronavirus als besonders gefährlich für ältere Menschen über 65 Jahren und Personen mit bestimmten Vorerkrankungen wie Bluthochdruck, Herz-Kreislauf-Erkrankungen, Diabetes oder chronischen Atemwegserkrankungen betont wurde, galt folglich das Risiko einer Erkrankung eher als mild für jüngere und gesunde Personen (Bundesamt für Gesundheit 2020, World Health Organization 2020b). Aus soziologischer Sicht ist dies eine Interessante Situation, denn die verschiedenen Schutzmassnahmen, zu denen auch das Social-Distancing gehörte, haben sich an alle Personen gerichtet. Hieraus ergibt sich die theoretische Grundlage der ersten Publikation (Franzen und Wöhner 2021a) dieser Dissertation. Für die gefährdeten älteren und vorerkrankten Menschen war die Einhaltung der Social-Distancing-Massnahme allein schon zum Selbstschutz vor einer schwerwiegenden Erkrankung oder gar dem Tod sinnvoll. Für junge und gesunde Menschen entfiel das eigennützige Motiv des Selbstschutzes je-

doch weitestgehend. Zudem bringt das konsequente Zuhausebleiben Kosten für die einzelnen Personen wie Einsamkeit, Langeweile oder das Vermissen von Aktivitäten mit Freundinnen und Freunden mit sich. Das Einhalten der Social-Distancing-Massnahme ist demnach für die jüngere Bevölkerung wie die Entscheidung in einem öffentlichen Güter Dilemma zu kooperieren (Ling und Ho 2020, Van Bavel et al. 2020). Es wäre für die kollektive Erreichung des Ziels „Virusverbreitung stoppen" am besten, wenn alle möglichst nicht das Haus verlassen. Aus Sicht einer jüngeren Einzelperson ist das Einhalten der Massnahme aufgrund der Kosten jedoch in erster Linie ein freiwilliger Beitrag zum Kollektivgut, weil sie hauptsächlich zum Schutz für andere zu Hause bleiben. Aus soziologischer Sicht ergibt sich somit die interessante Frage, ob und wenn ja, unter welchen Bedingungen die weniger gefährdeten Personen den Einsatz verschiedener Schutzmassnahmen befürworten und dem Social-Distancing-Appell Folge leisten. Die Frage nach dem Befolgen der Schutzmassnahmen ist hinfällig, wenn die Personen gesetzlich zur Einhaltung verpflichtet sind. Da in der Schweiz vor allem im Hinblick auf das Social-Distancing stark auf Eigenverantwortung gesetzt wurde, sind hier Untersuchungen zu den Prädiktoren für die freiwilligen Beiträge zum Kollektivgut „Virusverbreitung stoppen" gut geeignet.

Um die Forschungsfragen zu beantworten, wurde eine Befragung bei den Studierenden an der Universität Bern direkt nach dem Ende des 1. Lockdowns zwischen Ende April und Mai 2020 durchgeführt. Bereits vor dem Ausbruch der Pandemie waren Herr Franzen und ich mit der ersten Welle einer auf zwei Erhebungszeitpunkte ausgelegten Studie an der Universität Bern im Feld. Das Auftreten des Coronavirus fiel unerwartet in den Zeitraum zwischen den beiden Wellen. Aufgrund dessen konnte die Untersuchung um Fragen zum Umgang mit der Pandemie in der zweiten Welle erweitert werden, mit deren Hilfe die Forschungsfragen geklärt werden konnten. Insgesamt haben rund 500 Studierende an der Befragung teilgenommen. Wie zuvor dargelegt, repräsentieren diese jungen Erwachsenen diejenigen Personen, die vom Coronavirus in der Regel weniger stark gefährdet sind und folglich einem Dilemma gegenüberstehen. Die Ergebnisse zeigen, dass die Studierenden die Situation wie erwartet eingeschätzt haben: Im Durchschnitt nahmen sie die Krankheit für sich selbst weniger gefährlich wahr, aber sie sahen eine Bedrohung für die Gesundheit der Bevölkerung insgesamt. Die theoretische Grundinterpretation der Situation als soziales Dilemma wird somit empirisch gestützt und bildet die Voraussetzung für weitere Analysen. Des Weiteren lässt sich feststellen, dass die Einstellung zum Einsatz der verschiedenen Schutzmassnahmen generell sehr positiv ausfiel, obwohl sie teilweise mit grossen Einschränkungen einhergingen. Besonders starken Zuspruch erhielten Händewaschen, Abstandhalten, die Schliessung von Restaurants und Freizeiteinrichtungen, die Fernlehre an den Universitäten sowie das Verbot von Treffen mit mehr als 5 haushaltsfremden Personen gleichzeitig. Weniger Zustimmung zeig-

te sich beispielsweise gegenüber den Schliessungen von Parks und Schulen sowie dem Tragen von Schutzmasken. Letzteres ist vermutlich auf die anfänglich ambivalente öffentliche Diskussion über den Nutzen von Masken zurückzuführen. Das Konstrukt „Einhalten des Social-Distancing-Appells“ wurden mit drei verschiedenen Indikatoren gemessen. Die Studierenden gaben an, 1.) wie strikt sie das Zuhausebleiben umgesetzt haben, 2.) wie häufig sie Ausnahmen davon gemacht haben und 3.) wie viele Personen sie zu Freizeitzwecken in den letzten sieben Tagen getroffen haben. Die Ergebnisse zeigen eine starke Befolgung des Social-Distancing-Appells. Das Kernstück der Forschung bildet ein Struk-turgleichungsmodell, bei dem das Social-Distancing-Verhalten mithilfe verschiedener Indikatoren erklärt werden soll. Die wichtigste Erkenntnis aus dem Modell ist, dass junge Erwachsene, welche die anderen Schutzmassnahmen für sinnvoll erachten und befürworten, dem Social-Distancing-Appell auch stärker Folge leisten. Dieser Zusammenhang zwischen der Einstellung und dem Verhalten ist mit Abstand der stärkste Prädiktor für das strikte Daheimbleiben. Ausserdem befolgen Frauen sowie Personen, die mit gefährdeten Haushaltsmitgliedern zusammenleben, den Appell stärker. Weiterhin zeigt sich, dass junge Erwachsene, die das Coronavirus als gefährlich für die Gesundheit der Bevölkerung einschätzen, die verschiedenen Covid-19-Schutzmassnahmen tatsächlich stärker befürworten. Jedoch beeinflusst diese Risikoeinschätzung nicht direkt ihr eigenes Social-Distancing-Verhalten, sondern ausschliesslich indirekt über die Zustimmung zu den Schutzmassnahmen. Interessanterweise hat das persönlich wahrgenommene Risiko des Coronavirus weder einen Einfluss auf die Einstellung zu den Schutzmassnahmen noch auf das Social-Distancing-Verhalten.

Trotz der aufschlussreichen Erkenntnisse aus der Studie, sind noch einige Frage offengeblieben. Der erste Lockdown in der Schweiz war im Vergleich zu den Nachbarstaaten verhältnismässig kurz und zudem weniger streng. Aufgrund dessen kann nicht beurteilt werden, ob die starke Einhaltung der Social-Distancing-Massnahmen Bestand haben wird oder im Laufe der Zeit nachlässt. Ein weiterer ungeklärter Aspekt ergibt sich aus dem Umstand, dass die Einstellungen zu den Schutzmassnahmen sowie die selbstberichtete Einhaltung des Social-Distancing-Appells gleichzeitig erhoben wurden. Folglich kann eine umgekehrt kausale Beziehung nicht ausgeschlossen werden, nach der – anders als angenommen – das Social-Distancing-Verhalten die Einstellungen zu den Schutzmassnahmen beeinflusst hat.

Weil die Coronapandemie länger anhielt als zunächst erwartet, wurde die erste Untersuchung mit einer Folgestudie fortgeführt (Franzen und Wöhner 2021b), in der die ungeklärten Fragen aus dem ersten Lockdown beantwortet werden konnten. Hierzu wurden rund ein Jahr später die gleichen Studierenden erneut zu ihren Einstellungen zu den Schutzmassnahmen und ihrem Social-Distancing-Verhalten befragt und

ein Paneldatensatz erstellt. Der Erhebungszeitpunkt der zweiten Welle der Studie war im März und April 2021 und lässt sich somit am Ende des zweiten Schweizer Lockdowns verorten. Insgesamt haben rund 400 Studierende an der Folgestudie teilgenommen. Der Fragebogen zum zweiten Lockdown wurde zudem mit weiteren möglichen Indikatoren ergänzt, die sich in der Coronaforschung zwischenzeitlich als relevant erwiesen haben. Hierzu zählen das Vertrauen in politische Institutionen (z.B. Nivette et al. 2021) sowie die deskriptive Norm, also die Wahrnehmung dessen, was andere tun (z.B. Rudert und Janke 2021). Die Ergebnisse veranschaulichen, dass die Unterstützung für die verschiedenen Schutzmassnahmen verglichen mit dem ersten Lockdown deutlich abgenommen hat. Eine Ausnahme bilden einfach umzusetzende Massnahmen wie Handwäschen und 1.5. Meter Abstand halten bei persönlichen Interaktionen, welche nach wie vor für sinnvoll erachtet werden. Ausserdem ist die Akzeptanz für das Schutzmasketragen, welche ebenfalls eine Massnahme mit relativ geringer Einschränkung ist, deutlich angestiegen. Weiterhin zeigt sich eine gewisse Ermüdungserscheinung bezüglich der Schutzmassnahmen, denn im zweiten Lockdown befolgten die Studierenden den Social-Distancing-Appell signifikant weniger und sie trafen wieder mehr Leute zu Freizeitzwecken. Das Strukturgleichungsmodell zeigt, dass die neu inkludierte deskriptive Norm, also das wahrgenommene Social-Distancing-Verhalten von befreundeten und verwandten Personen, der stärkste Prädiktor für das Zuhausebleiben ist. Dennoch stellt sich nach wie vor die Einstellung zu den Schutzmassnahmen als ein wichtiger Erklärungsfaktor für die Befolgung des Social-Distancing-Appells heraus.

Um nun die Frage nach der kausalen Interpretation zwischen der Einstellung und dem Verhalten zu beantworten, wurden zwei verschiedene Analysen durchgeführt. Erstens wurde ein Strukturgleichungsmodell gerechnet, welches das Verhalten im ersten Lockdown als Prädiktor die Einstellung und das Verhalten im zweiten Lockdown modelliert. Es zeigt sich, dass das frühere Verhalten mit dem späteren Verhalten positiv assoziiert ist. Personen, die dem Appell im ersten Lockdown Folge leisteten, taten dies auch vermehrt im zweiten. Wichtiger ist allerdings, was nicht gefunden wurde: Es gibt keinen statistisch signifikanten Zusammenhang zwischen dem Social-Distancing-Verhalten im ersten Lockdown und der Einstellung zu den Schutzmassnahmen im zweiten. Dies zeigt, dass keine umgekehrte Kausalität vorliegt und wie erwartet die Einstellungen das Verhalten beeinflussen. Zweitens wurde mithilfe einer First-Difference-Panelanalyse das Problem von unbeobachteter Heterogenität adressiert. Auch hier zeigen die Ergebnisse, dass der Einfluss von der Einstellung zu den Schutzmassnahmen auf die Einhaltung des Social-Distancing-Appells kausal interpretiert werden kann. Auch in der zweiten Welle zeigt sich, dass die meisten anderen erklärenden Faktoren, wie die Risikoeinschätzung oder das Vertrauen, nicht direkt das Verhalten beeinflussen, sondern über die Einstellung vermittelt werden.

Sie erhöhen die Akzeptanz von Schutzmassnahmen, was sich dann wiederum in einer strikteren Einhaltung des Social-Distancings widerspiegelt.

Wer bleibt also in Coronazeiten zum Schutz der anderen zu Hause? Die Ergebnisse der beiden Studien implizieren, dass vor allem Personen mit einem Umfeld, das sich ebenfalls an den Social-Distancing-Appell hält, ihren Beitrag zum Kollektivgut „Virusverbreitung stoppen“ leisten. Ausserdem befolgen Individuen, welche die verschiedenen Schutzmassnahmen befürworten, und Personen, die mit gefährdeten Angehörigen zusammenleben stärker den Social-Distancing-Appell.

2.2 Artikel 1: Coronavirus risk perception and compliance with social distancing measures in a sample of young adults: Evidence from Switzerland

Die erste veröffentlichte Forschungsarbeit im Rahmen dieser Dissertation befindet sich auf den Seiten 19 – 32.

Zitation: Franzen, Axel und Fabienne Wöhner, 2021. Coronavirus risk perception and compliance with social distancing measures in a sample of young adults: Evidence from Switzerland. *PLoS ONE* 16(2), e0247447.
DOI: https://doi.org/10.1371/journal.pone.0247447

PLOS ONE

RESEARCH ARTICLE

Coronavirus risk perception and compliance with social distancing measures in a sample of young adults: Evidence from Switzerland

Axel Franzen[☯]*, **Fabienne Wöhner**[☯]

Institute of Sociology, University of Bern, Bern, Switzerland

☯ These authors contributed equally to this work.
* franzen@soz.unibe.ch

Citation: Franzen A, Wöhner F (2021) Coronavirus risk perception and compliance with social distancing measures in a sample of young adults: Evidence from Switzerland. PLoS ONE 16(2): e0247447. https://doi.org/10.1371/journal.pone.0247447

Editor: Valerio Capraro, Middlesex University, UNITED KINGDOM

Received: December 8, 2020

Accepted: February 6, 2021

Published: February 19, 2021

Peer Review History: PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: https://doi.org/10.1371/journal.pone.0247447

Data Availability Statement: The data is stored in the public repository of the University of Bern and available under https://boris.unibe.ch/151813/

Abstract

The health risk of the coronavirus pandemic is age-specific. The symptoms of a COVID-19 infection are usually mild in the healthy population below the age of 65; however, the measures laid down to prevent the spread of the virus apply typically to the whole population. Hence, those who have a low risk of severe symptoms face a social dilemma in cooperating and complying with the safety measures: Cooperating in preventing the spread of the disease is good for society but comes with individual costs. These costs provide an incentive not to cooperate with the safety measures. In this paper we analyze via structural equation modelling a sample of young adults (N = 510) who were surveyed right after the end of the first lockdown period in Switzerland. We investigate why and to what extent they cooperated in preventing the epidemic by following the recommendation to stay at home as much as possible. We hypothesize that those respondents who perceive themselves to be personally at risk, or who have relatives belonging to the risk group, complied more often with the safety measures as compared to those without severe risks. Cooperating should also be linked to individuals' pro-social orientation. Furthermore, we hypothesize that those who believe that the virus is dangerous for society or who have a personal interest in protection show higher support for the general safety measures. Our empirical results show that compliance with the coronavirus social distancing measures was generally very high during the first lockdown. Although young adults perceived themselves to be at low personal risk, they still believed that the virus is dangerous for society. Those who had a personal interest in staying at home because they had relatives belonging to the risk group complied more often with the safety measures. Overall, the results suggest that the support of the preventive measures is the most important promoter of cooperation to prevent the spread of COVID-19.

Introduction

The coronavirus pandemic arrived in Switzerland in February 2020, relatively soon after it had spread through neighboring Italy. The first Swiss COVID-19 death occurred in Lausanne on March 6, 2020. On March 16, the government of Switzerland declared a state of emergency:

Funding: The authors received no specific funding for this research

Competing interests: The authors have declared that no competing interests exist.

Among other measures, public meetings with more than 5 people were strictly forbidden. All shops, restaurants, schools, universities, and other public facilities had to close; exceptions were pharmacies, grocery stores, online-shops, and takeout restaurants. These measures lasted until April 27, and were subsequently relaxed. Hence, the first Swiss lockdown was intermediate in its severity, not as strict as the one in France, Italy or Spain but stricter that the one in Sweden. In particular, most companies in the service or industry sectors were allowed to stay open for business, and inhabitants could move freely outside their houses as long as physical distances of 2 meters or more were maintained.

By the end of 2020, the official coronavirus death toll in Switzerland had increased to about 7400 [1], and comparing the total number of deaths for 2020 (76,231) with the number the year before (67,515) or with other years reveals that there has been a substantive excess in deaths in 2020 [2]. However, the risk of dying from COVID-19 is age-specific. In Switzerland, as in most other countries, death from coronavirus occurs predominantly in the group of people who are 80 years or older (72%), and there are very few cases in the age groups below 65 (5%) [3]. Moreover, those who died from COVID-19 below the age of 65 mostly suffered from other health problems e.g. high blood pressure, cardio-vascular diseases, diabetes, chronic respiratory insufficiency, cancer or a weakened immune system [1].

In Switzerland 18.7% of the population belongs to the age group of 65 or above, and an estimated 14% below 65 suffers from relevant health problems [4, 5]. Hence, given that two thirds of the population does not belong to the group which is at severe risk of dying should they contract COVID-19, the interesting question is what did those who were not directly affected think about the crisis? How did they perceive the risk? To what extent did they approve of the political measures taken to prevent the spread of the infection, and how much did they comply with the social distancing measures?

For members of the risk group the decision to comply with the safety rules and to stay at home as much as possible potentially saves their lives. Hence, for at-risk individuals, complying with the safety regulations is self-beneficial and there is no incentive not to do so. However, the situation is different for the group not at risk. For individuals not directly experiencing a health risk the decision to comply with the safety regulations is like the decision to cooperate in a public good game [6, 7]. If they stay home, they are doing it predominantly for the benefit of others. If many stay home, the public good of interrupting the spread of the virus will be provided. However, each individual in this age group faces the temptation to freeride and to leave the provision of safety to others. Of course, if nobody complies with the restrictions, the infection rate will increase, possibly causing more deaths. But from the point of view of a single actor who is not directly affected by the risk, restricting the freedom of movement is a contribution to a public good.

In this study, we report the results of an online survey among a random sample of 510 young adults from the University of Bern, which was conducted in May 2020, immediately after the first lockdown was suspended in Switzerland. Hence, we study the behavior of individuals who are not directly affected in terms of health risks but who were asked to restrict their social activities for the common good. Our main research question is who complied with the measures to prevent the spread of COVID-19, and what are the most relevant drivers of cooperative behavior from those people mainly not at risk during the coronavirus pandemic.

The rest of the article is organized into 4 sections. In section "Theory and hypotheses" we review some studies that are similar to ours. Particularly, we review studies on vaccination, since the decision to vaccinate can also be conceptualized as the decision to contribute to a public good. Moreover, we take a look at recent studies that investigate the effect of differently framed appeals on participants' intention to engage in preventive measures to avoid the spread of COVID-19. At the end the section, we derive some hypotheses concerning the compliance

with the COVID-19 measures. Section "Data and methods" describes the survey and reports some descriptive results. The following section presents the result of a structural equation model which tests our hypotheses. Finally, in the last section, we discuss and summarize the main findings and suggest further research questions that emerge with the 'Corona Crisis'.

Theory and hypotheses

In reaction to the coronavirus pandemic, on March 16, 2020 the Swiss government released a number of measures in order to prevent the spread of the virus. Some of them were recommended and voluntary, such as frequent disinfection of hands, and wearing masks; others were mandatory, such as the closure of public facilities (e.g. kindergartens, schools, and universities) and stores (with the exception of grocery stores or takeout restaurants). In comparison with other countries, the lockdown was less strict in Switzerland. Thus, it was recommended to stay at home whenever possible, but this was not mandatory. However, people were required to keep a distance of at least two meters and were not allowed to gather in groups of more than five people. Given that in Switzerland about two thirds of the population does not belong to the risk group, the interesting research question is why those people not at risk chose to comply with the measures. For those who are at risk, compliance with the safety measures is in their immediate self-interest. But for individuals who do not belong to the risk group, compliance with the coronavirus safety measures is like the decision to participate in vaccination programs against other infectious diseases [8]. Through vaccination, healthy individuals, who would only show mild symptoms if they were to catch the disease, protect mainly other individuals. Therefore, every individual recipient of a vaccination contributes to the extinction or containment of an infectious disease, as is the case with smallpox or MMR. Hence, the decision to participate in a vaccination program is like the decision to contribute to a public good. Generally, the literature on the provision of public goods has identified a number of conditions that increase individuals' willingness to contribute [9–14]. In particular, individuals contribute more often when the benefits of the public good are high and when the individual costs of contributing are low. Applied to the decision to participate in vaccination this means that individuals are more willing to participate if the consequences of the disease are severe, or put differently, if the benefits of extinction of the disease are great, and if the individual health risks associated with the vaccine are low [15–19].

Recent studies have applied the public good framework to the intention of complying with safety measures in the COVID-19 pandemic [20–25]. For example, Jordan et al. investigate in a series of studies using Amazon Mechanical Turk the effect of differently framed text messages on participants' intention to engage in various safety measures (e.g. washing hands, or avoiding to socialize with others). The messages either highlighted that the virus is a personal threat or a threat for the community. They found that the prosocial frame increased participants' intention to engage in preventive behaviors more or at least as well as the personal frame as compared to a control group [20]. Similar results are also reported in related studies that also use Amazon Mechanical Turk and investigate the intention to wear a face mask [21, 22]. However, some studies also present mixed results. For instance, Banker and Park presented three different ads on Facebook "protect yourself" "protect your loved ones", and "protect your community". They found that the ads referring to self and loved ones elicited slightly higher clickthrough rates than the community frame [23]. A study by Heffner et al. investigates pro-social framed messages versus threat-related messages on participants' willingness to self-isolate. They find that both types of messages perform equally well [26].

While most former studies focus on individuals' intention to comply with the Corona safety measures, we study individuals' actual behavior. Drawing on the results of former studies we

formulate a number of hypotheses of why individuals are expected to conform to the safety measures to avoid the spread of COVID-19. First, following key results from vaccinations studies, we hypothesize that compliance with the coronavirus measures increases with increased acceptance of the safety measures (H1). If the safety measures are evaluated as meaningful, efficient, and safe then compliance with the coronavirus measures should increase.

Second, individuals' subjective risk perception that the virus is personally harmful for them should increase compliance with coronavirus safety measures (H2). For individuals with a health risk complying with the safety measures is directly self-beneficial. Additionally, the perception that the virus is personally harmful should also increase the general acceptance of safety measures (H3) because these measures supposedly limit the spread of the virus and thereby the individual risk of becoming infected. Thus, individual risk perceptions should have a direct effect on compliance with the safety measures as well as an indirect effect via the acceptance of the measures.

Moreover, even when individuals are not personally at risk they may still have relatives and friends that belong to the risk group. The closer the contact to members of the risk group, the stronger should be the motive for complying with the measures (H4). Additionally, concern for friends and family should also increase the acceptance of coronavirus safety measures, since these protect friends and relatives (H5). For individuals who are not personally at risk, and also have no close contacts to members of the risk group, compliance with the coronavirus measures resembles the decision to contribute to a public good. The necessity to do so should become more understandable and convincing if the virus is perceived as being harmful to society. Hence, the more the virus is perceived as threatening to others in society, as compared to being less or not at all dangerous, the stronger the motive for accepting the public safety measures (H6). In contrast to the individual risk perception, the perception that the coronavirus is dangerous for society (social risk) should not necessarily increase compliance with the safety measures since compliance with the measures is a public good, and also since—in the absence of a personal risk—incentives to contribute to the public good are lacking.

Much laboratory research in game theory and on public good provision has demonstrated that not all individuals behave in the same way. Some individuals show more empathy [27, 28] than others, or show a stronger prosocial orientation [29, 30]. Similarly, we expect that individuals with a higher prosocial attitude comply more often with the coronavirus measures than individuals with a stronger pro-self orientation (H7). Also, research on public good provision suggests that individuals comply more often when they are embedded in social networks that reward prosocial behavior or sanction uncooperative behavior [14, 31]. Hence, the opportunity to gain social approval (or to avoid disapproval) might be a reason for individuals to comply with COVID-19 measures. However, in the case of coronavirus measures compliance is not easily visible or obvious. One of the measures recommends staying at home as much as possible; hence, leaving the home is legitimate if necessary, and it is exactly the nature of this necessity that is not visible. Thus, uncooperative behavior is not detectable by social contacts making the motive of social approval-seeking less applicable in this case.

Moreover, much research on health-related behavior has found that women are generally more risk averse and more health conscious then men [32, 33]. This also applies to compliance with measures against pandemics [34] and to social distancing in the coronavirus pandemic [35, 36]. Hence, we generally expect that women more often comply with the measures as compared to men (H8). Taken together, our theoretical considerations can be summed up by the model depicted in Fig 1. Since the theoretical model contains manifest variables (indicated by a rectangle), which are measured directly by a single indicator, as well as latent constructs (indicated by an oval), which are measured by multiple indicators, we employ structural

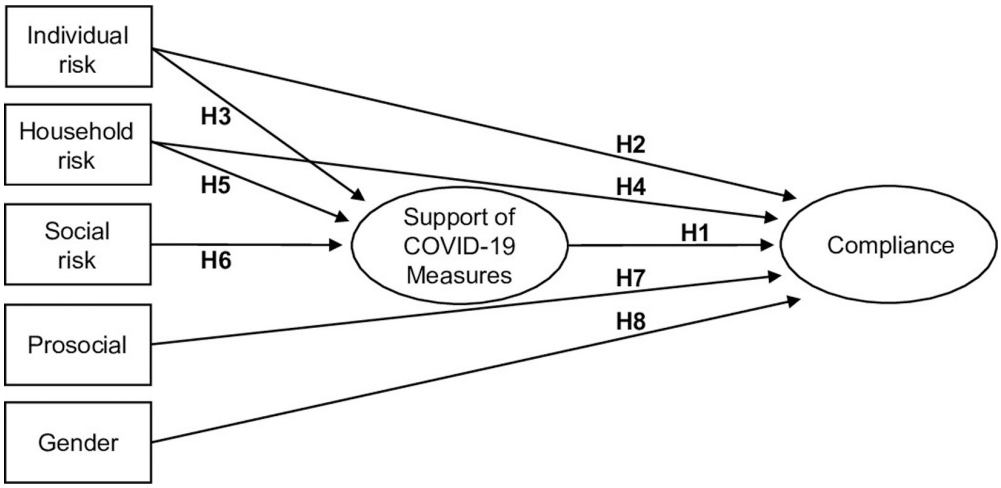


Fig 1. The hypothesized determinants of complying with coronavirus social distancing measures.

https://doi.org/10.1371/journal.pone.0247447.g001

equation modelling to test the hypotheses. Before the result of such a model is presented, we next describe the data and the measurements of the variables.

Data and measurements

The original purpose of our study was to test the reliability and validity of various measurement instruments. For this reason, we conducted a two-wave panel survey of a random sample of 510 students enrolled in a regular BA or MA program at the University of Bern. Ethical clearance was obtained by the Ethics Committee of the Faculty of Business Administration, Economics and Social Sciences of the University of Bern. The first wave took place between the end of February 2020 and middle of March 2020 and the second wave between end of April 2020 and end of May 2020. The coronavirus safety measures were implemented in Switzerland on March 16, 2020, just after we finished the first wave, and lasted until April 27. Hence, we were able to incorporate questions on the perception of the coronavirus epidemic into the second wave, which we started right after lockdown ended. In this paper we only report the findings that result from the second wave of the survey. For purposes that are not relevant for this study about half of the interviews were conducted face-to-face either personally or via online communication tools (e.g. Skype or Zoom). Besides questions on the coronavirus, the questionnaires of the first and second wave were mostly identical. Both waves contained around 50 questions, and lasted on average for about 25 minutes. Since we did not find any mode effects, in what follows we report the results of both interviewing modes. Because most questions on what the survey participants think about the coronavirus safety measures or what they did during the lockdown are retrospective, it is very important that the time lag between the lockdown period and the interviews is as short as possible. Hence, we were fortunate to be able to integrate the questions about the coronavirus crisis into the second wave of an ongoing study right after the end of the lookdown. This makes this data particularly valuable for a test of our hypotheses.

For our analyses, we excluded respondents older than 40 years (N = 5), since these cases are untypical for the student population. Also, people with a gender other than male or female were excluded from our analyses due to the very small number of three observations. In order to be able to detect respondents who did not answer the questionnaire thoroughly, we included

a fake question in the online version of the survey. This question simply contained the instruction that none of the given answer categories should be ticked. Hence, respondents who nonetheless ticked an answer category in this question either did not read this and possibly other questions very carefully or ignored the instructions. Also, these cases were excluded from further analyses (N = 9). Overall, these exclusions result in a valid sample of 493 observations. However, these exclusions did not affect our results. Mean age of the survey participants is 23.6, and 65% are female. Hence, females are slightly overrepresented in our survey as compared to the student population of the University of Bern (57% female). But other socio-demographic variables (e.g. subject areas, proportion enrolled in Bachelor and Master) resemble the distribution of the population.

We conceptualize compliance to the coronavirus safety regulations as a latent variable, and measure it according to three indicators. First, on a 5-point Likert scale ranging from "not at all" (1) to "very strictly" (5), participants were asked how much they complied with the recommendation to stay at home as much as possible. The second indicator is the question of whether respondents made occasional exceptions to staying at home. The question has five answer categories ranging from "never" (1) to "very often" (5), and hence, is coded in the opposite direction as compared to the first indicator, balancing the index. For the statistical analysis, the coding of the answer categories is reversed. Thirdly, we asked how many friends or relatives participants met in their leisure time during the week before the interview. Meeting a large number of friends is not conforming to the coronavirus measures and hence indicates non-compliance to the safety measures. For the analyses, we took the natural logarithm of the number of people, to achieve a more similar range and variance compared to the other two 5-point scales used for the construction of the latent compliance variable. Overall, 83% of the respondents report that they complied most of the time or very strictly with the recommendation to stay at home. Accordingly, 55.6% said that they never or rarely made exceptions, and the average number of people met in the week before the interview was 4.9 as compared to 9 in the first wave of the survey before the lockdown, which included the same question. Hence, the answers to all three indicators demonstrate that participants did show high levels of compliance with the social distancing measures.

Next, we quantify the support of the coronavirus measures using the acceptance of 12 different single measures put into practice by the Swiss government. Fig 2 lists the 12 different measures. For each measure respondents were asked to what extent they agree with the measure on a five-point answering scale ranging from "not at all" (1) to "very much" (5). Fig 2 depicts the percentage of respondents agreeing or agreeing very much with a measure. As can be seen most measures were highly accepted. This is particularly true for washing hands thoroughly (99%) and keeping social distance (93%). High acceptance can also be observed for the closing of restaurants and bars (84.7%), and universities (79%). Wearing a face mask received very little support in Switzerland (28%), which reflects the ambivalent public discussion in Switzerland about the preventive effect of masks during the first lockdown.

As hypothesized, compliance with the coronavirus measures should be driven by acceptance of the safety regulations, which should be directly affected by the individual and social risk perception. We measured individuals' risk perceptions by asking how dangerous respondents think a coronavirus infection would be for themselves personally on an 11-point answering scale ranging from "not at all dangerous" (0) to "extremely dangerous" (10). Similarly, the social risk perception was measured by asking how dangerous respondents believe the coronavirus epidemic is for the health of the Swiss population. The distribution of the two variables is depicted in Fig 3. As can be seen from Fig 3, most respondents perceive a low individual risk (median = 2) but a high social risk (median = 6). The descriptive results confirm previous findings [37] and reflect the fact that we have a sample of young adults for whom the virus is

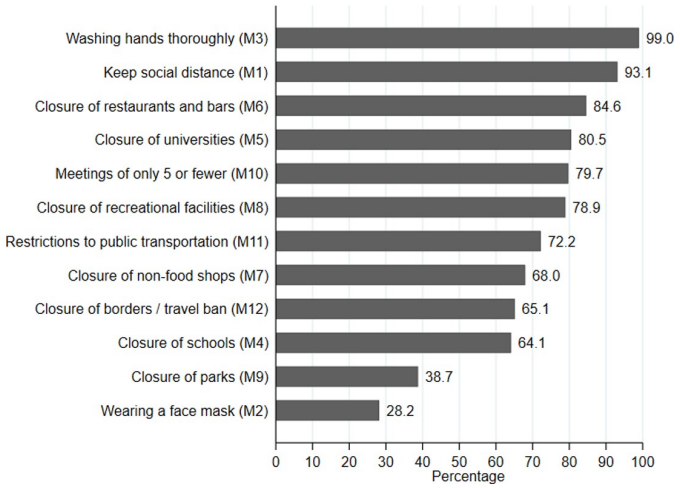


Fig 2. Acceptance of coronavirus measures. N = 493. Each measure was surveyed via five point Likert scales ranging from "do not agree at all" (1) to "agree very much" (5). The figure displays the proportion of respondents supporting a measure weakly or strongly (categories 4 and 5).

https://doi.org/10.1371/journal.pone.0247447.g002

mostly harmless. A further reason to conform to the safety measures is if subjects live together in one household with individuals who belong to the risk group. This might apply in our sample to students who still share the household for instance with their parents or other family members who might be older or suffer from health risks. In our sample 27% of respondents report that they live together with at least one at-risk person.

Finally, our theoretical model proposes that individuals with a prosocial attitude should conform more strictly to the coronavirus measures as compared to individuals who are less prosocial. We measure pro-sociality via a revealed preference approach. Participants received 20 Swiss Francs (about $20) for participation in the survey. At the end of the questionnaire, we asked respondents if they wished to donate some of their payment to a charitable organization. A relatively large proportion of our respondents (58%) decided to donate some money to a

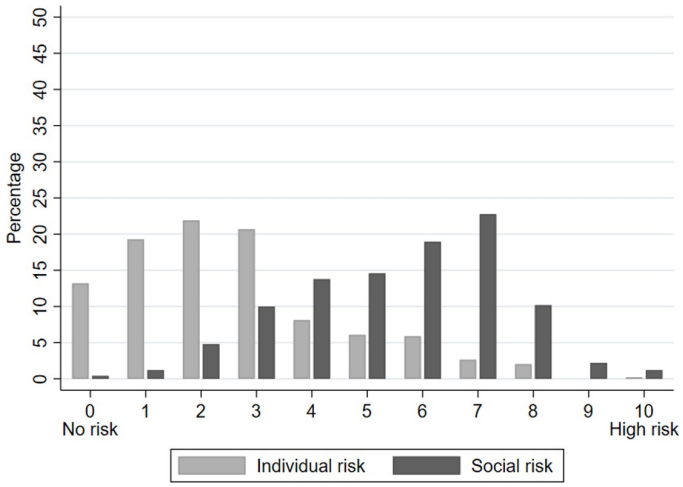


Fig 3. Perceived individual and social risk. N = 493.

https://doi.org/10.1371/journal.pone.0247447.g003

charitable organization. Respondents who chose the option of donating were then asked how much and to which organization they wanted to donate. We listed some environmental organizations (Greenpeace, World Wide Fund for Nature WWF) but participants also had the chance to name an organization of their own choice. Those who decided to donate some money are classified as pro-social individuals. Descriptive information of all variables are depicted in S1 Table.

Results

Since some of our variables can be conceptualized as latent variables, we test hypotheses H1 through H8 via a structural equation model [38–40]. We estimated the model using the software program Stata 16 [41–43]. Since our variables are neither normally distributed nor follow a multivariate normal distribution, we use maximum likelihood estimation applying the Satorra-Bentler correction for standard errors and model fit parameters [43–45]. We regressed all exogenous variables on both dependent latent constructs. Modification indices suggested the addition of an error covariance between M_4 (closure of schools) and M_5 (closure of universities), which are both indicators of the latent construct of the support of measures. The inclusion of this covariance results in an improvement of the model fit ($\chi^2 = 97.7$, df = 1, $p < 0.01$), and makes sense from a theoretical perspective, since both indicators are addressing educational facilities. The Satorra-Bentler corrected χ^2 value of the model is 338 with 166 degrees of freedom. However, because of the large sample size and the relatively large number of indicators the χ^2-statistic is not an appropriate test statistic for this model [46–48]. Following the literature, we focus on CFI and TLI instead as goodness-of-fit statistics. In our model the Satorra-Bentler corrected CFI statistic results in a value of 0.93 and the TLI goodness-of-fit statistic in a value of 0.91. Both exceed the minimal threshold of 0.9 indicating an acceptable model fit. The SRMR fit statistic has a value of 0.042, which is smaller than 0.05 suggesting also a good model fit. A further test statistic is the RMSEA. In our case, RMSEA has a value of 0.049 with a 90% confidence interval (CI) of 0.042 to 0.056. Hence, also the RMSEA indicates a good model fit. Additionally, the test of close fit—testing that RMSEA is smaller than 0.05—is statistically non-significant (p = 0.65), as desired. Overall, the different fit statistics indicate an adequate to good fit of our theoretical model to the observed data.

The unstandardized results of the estimation are depicted in Fig 4. The three indicators "staying at home", "making exceptions", and the "number of meetings with friends" are all making statistical significant contribution to the measurement of the latent construct "Compliance". Similar conclusions can be drawn for the measurement of the latent construct "Support of COVID-19 Measures", which we measure using the 12 indicators that are listed in S1 Table. All indicators contribute statistically significantly to the measurement of this latent variable. However, some of the 12 indicators only make small contributions to the measurement of the COVID-19 measures. Therefore, we also ran a model in which we excluded all indicators with low factor loadings (e.g. M2, M3, M11, and M12). The exclusion of these indicators improved the model fit ($\chi^2 = 203$, df = 96, CFI = 0.952, TLI = 0.939, SRMR = 0.035, RMSEA = 0.048). However, neither the results of our structural coefficients nor their standard errors changed substantially. Because there was no difference in the results, and due to the theoretical interest in all different COVID-19 measures, we decided to report the complete model despite its slightly lower fit.

Next, we discuss the empirical results with respect to the hypotheses. The latent variables are coded according to the coding of the indicator that is restricted to 1. Hence, in our case both latent constructs have a range from 1 (low compliance, low support) to 5 (strict compliance, high support). Consequently, a one-unit increase in the Support of Measures leads to a 0.45 unit increase in Compliance (see Fig 4). The standardized coefficient of this effect is 0.44.

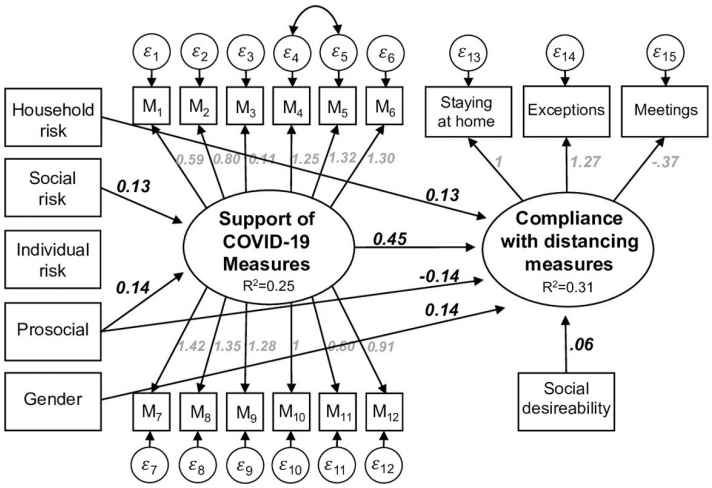


Fig 4. A structural equation model of the compliance to corona measures. N = 493. All reported coefficients are unstandardized and statistically significant at least at the 5% level.

https://doi.org/10.1371/journal.pone.0247447.g004

Thus, the support of coronavirus measures has the strongest impact on Compliance among all considered variables. Therefore, individuals who are in favor of the measures also show strong compliance with them. This result confirms hypothesis H1.

The effects of individuals' risk perception (individual risk, household risk and social risk) are somewhat ambivalent. According to our results, respondents' perception of their own individual risk has neither a statistically significant effect on the acceptance of the measures nor on complying with them. Hence, hypotheses H2 and H3 are not supported by our data. However, individuals who live in one household with members of the risk group do show higher compliance with the measures, e.g. reported to stay home more often. However, the effect of living with a member of the risk group is relatively weak (0.13). In contrast, no statistically significant effect was found of living with a member of the risk group on the acceptance of the measures. Therefore, hypothesis H4 does receive empirical support but hypothesis H5 does not. As expected, individuals' perception of the social risk of the coronavirus has a positive impact on the acceptance of the measures (0.13), which supports hypothesis H6. This effect is also quite substantial since the social risk is measured on an 11-point scale. Put differently, a one standard deviation increase in the perceived social risk (which corresponds to approximately 2 points on the 11-point scale), leads to a 0.44 standard deviations increase on the support of measures. Prosocial orientation has an ambivalent effect: prosocial individuals (measured by donations) accept the measures more often (0.14), but comply to them less strictly (-0.14). This result actually contradicts hypothesis H7, which assumes that a prosocial orientation should also increase compliance. Finally, hypothesis H8, which states that women comply more often than men with the coronavirus measures, is supported by our data, but the effect is relatively small (0.14).

Since our data is based on a survey of self-reported behavior, socially-desirable answering needs to be considered. To control for such influences, we measured social desirability according to the well-known Marlowe-Crowne Scale [49, 50] and incorporate it into the model. As expected, the results show that individuals with higher levels of social desirability also report behavior more compliant with the measures. However, the effect (0.06) is relatively small (in terms of standard deviation 0.2). Overall, the model explains 31% of the variance of the social distancing compliance and 25% of the variance of the acceptance of the measures.

Summary and discussion

In this study we formulated eight hypotheses specifying the reasons why young adults should accept the safety measures to prevent the spread of the coronavirus and which factors are driving social distancing compliance. The empirical model supports hypothesis H1: Individuals who are in favor of the coronavirus measures also conform to them, e.g. they stay home, rarely make exceptions and limit meetings with friends and relatives. This effect of the acceptance of the measures on compliance with them is the strongest and most important one in our model. Surprisingly, individuals' personal and social risk perceptions do not matter for the degree of compliance; hence, the empirical analysis refutes H2 and H3, which confirms also findings by Moussaoui et al. [36]. Another important finding is that the perceived risk of the coronavirus to society increases the acceptance of the different safety measures (H6). This effect is also very strong. Living together in one household with people who belong to the risk group increases compliance, lending support to H4. Prosocials support the safety measures, which we did not expect, but do not comply more strictly, as we expected, refuting hypothesis H7. Finally, we find that women comply somewhat more with the measures than do men.

In summary, our study shows that acceptance of the coronavirus safety measures was very high for young adults during the first lockdown period in Switzerland and this acceptance dominates the compliance with the coronavirus measures. This result is surprising. After all, for young and healthy individuals complying with the coronavirus social distancing measures is like contributing to a public good. Much research has shown that in other areas contributions to public goods are typically low. For instance, research on the determinants of environmental behavior consistently shows that individuals have high levels of environmental concern but do not act in accordance with their attitudes [51, 52]. Gaps between attitudes and behavior are also found in health-related behavior. Individuals often have the goal of living healthily but the associated overt action (good nutrition, sport) lags substantially behind [53–55]. Our results demonstrate that such a gap between attitudes and behavior was basically absent during the first lockdown in Switzerland. The emergency situation obviously induced many to comply with their convictions to stay at home as much as possible even if this behavior is costly and not self-beneficial.

Our research also has a number of limitations and raises many questions for further research. First of all, the first lockdown was relatively short in Switzerland and it was not particularly strict. Hence, the freedom to leave the house and move around was not restricted. In this situation maybe acceptance was also high because individuals in Switzerland were well aware that the lockdown was much stricter in the rest of Europe, particularly in neighboring Italy and Germany. Furthermore, the first lockdown was short in Switzerland and lasted only 6 weeks. Hence, it's possible that the high acceptance of the governmental safety measures might erode if lockdowns were to last longer [56]. Moreover, in Switzerland governmental institutions generally enjoy high levels of trust. Hence, it would be interesting to compare compliance with lockdown measures in Switzerland with compliance in other countries where lockdown lasted longer, was stricter, and where governments perhaps experience less trust. It would also have been interesting to investigate a random sample of the whole population instead of a sample of young adults. Random population samples would probably have generated larger variance of key variables such as the perceived individual and social risk. Also, we have investigated basically the conformity to injunctive norms, e.g. to the norm that the safety measures should be adhered to. However, many research areas in sociology also pay attention to descriptive norms, e.g. the perception of what other people do [24]. Unfortunately, questions of what the respondents think of what others do and how others react to the crisis were not included in this study. Finally, our analysis is based on a survey of self-reported behavior

which is knowingly biased by social desirability. We did control for this by measuring and incorporating social desirability; however, the control is not perfect and most likely does not eliminate the bias completely. Future research could vastly profit by using nonreactive compliance measures such as GPS-based mobility profiles of the sample under scrutiny. Since we measured attitudes and self-reported behavior at the same time, we also cannot exclude the possibility that subjects adopted their attitudes to their self-perceived behavior instead of the other way round. Hence, the assumed causal attitude-behavior link should be investigated by non-intrusive behavioral measures in combination with a time lag of the observed behavior.

Supporting information

S1 Table. List of variables.
(DOCX)

Author Contributions

Conceptualization: Axel Franzen.

Data curation: Fabienne Wöhner.

Formal analysis: Axel Franzen, Fabienne Wöhner.

Investigation: Axel Franzen.

Methodology: Axel Franzen, Fabienne Wöhner.

Project administration: Axel Franzen.

Supervision: Axel Franzen.

Visualization: Fabienne Wöhner.

Writing – original draft: Axel Franzen.

Writing – review & editing: Axel Franzen, Fabienne Wöhner.

References

1. FOPH. Weekly situation report on the epidemiological situation in Switzerland and the Principality of Liechtenstein: Week 53. Federal Office of Public Health, Switzerland 2021.
2. FSO. Death according to age, week, and canton. Federal Statistical Office, Switzerland. 2020. FSO number: cc-d-01.04.02.01.32.
3. FOPH. COVID-19 Switzerland. Information on the current situation. Laboratory-confirmed deaths. Distribution by age group. Federal Office of Public Health, Switzerland 01/2021.
4. FSO. Permanent resident population by age, category of citizenship and sex, 1999–2019. Federal Statistical Office, Switzerland. 2020. FSO number: je-e-01.02.03.03
5. FSO. Swiss Health Survey. Federal Statistical Office, Switzerland. 2020.
6. Van Bavel JL, Baicker K, Boggio PS, Capraro V, Cichocka A, Cikara M, et al. Using social and behavioural science to support COVID-19 pandemic response. Nat Hum Behav. 2020; 4: 460–471. https://doi.org/10.1038/s41562-020-0884-z PMID: 32355299
7. Hoh Teck Ling G, Mee Chyong Hu C. Effects of the coronavirus (COVID-19) pandemic on social behaviours: From a social dilemma perspective. Tech Soc Sci J. 2020; 7: 312–320.
8. Fine PEM, Clarkson JA. Individual versus public priorities in the determination of optimal vaccination policies. Am J Epidemiol. 1986; 124: 1012–1020. https://doi.org/10.1093/oxfordjournals.aje.a114471 PMID: 3096132
9. Chaudhuri A. Sustaining cooperation in laboratory public goods experiments: A selective survey of the literature. Exp Econ. 2011; 14: 47–83.
10. Fehr E, Gächter S. Altruistic punishment in humans. Nature 2002; 415: 137–140. https://doi.org/10.1038/415137a PMID: 11805825

11. Franzen A, Mader S, Bahr S. Governing the commons: Why self-administered farm outlets flourish in Switzerland. Int J Commons. 2019; 13: 1079–1091.

12. Ledyard JO. Public Goods: A survey of experimental research. In: Kagel JH, Roth AE, Editors. The Handbook of Experimental Economics. Princeton: Princeton University Press; 1995. p. 111–194.

13. Milinski M, Semmann D, Krambeck H-J. Reputation helps solve the 'tragedy of the commons'. Nature. 2002; 415: 424–426. https://doi.org/10.1038/415424a PMID: 11807552

14. Rand D G, Dreber A, Ellingsen T, Fudenberg D, Nowak MA. Positive interactions promote public cooperation. Science. 2009; 325: 1272–1275. https://doi.org/10.1126/science.1177418 PMID: 19729661

15. Larson HJ, Jarrett C, Eckersberger E, Smith DMD, Paterson P. Understanding vaccine hesitancy around vaccines and vaccination from a global perspective: A systematic review of published literature, 2007–2012. Vaccine. 2014; 32: 2150–2159. https://doi.org/10.1016/j.vaccine.2014.01.081 PMID: 24598724

16. Schmid P, Rauber D, Betsch C, Lidolt G, Denker M-L. Barriers of influenza vaccination intention and behavior—A systematic review of influenza vaccine hesitancy, 2005–2016. PLoS ONE. 2017; 12 e0170550. https://doi.org/10.1371/journal.pone.0170550 PMID: 28125629

17. Van Ackere A, Schulz PJ. Explaining vaccination decisions: A system dynamics model of the interaction between epidemiological and behavioural factors. Socioecon Plann Sci. 2020; 71: 100750.

18. Yaqub O, Castle-Clarke S, Sevdalis N, Chataway J. Attitudes to vaccination: A critical review. Soc Sci Med. 2014; 112: 1–11. https://doi.org/10.1016/j.socscimed.2014.04.018 PMID: 24788111

19. Horney JA, Moore Z, Davis M, MacDonald PDM. Intent to receive pandemic influenza A (H1N1) vaccine, compliance with social distancing and sources of information in NC, 2009. PLoS ONE. 2010; 5: e11226. https://doi.org/10.1371/journal.pone.0011226 PMID: 20585462

20. Jordan JJ, Yoeli E, Rand DG. Don't get it or don't spread it? Comparing self-interested versus prosocial motivations for COVID-19 prevention behaviors. 2020; https://psyarxiv.com/yuq7x.

21. Luttrell A, Petty RE. Evaluation of self-focused versus other-focused arguments for social distancing. An extension of moral matching effects. Soc Psychol Personal Sci. 2020; https://doi.org/10.1177/1948550620947853 PMID: 32577160

22. Capraro V, Barcelo H. The effect of messaging and gender on intentions to wear a face mask to slow down COVID-19 transmission. J Behav Econ Pol. 2020; 4: 45–55.

23. Banker S, Park J. Evaluating posocial COVID-19 messaging frames: Evidence from a field study on Facebook. Judgm Decis Mak. 2020; 15: 1037–1043.

24. Bilancini E, Boncinelli L, Capraro V, Celadin T, Paolo RD. The effect of norm-based messages on reading and understanding COVID-19 pandemic response governmental rules. J Behav Econ Pol. 2020; 4: 45–55.

25. Lunn PD, Timmons S, Belton CA, Barjakova M, Julienne H, Lavin C. Motivating social distancing during the COVID-19 pandemic: An online experiment. Soc Sci Med. 2020; 265: 113478. https://doi.org/10.1016/j.socscimed.2020.113478 PMID: 33162198

26. Heffner J, Vives M-L, FeldmanHall O. Emotional response to prosocial messages increase willingness to self-isolate during the COVID-19 pandemic. Pers Individ Dif. 2021; 170: 110420. https://doi.org/10.1016/j.paid.2020.110420 PMID: 33082614

27. Franzen A, Mader S, Winter F. Contagious yawning, empathy, and their relation to prosocial behavior. J Exp Psychol Gen. 2018; 147: 1950–1958. https://doi.org/10.1037/xge0000422 PMID: 29771564

28. Pfattheicher S, Nockur L, Böhm R, Sassenrath C, Petersen MB. The emotional path to action: Empathy promotes physical distancing and wearing of face mask during the COVID-19 pandemic. Psychol Sci. 2020; 31: 1363–1373. https://doi.org/10.1177/0956797620964422 PMID: 32993455

29. Brekke KA, Hauge KE, Lind LT, Nyborg K. Playing with the good guys. A public good game with endogenous group formation. J Public Econ. 2011; 95: 1111–1118.

30. Shim E, Chapman GB, Townsend JP, Galvani AP. The influence of altruism on influenza vaccination decisions. J R Soc Interface. 2012; 9: 2234–2243. https://doi.org/10.1098/rsif.2012.0115 PMID: 22496100

31. Fehr E, Gächter S. Cooperation and punishment in public goods experiments. Am Econ Rev. 2000; 90: 980–994.

32. Bish A, Michie S. Demographic and attitudinal determinants of protective behaviours during a pandemic—A review. Br J Health Psychol. 2010; 15: 797–824. https://doi.org/10.1348/135910710X485826 PMID: 20109274

33. Hiller J, Schatz K, Drexler H. Gender influence on health and risk behavior in primary prevention: a systematic review. J Public Health (Oxf). 2017: 25: 339–349. https://doi.org/10.1007/s10389-017-0798-z PMID: 32215245

34. Eastwood K, Durrheim D, Francis JL, Tursan d'Espaignet E, Duncan S, Islam F, et al. Knowledge about Pandemic Influenza and Compliance with Containment Measures among Australians. Bull World Health Organ. 2009; 87: 588–594. https://doi.org/10.2471/blt.08.060772 PMID: 19705008

35. Pedersen MJ, Favero N. Social Distancing during the COVID-19 Pandemic: Who Are the Present and Future Noncompliers? Public Adm Rev. 2020; 80: 805–814.

36. Moussaoui LS, Ofosu ND, Desrichard O. Social psychological correlates of protective behaviors in the COVID-19 Outbreak: Evidence and recommendations from a nationally Representative Sample. Appl Psychol: Health Well Being. 2020; 12: 1183–1204. https://doi.org/10.1111/aphw.12235 PMID: 32981212

37. Dratva J, Zysset A, Schlatter N, von Wyl A, Huber M, Volken T. Swiss university students' risk perception and general anxiety during the COVID-19 Pandemic. Int J Environ Res Public Health. 2020; 17: 7433. https://doi.org/10.3390/ijerph17207433 PMID: 33066008

38. Bollen KA. Structural equations with latent variables. New York: Wiley; 1989.

39. Kline RB. Principles and practice of structural equation modeling, Fourth Ed. New York: Guilford Press; 1998.

40. Hoyle RH, Editors. Handbook of structural equation modeling. New York: Guilford Press; 2012.

41. StataCorp. Stata structural equation modeling reference manual: Release 16. College Station: StataCorp LLC; 2019.

42. Acock AC. Discovering structural equation modeling using Stata. College Station: Stata Corp LP; 2013.

43. Aichholzer J. Einführung in lineare Strukturgleichungsmodelle mit Stata. Wiesbaden: Springer; 2017.

44. Satorra A, Bentler PM. Corrections to test statistics and standard errors in covariance structure analysis. In: von Eye A, Clogg CC, Editors. Latent variables analysis: Applications for developmental research. Thousand Oaks: Sage Publications; 1994. p. 399–419.

45. Finney SJ, DiStefano C. Non-normal and categorical data in structural equation modeling. In: Hancock GR, Mueller RO, Editors. Structural equation modeling: a second course. Greenwich: Information Age Publishing; 2006. p. 269–314.

46. Bentler PM, Bonett DG. Significance tests and goodness of fit in the analysis of covariance structures. Psychol Bull.1980; 88: 588–606.

47. Yu C-Y. Evaluating Cutoff Criteria of Model Fit Indices for Latent Variable Models with Binary and Continuous Outcomes. Los Angeles: University of California; 2002.

48. Urban D, Mayerl J. Strukturgleichungsmodellierung: Ein Ratgeber für die Praxis. Wiesbaden: Springer VS; 2014.

49. Crowne DP, Marlowe D. A New scale of social desirability independent of psychopathology. J Consult Psychol. 1960; 24: 349–354. https://doi.org/10.1037/h0047358 PMID: 13813058

50. Franzen A, Mader S. Do phantom questions measure social desirability? methods, data, analyses. 2019; 13: 37–57.

51. Diekmann A, Preisendörfer P. Green and greenback. The behavioral effects of environmental attitudes in low-cost and high-cost situations. Ratio Soc. 2003; 15: 441–472.

52. Kollmuss A, Agyeman J. Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? Environ Educ Res. 2010; 8: 239–260.

53. Cawley J, Ruhm CJ. The economics of risky health behaviors. In: Pauly M, McGuire T, Barros PP, Editors. Handbook of Health Economics. Oxford: North Holland: 2012; 95–199.

54. Fudenberg D, Levine DK. A Dual-Self Model of Impulse Control. Am Econ Rev. 2006; 96: 1449–1476. https://doi.org/10.1257/aer.96.5.1449 PMID: 29135208

55. Webb TL, Sheeran P. Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. Psychol Bull. 2006; 132: 249–268. https://doi.org/10.1037/0033-2909.132.2.249 PMID: 16536643

56. Briscese G, Lacetera N, Macis M, Tonin M. Expectations, reference points, and compliance with Covid-19 social distancing measures. NBR Work Pap Ser. 26916: 2020.

S1 Table. List of variables

Variable	Obs	Min	Max	Mean	SD	Description
Staying at home	493	1	5	4	0.69	1 = not at all *to* 5 = very strictly
Making exceptions	493	1	5	3.54	0.87	1 = very often *to* 5 = never
Number of people met	493	0	25	4.93	3.32	In the week before the interview
Individual risk	493	0	10	2.6	1.98	0 = not at all dangerous *to* 10 = extremely dangerous
Social risk	493	0	10	5.52	1.9	0 = not at all dangerous *to* 10 = extremely dangerous
Household risk	493	0	1	0.27		0 = no high-risk person in household, 1 = living with high-risk person
Sex	493	0	1	0.65		0 = male, 1 = female
Age	493	18	40	23.56	3.27	years
Donation	493	0	1	0.58		0 = no donation, 1 = donation
Social desirability	493	0	10	6.16	1.93	0 = no social desirability *to* 10 = high social desirability
M1 Keep social distance	493	1	5	4.6	0.64	1 = agree not at all *to* 5 = agree very much
M2 Wearing a face mask	493	1	5	2.88	1.09	1 = agree not at all *to* 5 = agree very much
M3 Washing hands thoroughly	493	2	5	4.91	0.34	1 = agree not at all *to* 5 = agree very much
M4 Closure of schools	493	1	5	3.77	1.05	1 = agree not at all *to* 5 = agree very much
M5 Closure of universities	493	1	5	4.15	0.98	1 = agree not at all *to* 5 = agree very much
M6 Closure of restaurants/ bars	493	1	5	4.31	0.91	1 = agree not at all *to* 5 = agree very much
M7 Closure of non-food shops	493	1	5	3.9	1.1	1 = agree not at all *to* 5 = agree very much
M8 Closure of recreational facilities	493	1	5	4.18	0.98	1 = agree not at all *to* 5 = agree very much
M9 Closure of parks	493	1	5	3.11	1.21	1 = agree not at all *to* 5 = agree very much
M10 Meetings of only 5 or fewer	493	1	5	4.15	0.88	1 = agree not at all *to* 5 = agree very much
M11 Restrictions to public transport	493	1	5	3.98	1.02	1 = agree not at all *to* 5 = agree very much
M12 Closure of boarders / travel ban	493	1	5	3.82	1.19	1 = agree not at all *to* 5 = agree very much

2.3 Artikel 2: Fatigue during the COVID-19 pandemic: Evidence of social distancing adherence from a panel study of young adults in Switzerland

Die zweite veröffentlichte Forschungsarbeit im Rahmen dieser Dissertation befindet sich auf den Seiten 34 – 52.

Zitation: Franzen, Axel und Fabienne Wöhner, 2021. Fatigue during the COVID-19 pandemic: Evidence of social distancing adherence from a panel study of young adults in Switzerland *PLoS ONE* 16(12), e0261276.
DOI: https://doi.org/10.1371/journal.pone.0261276

PLOS ONE

RESEARCH ARTICLE

Fatigue during the COVID-19 pandemic: Evidence of social distancing adherence from a panel study of young adults in Switzerland

Axel Franzen *☯, **Fabienne Wöhner** ☯

Institute of Sociology, University of Bern, Bern, Switzerland

☯ These authors contributed equally to this work.
* axel.franzen@unibe.ch

OPEN ACCESS

Citation: Franzen A, Wöhner F (2021) Fatigue during the COVID-19 pandemic: Evidence of social distancing adherence from a panel study of young adults in Switzerland. PLoS ONE 16(12): e0261276. https://doi.org/10.1371/journal.pone.0261276

Editor: Asim Zia, University of Vermont, UNITED STATES

Received: August 9, 2021

Accepted: November 26, 2021

Published: December 10, 2021

Peer Review History: PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: https://doi.org/10.1371/journal.pone.0261276

Data Availability Statement: The data is stored at the public repository of the University of Bern: https://boris.unibe.ch/id/eprint/159890.

Abstract

In this paper we analyze panel data (N = 400) to investigate the change in attitudes towards the Covid-19 measures and the change in compliance behavior between the first and second lockdowns in a sample of young adults from the University of Bern, Switzerland. We find considerable fatigue. While respondents expressed high acceptance of and compliance with the Covid-19 measures during the first lockdown, both acceptance and compliance behavior decreased substantially during the second lockdown. Moreover, we show via a structural equation model that respondents' compliance behavior is largely driven by the perception of how others behave and by the acceptance of the Covid-19 measures. All other effects scrutinized e.g., individual and social risk perception, trust in politics, and pro-social orientations affect compliance behavior via the acceptance of Covid-19 measures. We also conduct two tests of causality of the estimated relation between attitudes towards the measures and social distancing behavior. The first test incorporates the effect of compliance behavior reported during the first lockdown on attitudes during the second lockdown. The second test involves estimating a first difference panel regression model of attitudes on compliance behavior. The results of both tests suggest that the effect of Covid-19 attitudes on social distancing behavior can be interpreted causally.

1. Introduction

Switzerland has experienced two lockdowns so far during the Covid-19 pandemic. The first started in the middle of March 2020 and lasted for 6 weeks until the end of April 2020. The second lockdown started on January 18, 2021. The first easing of measures occurred on March 1, 2021, but severe restrictions lasted until April 19, 2021. Generally, the measures during the lockdowns included the closure of shops, restaurants, public facilities, cancellation of events, closure of schools and universities, restrictions in the form of meeting no more than five people, obligations to wear masks, and the recommendation to stay home as much as possible. Additionally, during the second lockdown working from home was mandatory whenever possible. Generally, the measures imposed by the Swiss government were less restrictive as

Funding: The author(s) received no specific funding for this work.

Competing interests: The authors have declared that no competing interests exist.

compared to other European countries. Thus, there was never any curfew in Switzerland as for instance in Germany, France or Italy.

Since Covid-19 infections cause severe health risks predominantly for the elderly population, compliance with measures designed to avoid the spread of the virus constitutes a social dilemma for the young population. Cooperation in the form of compliance with these measures is good for society but comes along with substantial individual costs. Hence, young people who have a low health risk face incentives not to contribute to the public good through staying at home and limiting social contacts. Hence, in a previous study we analyzed how young adults behaved during the first lockdown [1]. We found that acceptance of and compliance with the measures were surprisingly high during the first lockdown. Most young adolescents believed that the measures were meaningful in an effort to avoid the spread of the virus and they adhered voluntarily even to those measures that were not enforced, such as staying at home and not meeting friends and relatives. In fact, we found that high acceptance of the measures was the most important prerequisite to compliance with the social distancing measures.

The results we present in this article are a continuation of our first study. In particular, we surveyed the same individuals right at the end of the second lockdown asking again to what degree the imposed measures are accepted and to what extent they followed the social distancing restrictions. Our interpretation of the first study was that the unusual emergency situation caused high compliance and high solidarity. One of our main research questions in this second study is to what extent the prolonged nature of the pandemic causes fatigue, and how this fatigue affects acceptance of and compliance with the Covid-19 measures.

The remainder of this article is structured into four sections. Section two presents a short literature overview of what is known so far about compliance in the Covid-19 pandemic. The third section then describes the data and presents some descriptive results on how acceptance of and compliance with the measures changed between the first and the second lockdowns. In section four we present the multivariate results of a structural equation model trying to explain compliance with the Covid-19 measures. Since we are interested in causal explanations of compliance behavior we conduct a number of tests to exclude the possibility that acceptance of the measures is not a cause but rather a rationalization of the behavior. We do this by first investigating to what extent compliance during the first lockdown influences the acceptance of measures during the second lockdown. Furthermore, we conduct a first-difference panel regression model of how the changes in attitudes are related to the changes in behavior. Finally, section five concludes and discusses the results.

2. Literature review

There are numerous studies describing and investigating compliance with Covid-19 measures in various countries, particularly for the US [2–7], Germany [8], Italy [9], Switzerland [1, 10], Slovakia [11], Israel [12], South Korea [13], Japan [14], Indonesia [15], or Côte d'Ivoire [16]. Even though many of these studies only use opportunity samples or student samples, a few consistent results have still emerged. Generally, many studies report high compliance with measures against the spread of Covid-19 such as keeping physical distance or engaging in frequent hygiene-related precautions. However, there are also some socio-demographic differences. Thus, women adhere more often to preventive measures than do men [1, 5, 7, 10, 13–15]. Less consistent are the findings concerning age. Most studies report that younger people are less inclined to comply with Covid-19 measures [5, 11], but there is also opposing evidence [2, 4, 14].

More interesting are findings concerning individuals' psychological dispositions like self-control, trust in government and health institutions, and risk perception. Not surprisingly,

subjects perceiving a higher risk of becoming infected exhibit more preventive behaviors (e. g. [7, 8, 11, 13, 14]. There are a number of studies investigating the effect of certain psychological dispositions on non-compliance with coronavirus safety measures. In particular, Nivette et al. [10] found in a sample of young Swiss adults that those with low self-control report less compliance with social distancing measures. Similarly, O'Connell et al. [2] report for a US sample that individuals who report anti-social behaviors (measured by the Subtypes of Antisocial Behavior Questionnaire (STAB)) also comply less with social distancing measures. A large number of psychological dispositions were considered in a study by Bailey et al. [4] using a US convenience sample. They found that those individuals with high behavioral emotional regulation skills and high values of agreeableness—a dimension of the Big Five—show greater compliance with social distancing recommendations.

Many studies also investigate how trust in the government and countries' health institutions affects compliance with social distancing recommendations [11, 12, 16–19]. Pak et al. [17] use a global survey on Covid-19 attitudes and behaviors conducted in 177 countries (see Fetzer et al. [20]). Their findings for the 58 countries included in the final analysis suggest that trust in the government amplifies the following of governmental restrictions implemented in order to avoid Covid-19. The finding that trust increases compliance with governmental restrictions is also supported by national studies for Cote d'Ivoire [16], Israel [12], France [19], and Slovakia [11]. In a similar vein, Farjam et al. [18] demonstrate via a survey experiment that participants react more responsively to Covid-19 measures when the recommendations were given by scientific experts as compared to politicians, leading to the assumption that trust makes a decisive difference.

Summing up, despite the fact that most studies concerned with compliance behavior during the first Covid-19 lockdown use non-random opportunity samples or are limited to specific populations (e.g. students) a few findings appear to be relatively consistent: Individuals seem to comply more often with the coronavirus measures if they are female and older, perceive higher personal risk associated with becoming infected or if they are surrounded by vulnerable relatives or friends. Furthermore, those who have shown antisocial behavior before, or have a certain psychological disposition (e.g. low self-control), also seem less likely to comply with coronavirus measures. Additionally, all studies incorporating trust in governments or health institutions suggest that trust in official representatives increases engagement in social distancing or hygiene measures.

The purpose of this study is to investigate attitudes towards Covid-19 measures and compliance behavior during the second lockdown and to compare this with attitudes and behaviors during the first lockdown. We are particularly interested in how attitudes and behaviors changed between the first and the second lockdown. The main results of our first study were that young adults in Switzerland expressed high support of the Covid-19 measures and complied strictly with social distancing measures. Since young adults have a low risk of severe health problems when infected with Covid-19, complying with measures is like contributing to a public good [1, 21–24]. Keeping social distance and staying at home avoids the spread of Covid-19, and hence, is beneficial for society. But social distancing comes with individual costs, particularly for young adults, and therefore provides an incentive not to comply with social distancing measures. In light of the fact that cooperation is often low in many public goods (e.g. environment, overpopulation) the finding that individuals cooperated during the coronavirus pandemic is surprising. We believe this high level of cooperation was due to the special emergency situation, since elevated levels of solidarity and cooperation can often be observed during times of severe crisis. Therefore, the interesting question is: How long did this solidarity last? Are participants still in favor of the measures during the second lockdown and are they still complying with the measures or are there signs of fatigue?

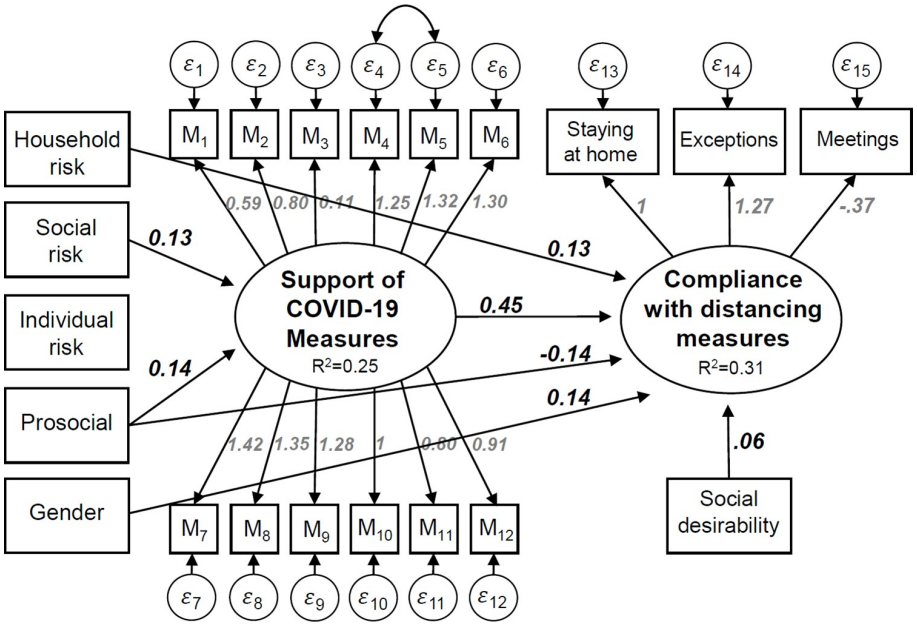


Fig 1. Results of a structural equation model explaining compliance with Covid-19 measures during the first lockdown in Switzerland. Note: N = 493. All reported coefficients are unstandardized and statistically significant at least at the 5% level [1].

https://doi.org/10.1371/journal.pone.0261276.g001

Furthermore, based on the first wave, our first study showed that compliance predominately depends on support of the preventive measures, which in turn depends on social risk perception and pro-social orientation. This hypothesized causal structure is by and large confirmed by the structural equation model depicted in Fig 1 which we obtained from a student sample surveyed during the first lockdown in spring 2020 (see [1] for more details).

3. Methods and data

Our database for this paper is a two-wave panel study of a random sample of students of the University of Bern in Switzerland. Ethical clearance was obtained by the Ethics Committee of the Faculty of Business, Economics and Social Sciences of the University of Bern. The first wave of the survey was conducted at the end of the first lockdown in May 2020. For the second wave we recontacted the 510 participants of the first wave by the end of the second lockdown during April 2021.

As in the first wave, we conceptualize compliance with the social distancing measures as a latent construct and measure it using three indicators. First, on a 5-point Likert scale ranging from "not at all" (1) to "strictly" (5), participants of the second wave were asked to what extent they complied with the recommendation to stay at home as much as possible during the last four weeks before the interview (S1 Table in the supplement list the exact wording of all questions). The second indicator is the question of whether respondents made occasional exceptions to staying at home. The question has five answer categories ranging from "never" (1) to "very often" (5), and hence, is coded in the opposite direction as compared to the first indicator, balancing the index. For the statistical analysis, the coding of the answer categories of the second indicator is reversed. Thirdly, we asked how many friends or relatives participants met in their leisure time during the week before the interview. Meeting a large number of friends is not conforming to the coronavirus measures and hence indicates non-compliance to the safety

measures. For the analyses, we took the natural logarithm of the number of people, to achieve a more similar range and variance compared to the other two 5-point scales used for the construction of the latent compliance variable.

The main result of our first study is that compliance with the social distancing measures depends directly on the acceptance of the Covid-19 regulations. Individuals who agree with the regulations also show higher compliance with them (see Fig 1). We measure acceptance of the regulations again in the second wave by asking participants how much they support 11 different single measures implemented by the Swiss government during both lockdowns. For each measure respondents were asked to what extent they agree with the measure on a five-point answering scale ranging from "not at all" (1) to "very much" (5). The 11 single measures were: washing hands (M3), keeping social distance (M1), closure of restaurants and bars (M6), closure of universities (M5), not meeting more than 4 others (M10), closure of recreation facilities (M8), restrictions of public transportation (M11), closure of non-food stores (M7), border restrictions (M12), closure of schools (M4), and wearing of face masks (M2).

Support of the measures depends on individuals' risk perception regarding Covid-19. We differentiate between the risk participants perceive for themselves, members of the household, or for society in general. Individual risk perception is measured in both waves on 11-point scales asking participants how dangerous they believe a Covid-19 infection would be for themselves. Social risk is measured in both waves by how dangerous participants believe Covid-19 is for the health of the Swiss population. As it turned out in our first study, the perception that Covid-19 poses an individual risk is related to neither the acceptance of the measures nor to compliance with distancing rules. Possibly, this non-finding is due to the fact that we are dealing with a sample of young adults of whom many perceive a low personal risk. However, the perception that Covid-19 poses a health risk to others increased acceptance of the recommended regulations. Moreover, living together in a household with a person who has a health risk increased compliance with the coronavirus measures (see Fig 1).

The model also incorporates pro-sociality. Our analysis of wave 1 found that pro-socials expressed higher support for the measures [1] which in turn increases compliance; this is consistent with the findings of other studies [2, 10]. However, and surprisingly, we also found that the direct effect on compliance is negative. As in study 1, we measure pro-social orientation in the second wave via a revealed preference approach. Respondents received 10 Swiss Francs (about $10) for participation in the second wave. At the end of the questionnaire they had the option to donate some (or all) of their payment to a charitable organization of their choice. Those who donate some of their payments (about 52%) are classified as pro-socials. Furthermore, as in wave one we also include the Marlowe-Crowne scale, which measures social desirability in this second model [25, 26].

In wave two we also incorporate two new variables. Since former studies suggest that trust in the government and health institutions increases compliance, we also include trust in the government in this study. For this purpose, we asked participants to rate how much trust they have in politics on an 11-point scale ranging from 0 (no trust at all) to 10 (very much trust). Furthermore, former research shows that individual behavior is not only guided by injunctive norms, e.g. the regulations aimed at avoiding the spread of Covid-19, but also by descriptive norms (e.g. [27]). Therefore, we added a measure of the descriptive norm by asking participants to what extent their friends and acquaintances followed social distancing measures on a 5-point scale ranging from 1 (never) to 5 (always). The assumption is that compliance behavior is also guided by the social influence of what others do.

In the following section, we first present a few descriptive results of how the 364 participants changed in attitudes and behavior from the first to the second lockdown. In a second step, we re-estimate an extended version of the structural equation model depicted in Fig 1 to

see if the assumed causal structure can be replicated. Finally, we conduct a few checks to see if the causal structure assumed by the structural model is justified by using data from both waves.

4. Results

Of the 510 respondents of the first wave, 400 participated again in the second study. The online questionnaire of the second wave contained about 75 questions and the average completion time was 14 minutes. The online questionnaire contained an attention check by asking participants not to tick any of the given answers to a fake question which was placed in the middle of the questionnaire. 25 participants failed to pass this attention check by ticking an answer category and were excluded from further analysis. Moreover, we encountered 11 missing values in some of the variables, which leaves us with 364 valid cases. Descriptive information regarding all relevant variables of the second wave is presented in the supporting information in S2 Table. The mean age of the second wave is 24.2 years with a range of 19–36, and a female share of 64%. There are no statistically significant differences between the two waves with respect to age (t-value = 1.09, degrees of freedom = 855, two-sided p-value = 0.28) and the sex distribution (t-value = 0.27, degrees of freedom = 855, two-sided p-value = 0.79).

Fig 2 shows the comparison of the acceptance of the 11 most important anti Covid-19 measures between the first and second lockdowns. For descriptive purposes the two highest answer categories were collapsed into one agreement category. Hence, the bars denote the proportion of respondents who either accept or accept the measures very much. As can be seen the two measures of washing hands thoroughly and keeping social distance receive very high acceptance during both lockdowns.

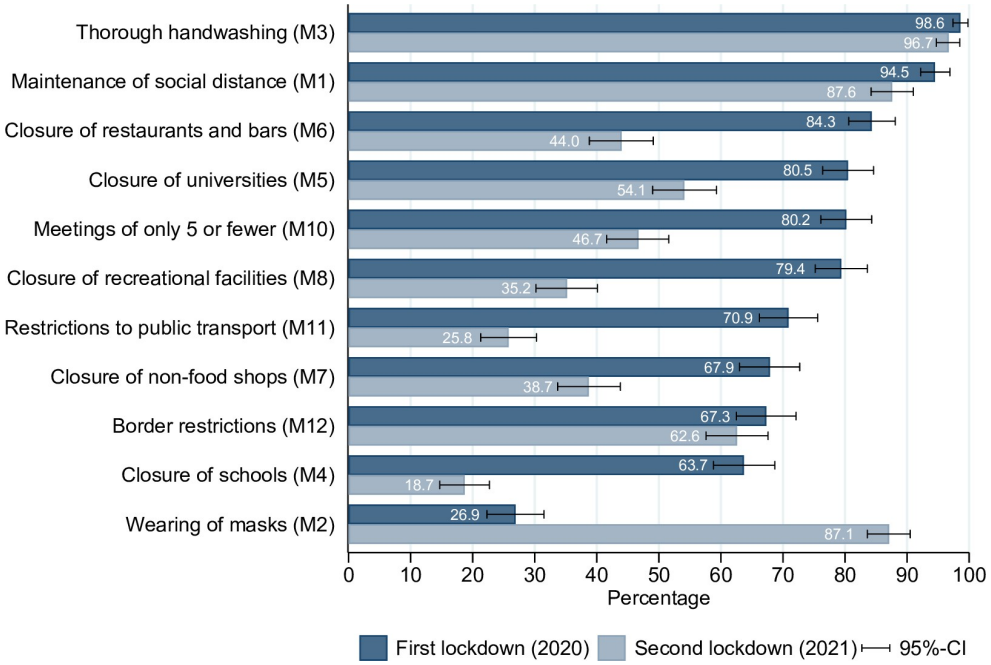


Fig 2. Acceptance of Covid-19 measures during the first and second lockdowns. Note: N = 364. Results for respondents who participated in both waves. Each measure was surveyed via five-point Likert scales ranging from "do not support at all" (1) to "support very much" (5). The figure displays the proportion of respondents supporting a measure weakly or strongly (categories 4 and 5).

https://doi.org/10.1371/journal.pone.0261276.g002

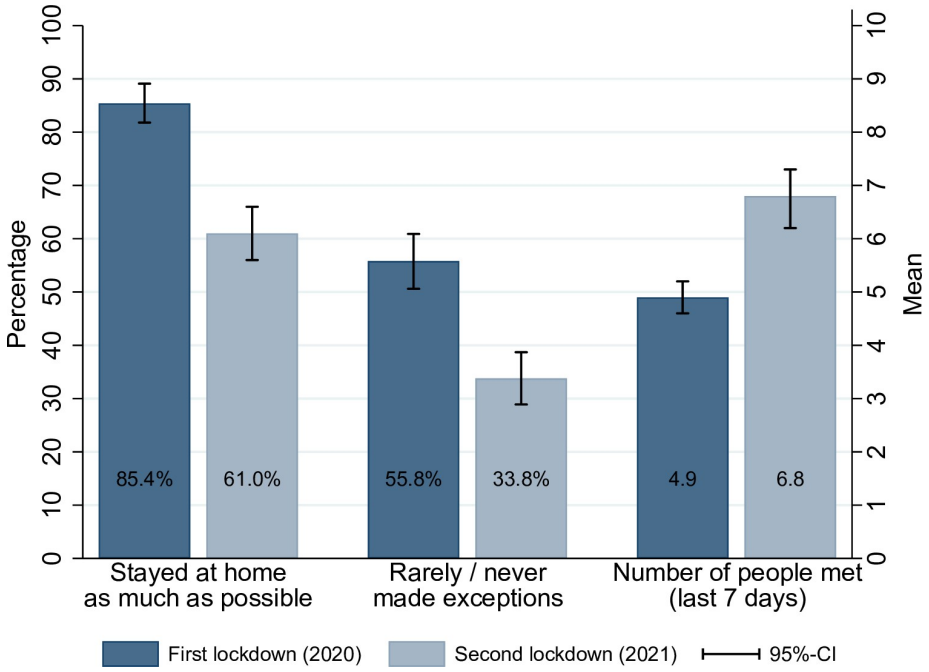


Fig 3. Adherence to social distancing measures during first and second lockdowns. Note: N = 364. Results for respondents who participated in both waves. Adherence was surveyed via five-point Likert scales, and the number of people met in the last 7 days. The figure displays the proportion of respondents, who stayed at home "mostly" or "strictly" (categories 4 and 5), the proportion of respondents, who "rarely" or "never" made exceptions (categories 4 and 5), and the average number of people met. The differences between the first and second wave are all statistically significant.

https://doi.org/10.1371/journal.pone.0261276.g003

However, the acceptance of most other measures such as the closing of schools, universities, restaurants, recreational facilities, and restrictions of public transport dropped substantially by about half of the agreement rates during the first lockdown. One exception to this observation is the wearing of face masks, which increased substantially. This is most likely a reflection of the special situation in Switzerland, where the use of face masks was discouraged by health officials during the first lockdown. Later on officials changed their opinions on the preventive effects of face masks and so did participants in our study.

Next, Fig 3 depicts the change in social distancing behavior. For descriptive purposes the original categories "mostly" and "strictly" as well as "rarely" and "never" were collapsed into single categories, respectively. Hence, Fig 3 depicts the proportion of participants who adhere to the social distancing measures. As can be seen, adherence to social distancing decreased substantially during the second lockdown; from 85% who report staying at home as much as possible during the first lockdown to 61% (t-value 8.83, degrees of freedom = 363, two-sided p-value < 0.001) in the second lockdown, and from 55% who rarely or never made exceptions to 35% (t-value = 7.34, degrees of freedom = 363, two-sided p-value < 0.001). In line with these findings, the number of people respondents met during the week before the interview increased from an average of 4.9 to an average of 6.8 (t-value 7.01, degrees of freedom = 363, two-sided p-value < 0.001). As denoted in the brackets, all of these differences are statistically highly significant.

Next, we replicate the structural equation model which we calculated for the first lockdown [1]. Structural equation modeling allows the simultaneous estimation of latent constructs and of the structural relations between them (e.g. [28–30]). We estimate the model using Stata 17

[31–33]. We regress all exogenous variables on both latent constructs. The latent construct "Support of Covid-19 measures" includes 8 different preventive measures, and not 12 anymore as in the first model. We dropped "closure of parks" from the model, because this measure was not in practice anymore during the second lockdown. The three indicators M3, M11, and M12 have only low factor loadings, meaning that the Bentler-Raykov [34] squared multiple correlation coefficient is smaller than 0.2. Hence, we excluded them from the model. Furthermore, we include the error covariance between M1 (maintain social distance) and M2 (wearing face mask), M4 (closure of schools) and M5 (closure of universities), M6 (closure of restaurants) and M7 (closure of non-food shops), and M7 and M8 (closure of recreational facilities) as suggested by modification indices. Because our variables do not follow a multivariate normal distribution, we use maximum likelihood estimation applying the Satorra-Bentler correction for standard errors and model fit parameters [33, 35, 36]. The Satorra-Bentler corrected χ^2 value of the model is 184.5 with 111 degrees of freedom. However, the χ^2-statistic is not an ideal test statistic for this model, because of the large sample size and the relatively large number of indicators. Therefore, we follow the literature [37–39], and use CFI and TLI as goodness-of-fit statistics. The Satorra-Bentler corrected CFI equals 0.957 and the TLI goodness-of-fit statistic is 0.945. Both indicate a good model fit, since they reach the threshold of 0.95. The SRMR fit statistic has a value of 0.039, which is smaller than the threshold of 0.05, also suggesting a good model fit. Another test statistic is the RMSEA. In our case, RMSEA has a value of 0.044 with a 90% confidence interval (CI) of 0.033 to 0.055, which also indicates a good model fit. In addition, the test of close fit, testing that RMSEA is smaller than 0.05, is statistically not significant ($p = 0.816$), as desired. Altogether, the different goodness of fit statistics indicate that the model explains the data structure very well.

The unstandardized results of the model estimation for the second lockdown are shown in Fig 4. We regressed all exogenous variables on both latent variables. Effects that are statistically significant are depicted by arrows. Variables that are not connected by arrows with any of the two latent constructs did not show any statistically significant relation. By and large the model is a very good replication of the model constructed for the first lockdown. Most importantly, the latent variables "compliance with social distancing measures" and "support of Covid-19 measures" are again well measured by the three measures depicted in Fig 3, and respectively the 8 selected preventive measures (see Fig 2 and also supporting material in S2 Table). Furthermore, the main structural effects describing the influence on social distancing behavior are replicated. Hence, a positive attitude towards the coronavirus measures and living with a person at risk drives compliance behavior. Interestingly, we cannot replicate the effects of gender, pro-sociality and social desirability on compliance, which however had only a small impact in the first model.

Also, the structural effects of household risk, social risk, and prosocial attitudes on the acceptance of the measures, are replicated. There are also some new insights that emerge from this second model. First, political trust increases the acceptance of the Covid-19 measures, but it has no direct effect on compliance. Hence, the effect of political trust on compliance is mediated by attitudes towards the measures. Furthermore, the descriptive norm has a very strong effect on compliance of 0.56. Put differently, the perception that others comply is the strongest predictor of compliance in our model, i.e., an increase by one standard deviation in the descriptive norm increases compliance by 0.47 standard deviations. In comparison, an increase of one standard deviation of the attitudes towards the measures increases compliance by 0.29 standard deviations. Hence, attitudes still predict behavior, but the model depicted in Fig 4 suggests that the perception of what others do is more important. Overall, the model explains 48% of the variance of the social distancing compliance, and 50% of the support of the preventive measures.

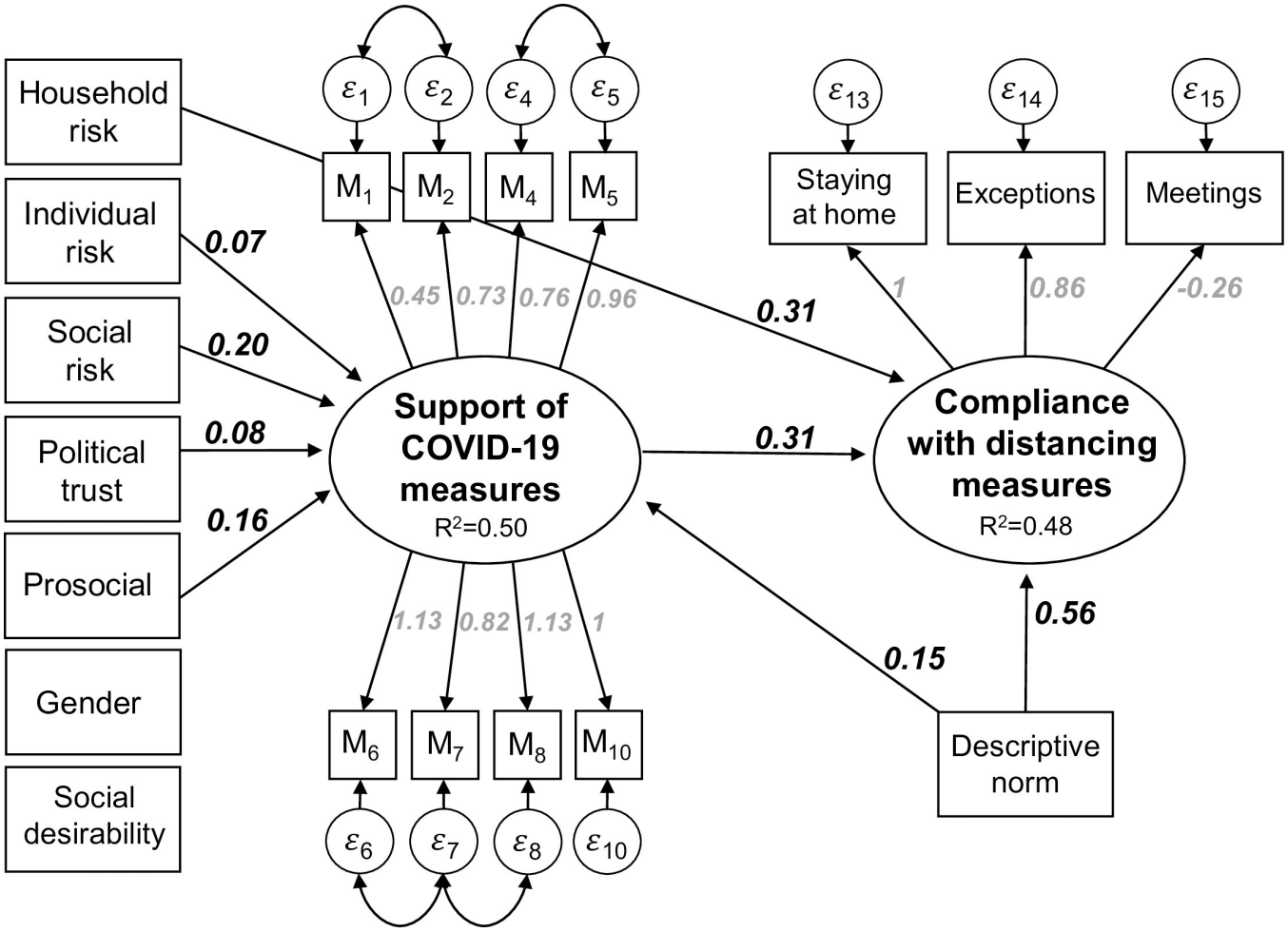


Fig 4. A structural equation model of compliance with the coronavirus distancing measures. Note: N = 364. All reported coefficients are unstandardized and statistically significant at least at the 5%-level.

https://doi.org/10.1371/journal.pone.0261276.g004

As with any attitude-behavior model that is solely tested via cross-sectional data analysis, we cannot exclude the possibility that favorable attitudes of the coronavirus measures are not the cause of compliance behavior but simply a rationalization of it. Hence, from the evidence presented so far it is theoretically possible that causality runs the other way and that behavior causes attitudes. A stronger test of causality is possible by using panel data. In what follows we conduct two more stringent tests by utilizing the panel structure of the data. If compliance behavior causes attitudes, then the compliance behavior participants reported in 2020 during the first lockdown should influence their attitudes measured in 2021 during the second lockdown. We tested this assumption by incorporating compliance behavior measured in 2020 into the structural equation model presented in Fig 4. We used the eight indicators of support of the Covid-19 measures in 2021 (M1, M2, M4, M5, M6, M7, M8, M10), and we measured compliance with distancing measures in 2020 and 2021 respectively with the three indicators each, which can be found in Fig 3. Modification indices suggested the addition of an error covariance between the number of people met in 2020 and in 2021. Theoretically, it makes sense to include it for two reasons: First, because some people meet more people in general

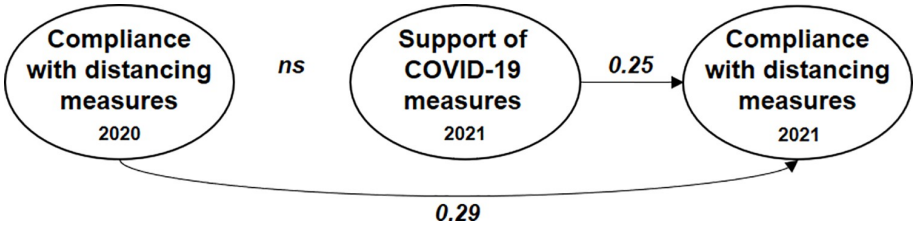


Fig 5. A test of the assumed causal structure via structural equation modeling. Note: N = 364. All reported coefficients are standardized and statistically significant at least at the 5%-level. Included control variables are individual risk, social risk, household risk, descriptive norm, trust in politics, prosocial, gender, and social desirability.

https://doi.org/10.1371/journal.pone.0261276.g005

than others. Second, the scale is different from the two other indicators used when measuring compliance. Also, we included the covariance between making exceptions of wave one and wave two. This model fits the data very well (χ^2 = 257, df = 156, CFI = 0.956, TLI = 0.942, SRMR = 0.042, RMSEA = 0.042, RMSEA 90%-CI = [0.033, 0.051]). The extended model explains 54% of the variance in the social distancing compliance, and 50% of the support of the Covid-19 measures.

The standardized results of this test are shown in Fig 5. For simplicity, we present only the structural coefficients of interest. However, all other results remain very similar as shown in Fig 4. As can be seen, the analysis does not result in a statistically significant effect of behavior in 2020 on attitudes in 2021. However, the social distancing behavior shown by participants in 2020 does influence their behavior in 2021. Hence, those who complied with the coronavirus measures in 2020 also did so in 2021, independently of their attitudes in 2021. However, in addition to the effect of the past behavior the effect of attitudes on behavior remains significant. Inclusion of the past behavior decreases the influence of attitudes, but an increase of one standard deviation of attitudes still increases compliance behavior by 0.25 standard deviations. Hence, attitudes still have a strong influence on compliance behavior even if past behavior is taken into account. This result confirms the assumed causal structure of the model depicted in Fig 4.

Another test of causality can be obtained by estimating a fixed effects panel regression. Hence, we are regressing the difference in behavior between the first and the second lockdown on the difference in attitudes between the lockdowns together with other time-varying variables. The structural equation model already indicates that three variables have direct effects on compliance. Next to attitudes these are the variables of household risk, and the descriptive norm. Since the descriptive norm was only measured in the second wave, the variable cannot be included in a first difference model. Therefore, our model contains three variables; the difference in attitudes towards the measures, the changes in household risk, and a time dummy variable indicating the second wave. The model can be written as follows:

$$Y_{it} - Y_{it-1} = \beta_0 + \beta_1(X_{1it} - X_{1it-1}) + \beta_2(X_{2it} - X_{2it-1}) + \beta_3 T + (\varepsilon_1 - \varepsilon_2)$$

The first term describes the difference of behavior of individual *i* between the two measurements. The difference in attitudes of individual *i* between the two measurements is denoted by X_{i1t}-X_{i1t-1}, and the change in household risk is denoted by X_{i2t}-X_{i2t-1}. T is a dummy variable denoting the second wave and catches all differences not otherwise accounted for that might occur between the two time periods. Finally, epsilon 1 and 2 denote the error terms of the two waves. The advantage of such a two-way fixed effects model is that it takes only the within individual variance into account for the estimation of the coefficients, and not the between individual variances that might be biased due to unobserved heterogeneity. Two-way fixed effects

models are seen in the literature as the best way to estimate unbiased causal effects of an independent variable X on Y [40, 41]. The estimation can of course still suffer from bias if there are measurement errors in any of the dependent or independent variables. Also, reversed causality can still be a problem in fixed effects regressions. However, we showed already in Fig 5 that reversed causality is very unlikely in our case.

To estimate a fixed effect panel regression the former latent variables need to be transformed into manifest variables. We do this by constructing indices. For the compliance index, the three indicators were summed up to an index. Hence, individuals who strictly stayed at home (ranging from 0 to 4), never made exceptions (ranging from 0 to 4), and who met no friends during the week before the interview receive the highest value on the index. For the purpose of constructing the index, the latter variable (meeting friends) was reversely coded by subtracting the maximum value of the log number of friends met (ranging from 0 to 3.87 in 2021, resp. to 3.04 in 2020).

For 2021, the index ranges from 0.61 to 11.87, and has a decent reliability in terms of Cronbach's alpha of 0.74. For 2020, the index ranges from 1.21 to 11.04, and has a Cronbach's alpha of 0.65. For the construction of the index of the attitudes towards the measures we took the 8 items (M1, M2, M4, M5, M6, M7, M8, M10) and summed the values of each item. Hence, the index runs from 8 (low approval of the measures) to 40 (high approval of the measures). The Cronbach's alpha of this scale is 0.85 for 2021 and 0.83 for 2020 indicating very high reliability. Descriptive information regarding the four indices is presented in the supporting information in S3 Table. The results of the fixed effects regression are presented in Table 1. As can be seen, the change in attitudes towards the measure is statistically significantly related to compliance behavior. An increase of one standard deviation in attitudes increases compliance by 0.34 standard deviations. Hence, the effect is similar in size as already obtained in the structural equation model. A change in household risk is not reliably related to a change in compliance

Table 1. Two-way fixed effects panel regression on the change of complying with social distancing measures.

Variables	Coefficient
Support of COVID-19 measures	0.34***
	(0.059)
Household risk	
Transition to household with person at risk§	0.35
	(0.183)
Leaving of household with person at risk§	0.07
	(0.186)
Second Wave§	-0.01
	(0.073)
Constant	-0.01
	(0.046)
Within R^2	0.143
n	364
n x T	728

Note

* = $p < 0.05$

** = $p < 0.01$

*** = $p < 0.001$. Standardized regression coefficients with standard errors in brackets.

§ = non-standardized dichotomous variables.

https://doi.org/10.1371/journal.pone.0261276.t001

behavior, and also the time dummy variable is not statistically significantly related to compliance indicating that there are no unaccounted further effects present.

5. Summary and discussion

The analysis of two-wave panel data collected during the first and second Covid-19-induced lockdowns reveals a few interesting results. First of all, we observe a fatigue effect in our sample of young adults. While the coronavirus measures received very high support during the first lockdown, and while study participants report high compliance during this period, support of the measures and compliance with social distancing decreased considerably during the second lockdown. This result is in line with other studies, e.g. for the UK [42] which reports that compliance decreased significantly during a period of 5 month. Second, a structural equation model shows that social distancing compliance is most importantly driven by the descriptive norm and the acceptance of the Covid-19 measures. Hence, respondents who believe that others are adhering to the social distancing rules also keep the rules themselves. Furthermore, our results suggest that many effects on compliance reported in the literature are mediated by the attitudes towards the measures. Thus, individual and social risk perception, trust in politics, and prosocial attitudes increase the acceptance of the measures which in turn leads to stronger adherence to the social distancing measures. Moreover, we used the data of both waves to conduct further tests on the causality of the relationship between attitudes and behavior. Both test results suggest that attitudes drive the compliance behavior and that the obtained relation can be interpreted causally.

While these results are interesting and add new insights to the existing literature on attitudes and compliance behavior during the Covid-19 pandemic, our study also has some limitations. Most importantly, we do not have a random population sample but only a random sample of students from the University of Bern. Hence, our sample consists of young and educated adults, and the results cannot be generalized to the whole population or to the whole younger generation. Particularly, the homogeneity with respect to age and education makes it impossible to assess how these socio-demographic characteristics influence compliance. The study is of course also limited to one region within Switzerland. Since other countries reacted with much more restrictive measures (e.g. including curfew) to the spread of Covid-19 or penalized non-compliant behavior more heavily, inhabitants of these countries might have responded differently in terms of acceptance of the measures as well as in terms of complying with the measures. Hence, international comparisons of how the different measures affected attitudes and compliance would certainly enrich the insights of Covid-19 related attitudes and behaviors.

Supporting information

S1 Table. List of variables and question wording.
(DOCX)

S2 Table. Descriptive information of variables of wave two (2021).
(DOCX)

S3 Table. List of index variables for the first wave (2020), and the second wave (2021).
(DOCX)

Author Contributions

Conceptualization: Axel Franzen.

Data curation: Fabienne Wöhner.

Formal analysis: Axel Franzen, Fabienne Wöhner.

Investigation: Axel Franzen, Fabienne Wöhner.

Methodology: Axel Franzen, Fabienne Wöhner.

Project administration: Axel Franzen.

Supervision: Axel Franzen.

Visualization: Fabienne Wöhner.

Writing – original draft: Axel Franzen.

Writing – review & editing: Axel Franzen, Fabienne Wöhner.

References

1. Franzen A, Wöhner F. Coronavirus risk perception and compliance with social distancing measures in a sample of young adults: Evidence from Switzerland. PLoS One. 2021; 16(2): e0247447. https://doi.org/10.1371/journal.pone.0247447 PMID: 33606826
2. O'Connell K, Berluti K, Rhoads SA, Marsh AA. Reduced social distancing early in the COVID-19 pandemic is associated with antisocial behaviors in an online United States sample. PloS One. 2021; 16 (1): e0244974. https://doi.org/10.1371/journal.pone.0244974 PMID: 33412567
3. Ravert RD, Fu LY, Zimet GD. Young Adults' COVID-19 Testing Intentions: The Role of Health Beliefs and Anticipated Regret. J Adolesc Health. 2021; 68(3): 460–463. https://doi.org/10.1016/j.jadohealth.2020.12.001 PMID: 33610234
4. Bailey B, Whelen ML, Strunk DR. Adhering to COVID-19 health guidelines: Examining demographic and psychological predictors of adherence. Appl Psychol Health Well-Being. 2021; 00: 1–18. https://doi.org/10.1111/aphw.12284 PMID: 34032383
5. Hao F, Shao W, Huang W. Understanding the influence of contextual factors and individual social capital on American public mask wearing in response to COVID–19. Health Place. 2021; 68: 102537–102537. https://doi.org/10.1016/j.healthplace.2021.102537 PMID: 33636596
6. Imbriano G, Larsen EM, Mackin DM, An AK, Luhmann CC, Mohanty A, et al. Online Survey of the Impact of COVID-19 Risk and Cost Estimates on Worry and Health Behavior Compliance in Young Adults. Front Public Health. 2021; 9: 612725–612725. https://doi.org/10.3389/fpubh.2021.612725 PMID: 33855007
7. De Bruin WB, Bennett D. Relationships between initial COVID-19 risk perceptions and protective health behaviors: A national survey. Am J Prev Med. 2020; 59: 157–167. https://doi.org/10.1016/j.amepre.2020.05.001 PMID: 32576418
8. Welter VDE, Welter NGE, Großschedl J. Experience and Health-Related Behavior in Times of the Corona Crisis in Germany: An Exploratory Psychological Survey Considering the Identification of Compliance-Enhancing Strategies. Int J Environ Res Public Health. 2021; 18(3): 933. https://doi.org/10.3390/ijerph18030933 PMID: 33494536
9. Barari S, Caria S, Davola A, Falco P, Fetzer T, Fiorin S, et al. Evaluating COVID-19 Public Health Messaging in Italy: Self-Reported Compliance and Growing Mental Health Concerns. Preprint. 2020; https://doi.org/10.1101/2020.03.27.20042820
10. Nivette A, Ribeaud D, Murray A, Steinhoff A, Bechtiger L, Hepp U, et al. Non-compliance with COVID-19-related public health measures among young adults in Switzerland: Insights from a longitudinal cohort study. Soc Sci Med. 2021; 268: 113370. https://doi.org/10.1016/j.socscimed.2020.113370 PMID: 32980677
11. Caplanova A, Sivak R, Szakadatova E. Institutional Trust and Compliance with Measures to Fight COVID-19 Int Adv Econ Res. 2021: 27(1): 47–60. https://doi.org/10.1007/s11294-021-09818-3
12. Ayalon L. Trust and Compliance with COVID-19 Preventive Behaviors during the Pandemic. Int J Environ Res Public Health. 2021; 18(5): 2643. https://doi.org/10.3390/ijerph18052643 PMID: 33807977
13. Lee J, Allen J, Lim H, Choi G. Determinants of Behavioral Changes Since COVID-19 among Middle School Students. Healthcare. 2021; 9(1): 75. https://doi.org/10.3390/healthcare9010075 PMID: 33466851
14. Cai G, Lin Y, Lu Y, He F, Morita K, Yamamoto T, et al. Behavioural responses and anxiety symptoms during the coronavirus disease 2019 (COVID-19) pandemic in Japan: A large scale crosssectional

study. J Psychiatr Res. 2021; 136: 296–305. https://doi.org/10.1016/j.jpsychires.2021.02.008 PMID: 33631655

15. Fuady A, Khoe LC, Azzahra TB, Lestari HM, Sutanto RL, Yo EC, et al. Good Knowledge but Poor Practice Toward COVID-19 Among Indonesian Youth. Asia-Pac J Public Health. 2021: 1–4. https://doi.org/10.1177/10105395211015048 PMID: 33998316

16. Yapi RB, Houngbedji CA, N'Guessan DKG, Dindé AO, Sanhoun AR, Amin A, et al. Knowledge, Attitudes, and Practices (KAP) Regarding the COVID-19 Outbreak in Côte d'Ivoire: Understanding the Non-Compliance of Populations with Non-Pharmaceutical Interventions. Int J Environ Res Public Health. 2021; 18(9): 4757. https://doi.org/10.3390/ijerph18094757 PMID: 33946980

17. Pak A, McBryde E, Adegboye OA. Does High Public Trust Amplify Compliance with Stringent COVID-19 Government Health Guidelines? A Multi-country Analysis Using Data from 102,627 Individuals. Risk Manag Healthc Policy. 2021; 14: 293–302. https://doi.org/10.2147/RMHP.S278774 PMID: 33542664

18. Farjam M, Bianchi F, Squazzoni F, Bravo G. Dangerous liaisons: an online experiment on the role of scientific experts and politicians in ensuring public support for anti-COVID measures. R Soc Open Sci. 2021; 8(3): 201310–201310. https://doi.org/10.1098/rsos.201310 PMID: 33959315

19. Atkinson-Clement C, Pigalle E. What can we learn from Covid-19 pandemic's impact on human behaviour? The case of France's lockdown. Humanit Soc Sci Commun. 2021; 8(1): 1–12. https://doi.org/10.1057/s41599-021-00749-2

20. Fetzer T, Witte M, Hensel L, et al. Global Behaviors and Perceptions in the COVID-19 Pandemic. 2020; available from https://doi.org/10.31234/osf.io/3kfmh

21. Capraro V, Boggio PS, Böhm R, Perc M, Sjåstad H. Cooperation and acting for the greater good during the COVID-19 pandemic. In: Miller MK, Editor. The Social Science of the COVID-19 Pandemic: A Call to Action for Researchers. Oxford: Oxford University Press; forthcoming.

22. Cato S, Iida T, Ishida K, Ito A, McElwain KM, Shoji M. Social distancing as a public good under the COVID-19 pandemic. Public Health. 2020; 188: 51–53. https://doi.org/10.1016/j.puhe.2020.08.005 PMID: 33120232

23. Hoh Teck Ling G, Mee Chyong Hu C. Effects of the coronavirus (COVID-19) pandemic on social behaviours: From a social dilemma perspective. Tech Soc Sci J. 2020; 7, 312–320.

24. Yong JC, Choy BKC. Noncompliance With Safety Guidelines as a Free-Riding Strategy: An Evolutionary Game-Theoretic Approach to Cooperation During the COVID-19 Pandemic. Front. Psychol. 2021; 12: 646892. https://doi.org/10.3389/fpsyg.2021.646892 PMID: 33796057

25. Crowne DP, Marlowe D. A new scale of social desirability independent of psychopathology. J Consult Psychol. 1960; 24: 349–354. https://doi.org/10.1037/h0047358 PMID: 13813058

26. Franzen A, Mader S. Do phantom questions measure social desirability? methods, data, analyses. 2019; 13: 37–57.

27. Rudert SC, Janke S. Following the crowd in times of crisis: Descriptive norms and subjective threat predict physical distancing, stockpiling, and prosocial behavior during the COVID-19 pandemic. Group Process Intergr Relat. 2021 (in press). https://doi.org/10.1177/13684302211023562

28. Bollen KA. Structural Equations with Latent Variables. New York: Wiley; 1989.

29. Kline RB. Principles and Practice of Structural Equation Modeling, Fourth Ed. New York: Guilford Press, 1998.

30. Hoyle RH, Editor. Handbook of structural equation modeling. New York: Guilford Press; 2012.

31. StataCorp. Stata Structural Equation Modeling Reference Manual: Release 17. College Station: StataCorp LLC; 2021.

32. Acock AC. Discovering Structural Equation Modeling Using Stata. College Station: Stata Corp LP; 2013.

33. Aichholzer J. Einführung in lineare Strukturgleichungsmodelle mit Stata. Wiesbaden: Springer; 2017.

34. Bentler PM, and Raykov T. On measures of explained variance in nonrecursive structural equation models. J Appl Psychol. 2000; 85: 125–131. https://doi.org/10.1037/0021-9010.85.1.125 PMID: 10740963

35. Satorra A, Bentler PM. Corrections to Test Statistics and Standard Errors in Covariance Structure Analysis. In: von Eye A, Clogg CC, Editors. Latent variables analysis: Applications for developmental research. Thousand Oaks: Sage Publications; 1994. p. 399–419.

36. Finney SJ, DiStefano C. Non-normal and Categorical data in structural equation modeling, in: Hancock GR, Mueller RO, Editors. Structural equation modeling: a second course. Greenwich: Information Age Publishing, 2006. p. 269–314.

37. Bentler PM, Bonett DG. Significance Tests and Goodness of Fit in the Analysis of Covariance Structures. Psychol Bull.1980; 88: 588–606.

38. Yu C-Y. Evaluating Cutoff Criteria of Model Fit Indices for Latent Variable Models with Binary and Continuous Outcomes. Los Angeles: University of California; 2002.

39. Urban D, Mayerl J. Strukturgleichungsmodellierung: Ein Ratgeber für die Praxis. Wiesbaden: Springer VS; 2014.

40. Brüderl J, Ludwig V. Fixed-Effects Panel Regression. In: Best H, Wolf C, Editors. The Sage Handbook of Regression Analysis and Causal Inference. Thousand Oaks: Sage; 2015. p. 327–357.

41. Wooldridge JM. Econometric analysis of cross section and panel data, Second Ed. Cambridge, Mass: MIT Press; 2010.

42. Wright L, Fancourt D. Do predictors of adherence to pandemic guidelines change over time? A panel study of 22,000 adults during the COVID-19 pandemic. Prev Med. 2021; 153: 106713. https://doi.org/10.1016/j.ypmed.2021.106713 PMID: 34242662

S1 Table. List of variables and question wording

Variable	Question	Answers categories
Staying at home	To what extent have you adhered to the appeal to stay at home as much as possible during the last four weeks?	• I did not adhere to it at all • I have rather rarely adhered to it • I have partially adhered to it • I have mostly adhered to it • I strictly adhered to it
Making exceptions	Did you occasionally make exceptions and left the house even if it was not necessary?	• Never • Rarely • Once in a while • Often • Very often
Number of people met	And how many people from your close or extended network of friends and family members have you met in your leisure time during the last week?	*Open numeric*
Individual risk	How dangerous do you think would a Corona infection be for yourself? The value 0 means "not at all dangerous" and the value 10 means "extremely dangerous".	11-poit scale • Lowest: Not at all dangerous • Highest: Extremely dangerous
Social risk	How dangerous do you think the Corona epidemic is for the health of the Swiss population? The value 0 means "not at all dangerous" and the value 10 means "extremely dangerous".	11-poit scale • Lowest: Not at all dangerous • Highest: Extremely dangerous
Household risk	In the past 4 weeks, did you live with persons in the household who belong to the risk group?	• Yes • No
Pro-Social: Donation	As a thank you for participation in our study, you will receive 10 Swiss francs. You can donate part of the 10 CHF. If you donate, the rest (10 minus the donation) will be transferred to your University credit card. Would you like to donate?	• Yes, I will donate part of my 10 francs. • No, I do not donate.
Descriptive norm: Staying at home of acquaintances	And what do you think: To what extent have your acquaintances and friends adhered to the recommendation to stay at home as much as possible during the last four weeks?	• They have never adhered to it • They have mostly not adhered to it • They have partially adhered to it and partially not • They have mostly adhered to it • They have always adhered to it

Trust in politics	One can have varying degrees of trust in the institutions of a society. On a scale from 0 (no trust at all) to 10 (very much trust), how much trust do you place into the following institutions? • Politics	11-poit scale • Lowest: No trust at all • Highest: Very much trust
Different coronavirus measures	To what extent do you support the following measures to curb the Corona epidemic in the second lockdown? • Maintain distance of two meters from other people • Wear protective mask • Regular hand washing • Closure of schools • Closure of universities • Closure of restaurants and bars • Closure of non-food stores • Closure of recreational facilities (e.g. sports club, cinema, museum) • Prohibition of meetings with more than 5 people • Reduction of the public transport offer • Entry restrictions	• I do not support it at all • I rather do not support it • I partially agree with it • I rather support it • I support it very much

S2 Table. Descriptive Information of variables of wave two (2021)

Variable	Obs	Min	Max	Mean	SD	Answer categories
Staying at home	364	1	5	3.5	0.997	1 = not at all *to* 5 = very strictly
Making exceptions	364	1	5	3.0	0.97	1 = very often *to* 5 = never
Number of people met	364	0	47	6.78	5.31	Open numeric
Individual risk	364	0	10	3.24	2.22	0 = not at all dangerous *to* 10 = extremely dangerous
Social risk	364	0	10	5.67	1.94	0 = not at all dangerous *to* 10 = extremely dangerous
Household risk	364	0	1	0.28		0 = no high-risk person in household, 1 = living with high-risk person
Sex	364	0	1	0.64		0 = male, 1 = female
Age	364	19	36	24.22	3.11	Open numeric birthday
Pro-Social: Donation	364	0	1	0.52		0 = no donation, 1 = donation
Descriptive norm: Staying at home of acquaintances	364	1	5	3.12	0.77	1 = not at all *to* 5 = very strictly
Trust in politics	364	0	9	5.25	1.99	0 = no trust at all *to* 10 = very much trust
Social desirability	364	0	10	6.18	1.91	0 = no social desirability *to* 10 = high social desirability
M1 Maintenance of social distance	364	1	5	4.38	0.8	1 = agree not at all *to* 5 = agree very much
M2 Wearing of masks	364	1	5	4.42	0.92	1 = agree not at all *to* 5 = agree very much
M3 Thorough handwashing	364	2	5	4.81	0.5	1 = agree not at all *to* 5 = agree very much
M4 Closure of schools	364	1	5	2.47	1.16	1 = agree not at all *to* 5 = agree very much
M5 Closure of universities	364	1	5	3.4	1.23	1 = agree not at all *to* 5 = agree very much
M6 Closure of restaurants/ bars	364	1	5	3.13	1.27	1 = agree not at all *to* 5 = agree very much
M7 Closure of non-food shops	364	1	5	3.04	1.23	1 = agree not at all *to* 5 = agree very much
M8 Closure of recreational facilities	364	1	5	2.96	1.23	1 = agree not at all *to* 5 = agree very much
M10 Meetings of only 5 or fewer	364	1	5	4.15	1.25	1 = agree not at all *to* 5 = agree very much
M11 Restrictions to public transport	364	1	5	2.58	1.26	1 = agree not at all *to* 5 = agree very much
M12 Border restrictions	364	1	5	3.59	1.3	1 = agree not at all *to* 5 = agree very much

Obs = number of observations, min = minimum, max = maximum, SD = standard deviation

S3 Table. List of index variables for the first wave (2020), and the second wave (2021).

Variable	Obs	Min	Max	Mean	SD	Description
Index Compliance with social distancing measures 2021	364	0.61	11.87	6.54	2.13	Additive index containing 2 distancing measures (each on a 5-point Likert scale, ranging from 0 to 4), and the reversed logarithm of the number of people met. Higher values indicate more compliance.
Index Compliance with social distancing measures 2020	364	1.21	11.04	7.01	1.57	Additive index containing 2 distancing measures (each on a 5-point Likert scale, ranging from 0 to 4), and the reversed logarithm of the number of people met. Higher values indicate more compliance.
Index Support for Covid-19 measures 2021	364	8	40	27.03	6.43	Additive index containing 8 preventive measures (each on a 5-point Likert scale, ranging from 1 to 5). Higher values indicate stronger support.
Index Support for Covid-19 measures 2020	364	8	40	32.01	5.14	Additive index containing 8 preventive measures (each on a 5-point Likert scale, ranging from 1 to 5). Higher values indicate stronger support.

Obs = number of observations, min = minimum, max = maximum, SD = standard deviation

3 Wie wirkt sich Home-Office auf die Mobiltät aus?

Im dritten Kapitel der Arbeit werden die Untersuchungen zum Mobilitätsverhalten präsentiert. Zuerst werden die beiden Studien, die im Rahmen des SNF-Forschungsprojektes (188866) entstanden sind, zusammengefasst. Im Anschluss daran werden die beiden veröffentlichten Publikationen zu den Auswirkungen von flexiblen Arbeitsformen auf die Verkehrsnachfrage (Wöhner 2022) und auf die Nutzung aktiver Fortbewegungsmethoden (Wöhner 2023) abgedruckt.

3.1 Zusammenfassung

Aufgrund des steigenden Strassenverkehrsaufkommens, das den Klimaschutzzielen entgegensteht und die Verkehrsinfrastruktur an ihre Grenzen bringt, wird das Potenzial der Digitalisierung des Arbeitsmarkes für Verkehrsreduktionen in der Schweiz eingeschätzt (Wöhner 2022). Im Fokus stehen hierbei die beiden flexiblen Arbeitsformen Telearbeit (Home-Office) und Gleitzeit, welche durch die Digitalisierung vermehrt im Arbeitsumfeld eingesetzt werden können (Meissner et al. 2016). Es herrscht weitestgehend Einigkeit darüber, dass flexible Arbeitsformen zu weniger Pendeln führen und den Verkehr besser über den Tag verteilen können (z.B. Andreev et al. 2009, Elldér 2020, He 2013, Hook et al. 2020). Dies ist insofern interessant, weil Home-Office auch mit der Arbeit am Arbeitsplatz an einem Arbeitstag kombiniert werden kann, was das Pendeln dann aber nicht ersetzen würde. Frühe Studien waren optimistisch, dass sich durch weniger Pendelfahrten die gesamte Verkehrsnachfrage verringert. Seit längerer Zeit wird bezüglich des Energieverbrauchs der sogenannte Reboundeffekt diskutiert, demzufolge durch erhöhte Effizienz gewonnene Einsparungen durch ein verstärktes Nachfrageverhalten vermindert oder neutralisiert werden können (z.B. Sorrell 2007). Ein Beispiel hierfür ist, wenn aufgrund von effizienteren Benzinmotoren mehr Auto gefahren wird oder grössere Modelle angeschafft werden (Sorrell 2007). Auch hinsichtlich des Einflusses von Telearbeit auf die Verkehrsnachfrage findet der Reboundeffekt heutzutage Beachtung. Es ist denkbar, dass Telearbeit auch Verkehr induzierenden kann. Zum Beispiel könnten Personen wegen der Möglichkeit, teilweise im Home-Office zu arbeiten, Jobs annehmen, die weiter vom Wohnort entfernt sind oder wegen der gesparten Pendelzeit zusätzliche Fahrten aus anderen Gründen unternehmen (z.B. Hook et al. 2020). Im Hinblick auf den Reboundeffekt bei Home-Office-Arbeit auf die Verkehrsnachfrage besteht in der Literatur kein eindeutiger Konsens (z.B. Hook et al. 2020). Während einige Studien zu dem Ergebnis kommen, dass Telearbeit den Verkehr reduziert, kommen jedoch die meisten neueren gross-angelegten Untersuchungen zu dem Schluss, dass Telearbeit

keinen Einfluss auf das Gesamtverkehrsaufkommen hat oder sogar zu mehr Verkehr führt.

Für die Schweiz gibt es zu dem Thema nur begrenzte Erkenntnisse, da der Grossteil der Forschung auf Pilotprojekten basiert. Viele vorherige Studien weisen zudem verschiedene Schwächen auf. So basieren manche von ihnen auf Annahmen und Hochrechnungen, verwenden nur ungenaue Messungen wie Luftlinien oder schätzen die zurückgelegten Distanzen nur mit Hilfe von Zeitangaben. Andere Untersuchungen sind auf Metropolregionen begrenzt oder betrachten nur einen Teil der erwerbstätigen Bevölkerung wie beispielsweise Büroangestellte. Einige Studien berücksichtigen nur die Distanz zwischen Wohn- und Arbeitsort anstelle der tatsächlichen Anzahl an zurückgelegten Kilometern oder beschränken sich ausschliesslich auf das Pendeln und lassen andere Verkehrszwecke aussen vor. Demgegenüber werden in dieser Dissertation Daten von einer landesweiten Stichprobe verwendet, die alle Erwerbstätigen berücksichtigt und sich nicht auf eine Berufsgruppe beschränkt. Zudem wurden sämtliche zurückgelegte Wegstrecken einer Person an einem Stichtag präzise mittels Georouting erfasst. Mit dieser Dissertation soll die Forschungslücke für die Schweiz mithilfe einer empirischen Analyse auf Basis von verhaltensbasierten Individualdaten geschlossen werden und eine Einschätzung über den Reboundeffekt von Telearbeit auf den Verkehr geliefert werden.

Die Studie beruht auf einer selbst durchgeführten Sekundärdatenanalyse des Mikrozensus Mobilität und Verkehr (MZMV) von 2015 (Bundesamt für Statistik und Bundesamt für Raumentwicklung ARE 2017). Dabei handelt es sich um eine schweizweite Verkehrsstudie auf Basis einer Zufallsstichprobe, welche rund alle 5 Jahre vom Bundesamt für Statistik und dem Amt für Raumentwicklung ARE durchgeführt wird. Der Erhebungszeitraum umfasst ein ganzes Jahr (14 Monate), wobei jeder befragten Person ein zufällig ausgewählter Stichtag zugewiesen wird. Es wird das gesamte Mobilitätsverhalten an diesem Stichtag dokumentiert und die Charakteristiken der zurückgelegten Wege (Distanz, Dauer, Verkehrsmittel und Grund) erfasst. Darüber hinaus enthält der MZMV sozio-ökonomische Variablen über die Befragten und Informationen über den Haushalt, in dem sie leben. Zusätzlich werden arbeitsbezogene Aspekte wie Home-Office-Arbeit und die Organisation der Arbeitszeit erfragt (Gleitzeit). Damit stellt der MZMV eine optimale Datenquelle dar, um den Zusammenhang zwischen flexiblen Arbeitsformen und dem Mobilitätsverhalten zu untersuchen. Alle Ergebnisse basieren auf rund 6700 erwerbstätigen Personen zwischen 18 und 65 Jahren.

Auf Basis des MZMV 2015 zeigt sich, dass die Mehrheit der Schweizer Erwerbstätigen nicht von zu Hause aus arbeiten kann oder diese Option nicht nutzen möchte (71%). Rund 26% der Befragten kombinieren die Arbeit am Arbeitsplatz mit Home-

Office-Arbeit im Laufe einer Arbeitswoche (in der Publikation "hybrid work‘“ und „part-time telework“ genannt). Weniger als 3% der Erwerbstätigen arbeiten ausschließlich von zu Hause aus. Für die Beurteilung von Veränderungen in der Verkehrsnachfrage ist vor allem die Gruppe derjenigen relevant, die teilweise im Home-Office arbeiten; denn es ist dieses Arbeitskonzept, das sich durch die Digitalisierung weiterverbreitet. Der MZMV beinhaltet allerdings nur eine generelle Messung der Home-Office-Nutzung und fragt nicht, ob am beobachteten Stichtag im Home-Office, am Arbeitsplatz oder an beiden Orten gearbeitet wurde. Deswegen werden mithilfe statistischer Regressionsmodelle Gruppenvergleiche zwischen den „part-time“ Home-Office-Arbeitenden und denjenigen, die immer am Arbeitsplatz sind, durchgeführt. Die zeitliche Flexibilität (hier Gleitzeit genannt) ist in der Schweiz relativ weit verbreitet, denn insgesamt knapp 60% der Erwerbstätigen können teilweise (bei Kernarbeitszeit) bis vollständig über ihre Arbeitszeiten entscheiden. Home-Office und Gleitzeit werden simultan in die Regressionsmodelle zur Verkehrsnachfrage integriert, um die räumliche Flexibilität des Home-Office von der zeitlichen Komponente analytisch trennen zu können (Allen et al. 2015), was in der vorherigen Forschung kaum berücksichtigt wurde. Das Mobilitätsverhalten der einzelnen Personen besteht aus drei Komponenten. Erstens wird die zurückgelegte Distanz aller gependelten Wege vom und zum Arbeitsplatz („commute“) berechnet. Zweitens wird die Distanz von allen anderen absolvierten Strecken ausser dem Pendeln (nicht-berufsbezogene Mobilität bzw. „non-work travel“) ermittelt, um den Reboundeffekt zu untersuchen. Drittens wird Gesamtdistanz aller Wege am Stichtag („total travel“) aus der Summe aller zurückgelegten Wege für Pendeln und die nicht-berufsbezogene Mobilität berechnet. Mit letzterem kann dann eingeschätzt werden, ob sich die Verkehrsnachfrage insgesamt verringert, gleichbleibt oder erhöht. Dieses Vorgehen kann auf anschauliche Art und Weise die verschiedenen Effekte vom flexiblen Arbeiten auf die Mobilität aufzeigen und kommt dabei ohne weitere Annahmen aus. Zunächst wird das Mobilitätsverhalten mit den Personenkilometern (PKT) gemessen, welche jeweils die Summe der Distanzen von allen Wegen mit sämtlichen Verkehrsmitteln (Auto, öffentlicher Transport, Fahrrad und zu Fuss) enthält. Da im Hinblick auf den Klimawandel vor allem der stark-emittierende Autoverkehr problematisch ist, werden zusätzlich die Fahrzeugkilometer (VKT) in separaten Analysen berücksichtigt. Die Fahrzeugkilometer summieren alle Distanzen auf, die ausschliesslich mit dem eignen Auto oder Motorrad zurückgelegt wurden.

Im Durchschnitt legen die Erwerbstätigen pro Tag 45,6 km Personenkilometer zurück. Diese bestehen hauptsächlich aus Wegen für nicht-berufsbezogene Mobilität (30,6 km), denn im Durchschnitt entfallen nur 15 km auf das Pendeln. Dies verdeutlicht, wie wichtig es ist, bei der Erforschung des Mobilitätsverhaltens auch die nicht-berufsbezogenen Wege zu berücksichtigen. Die multivariaten OLS-Regressionsmodelle

zeigen, dass Personen, die teilweise im Home-Office arbeiten durchschnittlich etwa 21% weniger Kilometer pendeln als Personen, die täglich den Arbeitsplatz aufsuchen. Dies deutet darauf hin, dass zumindest ein Teil der Telearbeitenden komplette Arbeitstage im Home-Office absolviert. Für zukünftige Studien zur Verkehrsnachfrage wäre es hilfreich zu wissen, in welchem Ausmass Home-Office für ganze Arbeitstage genutzt wird und wie oft Arbeit zu Hause mit der Arbeit am Arbeitsplatz an einem Tag kombiniert werden. In jedem Fall – und das ist die wichtigste Erkenntnis dieser Untersuchung – zeigt sich für die Telearbeit ein Reboundeffekt bei der nichtberufsbezogenen Mobilität. Dieser ist so gross, dass insgesamt kein reduzierender Effekt der Telearbeit auf die Verkehrsnachfrage identifiziert werden kann. Im Durchschnitt gibt es keinen statistisch signifikanten Unterschied in der Gesamtmobilität zwischen Personen, die teilweise das Home-Office nutzen und denjenigen, die ausschliesslich am Arbeitsplatz arbeiten. Dieses Ergebnis gilt sowohl für die Mobilität mit allen Verkehrsmitteln (Personenkilometer) als auch für die privaten Autofahrten (Fahrzeugkilometer).

Eine Ausnahme bilden Personen, die ausschliesslichen von zu Hause arbeiten („full-time telework“). Sie legen im Durchschnitt insgesamt geringere Distanzen zurück als Personen, die ausschliesslich am Arbeitsort arbeiten. Möglicherweise hat diese spezielle Gruppe ihren Alltag eher in Nähe des Wohnortes organsiert. Diese Gruppe ist zum einen relativ klein und profitiert zum anderen weniger von der zunehmenden Digitalisierung des Arbeitsmarktes – da sie bereits vollständig von zu Hause arbeitet. Dieser Befund ist vor allem aus methodischer Sicht wichtig und veranschaulicht, dass diese Gruppe explizit in der statistischen Modellierung zu berücksichtigen ist, um nicht falsche (zu optimistische) Schlussfolgerungen über den Einfluss der Arbeitsmarktflexibilisierung auf die Verkehrsnachfrage zu ziehen.

Möglicherweise können die flexiblen Arbeitsformen wenigstens einen Beitrag zur Abmilderung der Verkehrsspitzen auf den Strassen leisten. Aufgrund der erhöhten Flexibilität, die Gleitzeit und Home-Office mit sich bringen, könnte der Arbeitsweg auf Zeiten ausserhalb der Rushhour gelegt werden. Zwei separate logistische Regressionsmodelle über Pendelfahrten mit dem Auto während der Morgen- beziehungsweise der Abendverkehrsspitze zeigen, dass Home-Office-Arbeitende am Abend seltener mit dem Auto unterwegs sind. Dies könnte ein Indiz dafür sein, dass einige von ihnen die Nachmittage lieber im Home-Office verbringen. Eine solche Kombination von Telearbeit und dem Arbeitsplatzbesuch am selben Tag würde dann wiederum die Verkehrsnachfrage nicht reduzieren, aber eventuell die Rushhour abflachen. Im Gegensatz dazu zeigen die Resultate für die Morgenverkehrsspitze, dass Gleitzeitarbeitende sogar wahrscheinlicher zur Hauptverkehrszeit auf den Strassen zur Arbeit fahren. Möglicherweise haben sie aufgrund der Gleitzeit weniger Zeitdruck und ent-

scheiden sich deswegen zur selben Zeit wie ihre Familienmitglieder oder Kolleginnen und Kollegen zur Arbeit zu gehen. Allen in allem kann diese Untersuchung also kein Potenzial für Verkehrsreduktionen durch flexibles Arbeiten feststellen.

Die erste Studie hat insbesondere den umweltschädlichen Autoverkehr fokussiert. Ein anderer wichtiger Aspekt der täglichen Mobilität ist die aktive Fortbewegung. Wie zu Beginn der Dissertation erörtert wurde, sind Bewegungsmangel und die damit einhergehenden nicht-übertragbaren Krankheiten wie Herzkreislaufprobleme oder Übergewicht eine gesellschaftliche Herausforderung. Obwohl in der ersten Mobilitätsstudie keine Reduktion der Verkehrsnachfrage durch die flexiblen Arbeitsformen festgestellt werden konnte, könnten Telearbeit und Gleitzeit immerhin andere positive Effekte auf das Mobilitätsverhalten mit sich bringen. Ein solcher Anwendungsfall wären Vorteile für die öffentliche Gesundheit, wenn flexible Arbeitsformen mit mehr aktiver Fortbewegung – in diesem Fall Mobilität zu Fuss oder mit dem Fahrrad – verbunden sind. Frühere Forschungsergebnisse deuten darauf hin, dass Arbeitende im Home-Office ihre alltäglichen Erledigungen, wie beispielsweise Einkäufe, eher in der Nähe des Wohnortes erledigen (z.B. Saxena und Mokhtarian 1997). Es wird argumentiert, dass diese kürzeren Entfernungen dann auch leichter zu Fuss oder mit dem Fahrrad zurückgelegt werden können (Mokhtarian 1991). Wie die erste Verkehrsstudie dieser Dissertation gezeigt hat, gibt es einen Reboundeffekt bei dem die gesparte Zeit durch weniger Pendeln in andere Mobilitätszwecke reinvestiert wird. Der Reboundeffekt trat sowohl bei den Fahrzeugkilometern als auch bei den gesamten Personenkilometern auf. Folglich könnte sich der Reboundeffekt durch die Telearbeit nicht nur in weiteren Autofahrten manifestieren, sondern auch mit aktiven Fortbewegungsmitteln stattfinden. Weil durch die wegfallende Pendelstrecke Zeit gespart wird, könne diese dann auch in langsamere Fortbewegungsmethoden investiert werden (Elldér 2022). Im Hinblick auf die Telearbeit sind ausserdem frühere Untersuchungen relevant, die argumentieren, dass ein gewisses Grundmobilitätsbedürfnis bestehen kann und Mobilität teilweise um ihrer selbst willen praktiziert wird, zum Beispiel um draussen zu sein und die Natur zu geniessen (z.B. Mokhtarian und Salomon 2001). Alles zusammen genommen ist es denkbar, dass die Home-Office-Arbeit einen Beitrag zu mehr aktiver Fortbewegung leisten kann.

Bisher gibt es jedoch nur relativ wenige empirische Studien auf Individualebene zu diesem Thema (Elldér 2022), sodass diese Dissertation einen Beitrag zum kumulativen Verständnis leistet. Die wenigen Studien stellen fast durchgängig einen positiven Zusammenhang zwischen Telearbeit und aktivem Verkehrsverhalten fest. Dabei fällt jedoch auf, dass sich diese Studien meist nur auf die räumliche Flexibilität (Telearbeit) beziehen und die zeitliche Flexibilität (Gleitzeit) nicht berücksichtigen. Das ist bemerkenswert, denn oft wird argumentiert, dass Home-Office-Arbeit die durch die

Erwerbsarbeit vorgegebene Tagesstruktur insgesamt lockert. Es könnte zwar sein, dass die Telearbeit nicht nur räumlich, sondern auch zeitlich zu mehr Flexibilität führt, aber zwingend ist dies nicht. Wie zuvor bereits gesagt, sind es zwei verschiedene Aspekte und wenn diese nicht voneinander isoliert werden, ist nicht klar, ob beobachtete Ergebnisse auf die örtliche oder zeitliche Flexibilität zurückzuführen sind (Allen et al. 2015). Im Rahmen dieser Studie wird argumentiert, dass Gleitzeit, also die Möglichkeit teilweise oder vollständig über Start und Ende der eigenen Arbeitszeit zu bestimmen, die zeitliche Tagesstruktur flexibilisiert. Das könnte zum einen die Nutzung langsamerer Verkehrsmittel auf dem Arbeitsweg erleichtern. Zum anderen könnte Gleitzeit auch zusätzliche Gelegenheiten für die aktive Fortbewegung, zum Beispiel in Form von Spaziergängen in den Arbeitspausen sowie vor oder nach der Arbeit schaffen. Die bestehende Forschungslücke wird geschlossen, indem vier verschiedene Arten der Arbeitszeitflexibilität in die Analysen einbezogen werden: fest vorgegebene Arbeitszeit, Kernarbeitszeit, feste Anzahl an Arbeitsstunden pro Woche oder Monat und komplett flexible Arbeitszeit. Des Weiteren fällt auf, dass die vorherigen Studien zwei relevante Störvariablen weitestgehend vernachlässigt haben, die simultan sowohl die Telearbeit als auch das aktive Mobilitätsverhalten beeinflussen könnten. Die beiden Aspekte sind der Body-Mass-Index sowie die Wetterbedingungen. Gerade letzteres ist für Studien relevant, welche das Mobilitätsverhalten einer Person für einen einzigen Stichtag erfassen. An diesem Tag könnte dann beispielsweise schlechtes Wetter der Grund für Arbeit im Home-Office und den Verzicht auf aktive Fortbewegung sein. Zusammenfassend ist das Ziel dieser Studie, den Einfluss von Telearbeit und Gleitzeit auf das aktive Mobilitätsverhalten zu untersuchen und mögliche Vorteile für die öffentliche Gesundheit zu identifizieren.

Die Analysen wurden ebenfalls mit dem Mikrozensus Mobilität und Verkehr 2015 durchgeführt und beziehen sich auf die gleiche erwerbstätige Population zwischen 18 und 65 Jahren. Die Ergebnisse beruhen auf den Daten von mehr als 6700 Personen. Anders als bei der ersten Studie ist für die gesundheitlichen Vorteile weniger die zurückgelegte Distanz, sondern vielmehr die Dauer der aktiven Fortbewegung von Bedeutung. Für die Untersuchung wird die aktive Fortbewegung zu Fuss, mit dem Fahrrad und insgesamt (zu Fuss und mit dem Fahrrad) jeweils getrennt analysiert. Zunächst zeigen die Daten, dass sich durchschnittlich knapp 60% der Schweizer Erwerbstätigen an einem Tag aktiv fortbewegen. Im Durchschnitt verbringen sie rund 31 Minuten pro Tag mit aktiver Mobilität, wobei davon 25 Minuten zu Fuss zurückgelegt werden. Verschiedene multivariate logistische und OLS-Regressionsmodelle zeigen, anders als die vorherigen Studien, keinen statistischen Zusammenhang zwischen der Telearbeit und der aktiven Mobilität. Allerdings lässt sich feststellen, dass Gleitzeit – genauer gesagt die Kernarbeitszeit – mit mehr und längerer aktiver Mobilität korreliert. Dieser Befund lässt sich im Wesentlichen auf häufigeres und

längeres Laufen von Personen mit Kernarbeitszeit zurückführen. Diese Erkenntnis verdeutlicht die Bedeutung davon, die zeitliche und räumliche Flexibilität statistisch voneinander zu isolieren. Möglicherweise sind einige frühere positive Effekte der Telearbeit auf die aktive Mobilität zumindest teilweise von einer erhöhten zeitlichen Freiheit getrieben. Darüber hinaus veranschaulicht das Ergebnis, dass eine getrennte Analyse von Laufen und Radfahren sinnvoll ist, weil sie zu unterschiedlichen Schlussfolgerungen führen. Überraschend ist allerdings, dass ausschliesslich die Kernarbeitszeit mit der aktiven Mobilität zusammenhängt und nicht die beiden anderen noch flexiblen Arten der Gleitzeit. Auch wenn in den Modellen für vielfältige Job-Charakteristiken kontrolliert wurde, könnten die besonders zeitlich ungebundenen Jobs unberücksichtigte Eigenschaften haben – dieser Aspekt müsste in zukünftiger Forschung näher untersucht werden. Darüber hinaus lässt sich feststellen, dass der Body-Mass-Index und das Wetter zwei relevante Kontrollvariablen sind, die als mögliche Störfaktoren in der weiteren Forschung berücksichtigt werden sollten. Die Studie zeigt, dass der Body-Mass-Index negativ mit der aktiven Fortbewegung assoziiert ist, wohingegen gute Wetterbedingungen zu einer verstärkten Nutzung aktiver Fortbewegungsmethoden führen.

Um mögliche positive Auswirkungen auf die öffentliche Gesundheit zu bewerten, wird analysiert, ob flexibel-arbeitende Personen eher 30 Minuten und mehr pro Tag mit aktiven Fortbewegungsmethoden unterwegs sind. Dieser Schwellenwert basiert auf der WHO-Empfehlung für ein gesundes Maß an körperlicher Aktivität von mindestens 150 Minuten pro Woche (WHO 2010). Bei einer 5-tägigen Arbeitswoche von Vollzeiterwerbstätigen ergeben sich durchschnittlich 30 Minuten körperliche Aktivität pro Tag. Die Idee hinter diese Analyse ist, zu prüfen, ob bereits mit aktiver Mobilität (also ohne extra Trainingseinheiten) der WHO-Empfehlung für körperliche Aktivität nachgekommen werden kann. Etwa ein Drittel der Schweizer Erwerbstätigen erreicht diesen Schwellenwert. Darüber hinaus zeigen die logistischen Regressionsmodelle Modelle einen positiven Zusammenhang von Telearbeit und Gleitzeit (insbesondere der Kernarbeitszeit) mit dem Erreichen von mehr als 30 Minuten aktiver Bewegung am Tag. Insgesamt unterstreichen die Befunde der Studie wie wichtig es ist, die zeitliche Flexibilität in zukünftige Forschung zum aktiven Mobilitätsverhalten zu integrieren.

Wie wirken sich Home-Office und Gleitzeitarbeit zusammenfassend auf das Mobilitätsverhalten aus? Die Ergebnisse zeigen, dass die flexiblen Arbeitsformen – und insbesondere das viel beachtete Home-Office – bisher nicht mit einer Reduktion des motorisierten Individualverkehrs verbunden sind. Ein Nutzen für die Umwelt in Form von weniger Treibhausgasemissionen ist diesbezüglich folglich (noch) nicht gegeben. Für die Volkswirtschaft ergeben sich allenfalls schwache Vorteile in Form

von geringeren Staukosten, denn die Home-Office-Arbeitenden pendeln während der Abendverkehrsspitze seltener mit dem Auto. Nichtsdestotrotz könnten Telearbeit und Gleitzeit dazu beitragen, die Gesundheitskosten zu senken. Zum einen ist das Kernarbeitszeitmodell mit häufigeren und längeren Fusswegen verbunden. Zum anderen könnten Telearbeit und Gleitzeit helfen, ein gesundheitsförderliches Mass an Bewegung in den Arbeitsalltag zu integrieren. Es gilt allerdings zu bedenken, dass die Befunde der beiden Studien auf Querschnittsdaten basieren und deswegen nicht kausal interpretiert werden können. Trotz der vielfältigen Kontrollvariablen, die berücksichtigt wurden, könnten Selektionseffekte vorhanden sein. Dennoch bieten die theoretischen Überlegungen im Zusammenhang mit den gewonnenen empirischen Erkenntnissen eine informative Ausgangslage für weitere Forschung, Verkehrsprognosen und politische Massnahmen.

3.2 Artikel 3: Work flexibly, travel less? The impact of telework and flextime on mobility behavior in Switzerland

Die dritte veröffentlichte Forschungsarbeit im Rahmen dieser Dissertation befindet sich auf den Seiten 62 – 74.

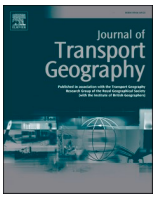
Zitation: Wöhner, Fabienne, 2022. Work flexibly, travel less? The impact of telework and flextime on mobility behavior in Switzerland. *Journal of Transport Geography* 102, 103390.
DOI: https://doi.org/10.1016/j.jtrangeo.2022.103390

Journal of Transport Geography 102 (2022) 103390

Contents lists available at ScienceDirect

Journal of Transport Geography

journal homepage: www.elsevier.com/locate/jtrangeo



Work flexibly, travel less? The impact of telework and flextime on mobility behavior in Switzerland

Fabienne Wöhner

Institute of Sociology, University of Bern, Fabrikstrasse 8, 3012 Bern, Switzerland

ARTICLE INFO

Keywords:
Telework
Flextime
Travel behavior
Rebound effect
Peak period
Switzerland

ABSTRACT

There is an ongoing discussion about the impact of flexible forms of work on travel behavior. Though it is generally accepted that telework decreases distance commuted, there are mixed conclusions about the notion that non-work-related journeys could be offsetting any saved commute. This paper investigates the influence of two flexible working arrangements – namely telework and flextime – on commutes, non-work traffic, and peak-period travel in Switzerland. Using the 2015 Swiss Mobility and Transport Microcensus (MTMC), this study analyzes flexible working arrangements with respect to their effects on traffic. The results show that people who work partly from home – compared to those who never telework – do indeed commute less; however, their non-work travel increases. This rebound effect completely offsets the saved commutes, resulting in a zero impact on the total distances covered. Only people who work exclusively remotely show less total mobility compared to those who never telework. However, only a small minority of people work only from home, with most teleworkers combining working on-site with some degree of working from home. Moreover, this study finds only slight potential for relieving traffic congestion through flexible working arrangements: Whereas teleworkers are less likely to commute during evening peak periods, people working flextime are even more likely to commute during morning rush hours. Hence, the distinction between morning and evening peak periods should be taken into account in future studies. Furthermore, research on flexible working arrangements and travel behavior benefits from the consideration of both non-work travel and total travel as well as the separation of part-time from full-time telework.

1. Introduction

In accordance with the Paris Agreement (United Nations Framework Convention on Climate Change UNFCCC, 2015) Switzerland adopted its long-term climate strategy at the beginning of 2021 (Swiss Federal Council, 2021): Greenhouse gas emissions should be halved by 2030, and by 2050, Switzerland is aiming to reach net zero greenhouse gas emissions. Currently, the transport sector (without air transport) is responsible for almost a third of Switzerland's greenhouse gas emissions (Swiss Federal Office for the Environment FOEN, 2021). Hence, it is advisable to reduce the volume of traffic and congestion. However, traffic in general and motorized private transport (MPT) in particular is increasing and this is expected to continue, mainly due to population and economic growth (Swiss Federal Office for Spatial Development ARE, 2016). Regarding MPT, regular traffic jams and congestion have been an issue in Switzerland for the last 20 years and are projected to continue to increase throughout the coming decades Swiss Federal Department of the Environment, Transport, Energy and Communications DETEC and Swiss Federal Roads Office FEDRO, 2018). In 2019, there were about 30,000 traffic jam hours, of which 89% were tracked back to a capacity overload (Swiss Federal Roads Office FEDRO, 2020). As data from 2015 shows, this entails costs for additional time as well as environmental, climate, energy, and accident costs due to traffic jams to the tune of 1888 million CHF (about 2060 million USD) (Keller, 2019).

Road capacity overload is particularly noticeable during rush hour, from 7 a.m. to about 9 a.m. and from 5 p.m. to 7 p.m. Not only are many commuters affected by this congestion, but they are also part of the problem (Swiss Federal Roads Office FEDRO, 2020; Swiss Federal Statistical Office, 2021). In Switzerland, 4 out of 5 labor market participants are commuters, totaling about 3.6 million people, of which 51% commute by car (Swiss Federal Statistical Office, 2021). Therefore, changes in commuting behavior are an important factor in fighting traffic-related greenhouse gas emissions.

The ongoing digitalization and the proceeding development of internet-based information and communication technologies (ICTs) also

E-mail address: fabienne.woehner@unibe.ch.

https://doi.org/10.1016/j.jtrangeo.2022.103390
Received 21 December 2021; Received in revised form 1 April 2022; Accepted 17 June 2022
Available online 25 June 2022

changes the Swiss labor market (e.g. Meissner et al., 2016). The spread of ICTs is making gainful employment more flexible via the increasing use of e-mails, online conferences or VPNs, for instance. Correspondingly, temporal flexibility in the form of flextime and spatial flexibility in terms of working remotely are also present on the Swiss labor market. Additionally, the COVID-19 pandemic has strongly promoted telework in Switzerland via Federal Council-imposed obligations that people work from home whenever possible. The amount of home-working increased due to this rule, suggesting that there is still untapped potential in offering flexible working arrangements more widely. This development could have a positive impact on traffic in two ways: First, the spread of ICTs could eliminate commuting to the workplace on a regular basis, which could reduce traffic overall. Second, the transport infrastructure reaches its limits predominantly during the morning and evening rush hours, while its capacities are less utilized during the rest of the day. Hence, it could be that a more even temporal distribution – promoted through flextime – could reduce the necessity for expanding national road infrastructures. Accordingly, the research question of this study is whether the digitalization of the labor market contributes to reductions in traffic and a better use of transport infrastructure. In particular, this study focuses on the effect of telework and flextime on commuting and travel behavior.

Previous research on this topic is inconclusive (e.g. Hook et al., 2020). While it is widely agreed that flexible working arrangementds distribute traffic more evenly and reduce commuting (e.g. Andreev et al., 2010; Asgari and Jin, 2018; Elldér, 2020; Haddad et al., 2009; He, 2013; Hook et al., 2020; Kim, 2017; Lachapelle et al., 2018), their impact on the total distances traveled is less clear. This is mainly because some studies find evidence for travel reduction through telework (e.g. Elldér, 2020; Mokhtarian et al., 2004) while others do not or even observe increasing impacts (e.g. de Vos et al., 2018; Chakrabarti, 2018; Kim, 2017; Zhu and Mason, 2014; Ravalet and Rérat, 2019). Moreover, studies often have some of the following weaknesses. For example, they are spatially limited to certain metropolitan areas (e.g. Asgari and Jin, 2018; Hu and He, 2016; Kim, 2017; Mokhtarian et al., 2004) or restricted to a specific part of the working population such as white collar workers (e.g. Kim et al., 2015). Some other studies only analyze the commuting time as a proxy for the distance covered (e.g. de Vos et al., 2018; Lachapelle et al., 2018). Yet others are based on imprecise distance measures such as Euclidian distances (e.g. Kim, 2017) or they only use categorical indicators for high and low amounts of travel (e.g. Chakrabarti, 2018). Some studies analyze one-way distances that do not capture the total traffic volume (Hu and He, 2016; Zhu, 2013) or analyze the commute only, and leave non-work travel out of consideration (e.g. Mokhtarian et al., 2004). Finally, some conclusions rely on specific assumptions about travel behavior and frequencies (e.g. Ravalet and Rérat, 2019). In comparison, this study aims to provide a detailed assessment of possible rebound effects and the potential to reduce and redistribute traffic through flexible working arrangements. For this purpose, a nation-wide sample with precisely measured trips is used to analyze the impact of telework and flextime on commutes, non-work travel, total distances covered and rush hour drives from a behavioral perspective.

Switzerland is an interesting and appropriate case to investigate the research question and adds to the literature for two reasons: First, the infrastructure is well developed. This is true for the ICT infrastructure as well as for the public transport system, which provides a viable alternative to motorized private transport in Switzerland. Second, the biggest economic sector in Switzerland is the tertiary sector (mainly consisting of services) (Swiss Federal Statistical Office, 2020), which is generally suitable for ICT usage, and hence, offers a good prerequisite for flexible working arrangements. The potential positive impact of ICTs and flexible working on the environment and the economy is highly anticipated in official reports (e.g. Swiss Federal Roads Office FEDRO, 2019) and forms the basis for various pilot projects and studies in Switzerland (Ecoplan, 2015; Perch-Nielsen et al., 2014; Weichbrodt et al., 2013). However, nationwide research on this topic using a completely behavioral approach is scarce.

The research question is addressed by using the Swiss Mobility and Transport Microcensus (MTMC) of 2015 – a nationwide representative micro-data trend survey on mobility behavior (Swiss FSO - Federal Statistical Office and Swiss ARE - Federal Office for Spatial Development, 2017a). This database allows the combining of information about travel-related behavior with temporal and spatial working conditions, considering socio-demographic, socio-economic and spatial factors. To answer the research question, multivariate regression analyses are used to estimate the effects of flexible working arrangements on different mobility measures (including commuting distance, non-work travel and rush hour commutes).

The remainder of this article is divided into four sections. The next section reviews some similar studies examining the relationship between flexible forms of work and their impact on mobility behavior, and elaborates the research hypotheses. Following that, section 3 describes the data, the operationalization and the analytical strategy used to answer the research question. Thereafter the results are presented. Finally, the paper closes with a conclusion and discussion of the results.

2. Literature review and research hypotheses

The digitalization of the labor market allows and promotes an abundance of different flexible working arrangements in Switzerland, such as telework, flextime, mobile work, desk sharing, part-time work, job sharing or crowdsourcing (e.g. Meissner et al., 2016). The subjects of the following analyses are telework and flextime. Both are forms of flexible working arrangements, which allows labor market participants to decide to some degree when and/or where to work. In this paper, telework is defined as working from somewhere other than the workplace, and in particular from home. In the following, flextime refers to the fact that the working hours are not completely predetermined, so that the worker enjoys some degree of scheduling flexibility. There are various conceptualizations and terms for these flexible working arrangements. Telework is also known as remote work, telecommuting, flexible work, flexplace, distance work, and hybrid work, while flextime can also be called flexible work schedule, schedule control or flexitime (Allen et al., 2015; Mokhtarian, 1991a). This section continues with an overview of the relationship between telework and travel behavior, then presents studies about flextime and traffic, and closes with three research hypotheses.

Since the 1970s, there has been research and an ongoing discussion about the impact of telework on energy use, commuting behavior as well as on general travel patterns (see overviews: e.g. Salomon, 1986; Mokhtarian, 1991b; Walls and Safirova, 2004; Andreev et al., 2010; Hook et al., 2020). The hope is that remote work replaces commuting journeys, which would save greenhouse gas emissions and hence, be beneficial for the environment. This relation is often discussed as substitution effect (Salomon, 1985, 1986). In contrast to this, telework and traffic could take the form of a complementary relationship, meaning that remote work also induces traffic, e.g. in the form of trips for other purposes or by changes in land use (Andreev et al., 2010; Salomon, 1986). Alternatively, the spread of telework could result in modifications to travel patterns, possibly in turn resulting in a neutral impact on traffic (Andreev et al., 2010). Presumably, modification as opposed to reduction is more likely (Salomon, 1985). However, which of these relationships between telework and travel is true, can be answered empirically.

Initially, telework was found to be a promising solution that reduces both traffic and greenhouse gases. An overview of early US remote work pilot projects concluded in 1991 that remote workers indeed commute less, and their non-work-travel does not increase (Mokhtarian, 1991b). About a decade later, another paper reviewed six recent empirical studies and came to the similar conclusion that telework reduces the number of daily trips as well as the commuting distance traveled by car,

and does not affect non-work-travel (Walls and Safirova, 2004). Both studies acknowledge though that more large-scale and long-term research is needed, because it is the number of people who work remotely and to what extent which will determine the total environmental impact. In 2010, one review considered more than 30 empirical studies from the United States and Europe (Andreev et al., 2010). Overall, it confirms substitution effects of telework on different travel indicators such as miles traveled (both generally and by car), the number of commutes or the avoidance of morning peak hours in the short term. Nevertheless, the conclusion is less clear for long-term effects due to possible relocation choices or induced travel and because of a lack of wide representative data (Andreev et al., 2010).

In contrast to these early findings, more recent results are inconclusive nowadays. As early as the beginning of the 2000s, Black (2001) questioned the traffic-reducing influence of the ever-expanding telework practice in cities. He even called this notion a myth and argued in a complementary manner that remote work offers more time and space flexibility, so that the availability of travel opportunities is likely to entail more traffic. He also assumed that a substitution of personal travel demand with virtual interactions due to the increasing usage of advanced ICTs was only wishful thinking. Lane (2019) revisits this essay nearly 20 years later and concludes by reviewing a selection of contemporary studies that (at least for the developed world) these two theses have indeed turned out to be more myth than truth.

Today, the evidence on the impact of remote work on commuting and general travel behavior is mixed, ranging from a substitutional influence (travel reduction), through to no effect, to a complementary impact in terms of induced travel. A recent systematic review by Hook et al. (2020) compares the relationship between telework on various energy consumptions indicators such as commuting, non-work travel and home energy use. This review includes 39 different empirical studies carried out since 1996, based on quantitative analyses of survey data (19), scenario modeling (14) and evaluations of pilot studies (6). Although most of the studies (26) report some energy savings through less commuting, they mostly rely on small samples and often only consider the commute itself. In contrast, the review concludes that the more rigorous studies with a broader scope (e.g. nationwide samples), which also contemplate other indicators such as non-work travel, usually find smaller savings or even an increase in energy consumption. Most studies are from the United States, which could influence the results, since the private car commute is most prominent there and public transport plays only a minor role. Moreover, vehicles and buildings tend to be larger and are less energy-efficient than in other countries (Hook et al., 2020: 7). Hence, the following detailed literature review focuses on recent and empirical survey research from different parts of the world, which considers more indicators than the commute alone.

A study by Zhu (2012) uses the US National Household Travel Surveys from 2001 and 2009 to investigate commuting behavior and non-work trips. It concludes that telework has a complementary effect on travel behavior. Using the same US National Household Travel Surveys, Zhu and Mason (2014) again find no travel reduction for remote workers compared to on-site workers concerning their daily work and non-work vehicle miles traveled. A further investigation by Zhu (2013) also showed on average longer one-way commutes of teleworkers compared to on-site workers for both one- and two-worker households in the US.

Research by Chakrabarti (2018) also makes use of the 2009 US National Household Travel Survey to evaluate, among other things, the effect of regular and occasional telework on the vehicle miles traveled. The study finds a shift to more active and environmentally friendly travel modes such as walking/cycling on remote working days. However, on an annual basis teleworkers are more likely than on-site workers to drive >20,000 miles per year (which corresponds to the top 10% of the annual miles driven in the US). A remote worker's one-way commute is on average 4 miles longer than that of on-site worker's, thus, offsetting saved miles on non-teleworking days. A former study of Mokhtarian et al. (2004) also finds longer one-way commutes for teleworkers as compared to on-site workers. Nonetheless, they observe on average fewer miles commuted by teleworkers measured on a quarterly per capita basis. However, these results are based on a teleworking pilot sample from California and only consider the commuting distance, and not the total distance traveled. A study from Hu and He (2016) uses the 2008 regional household travel survey from the Chicago metropolitan area to analyze the one-way commuting distance of workers as well as the daily total trip duration on the household level. As in the other studies, they observe a longer one-way distance between home and the workplace for people who occasionally work remotely compared to on-site workers. A special feature of this study is that the authors record whether a person teleworked. They find that the daily total trip duration is indeed shorter on teleworking days. Nevertheless, and in contrast to this, telework is generally associated with more time spent on the road during the day, suggesting longer distances traveled and therefore a complementary effect.

Most studies reviewed so far are based on data from the US. Next, research from other countries is presented, starting with two studies from South Korea using data from the 2006 Household Travel Survey in the Seoul Metropolitan Area. A study by Kim et al. (2015) analyzes the impact of telework for white-collar workers on the commuting and non-work distance traveled. As a special feature, they measure the same travel indicators for the household member(s) to investigate any intra-household dependencies of teleworking heads-of-household compared to full-time and part-time office workers. The study shows that although commuting by the teleworking head-of-household is reduced, their trips for other purposes as well as journeys made by their household members offset the saved commute. One reason is that the car is made available to other household members on remote working days in households with only one vehicle. Two years later, a similar study by Kim (2017) again shows that the saved commute of teleworking household heads is offset by a rebound effect of their own behavior and that of their household members. Moreover, this additional travel is mainly covered by car. However, one point of criticism is that only Euclidian distances between travel zones were observed, rather than true distances between origin and destination.

A panel study from the Netherlands by de Vos et al. (2018) finds that teleworkers compared to on-site workers, accept on average 5% longer commuting times. Because commuting time and distance are likely correlated (Hook et al., 2020), this could indicate that teleworking does not reduce travel and is associated with longer commutes due to sorting preferences. The results of a Swedish study by Elldér (2020) using nationwide micro-level travel data suggest that part-day and full-day telework lead to different outcomes. Whereas people who work exclusively remotely on the survey day do indeed travel less, it is the exact opposite case for hybrid workers who do part of their workload from home, but also commute to the workplace. However, the study concludes that overall, telework does reduce the travel demand – because the increase of part-day remote working is less than the decrease of the full-day teleworkers. This result is in contrast to the main findings of the review study by Hook et al. (2020) and the other studies presented. This is surprising, since the results of Elldér (2020) are very reliable, because it was directly measured whether a person teleworked and to what extent. Moreover, the results are based on large scale national transport surveys using different dependent travel indicators.

Looking to Switzerland, an analysis by Ravalet and Rérat (2019) also evaluates the impact of telework on different mobility aspects using the Swiss Mobility and Transport Microcensus (MTMC). Indeed, they find that people who work remotely live on average farther away from their workplace compared to on-site workers, and that this difference increased from 2010 to 2015. Moreover, the authors try to identify people, who actually worked from home on the target day, because this is not part of the survey. Actual remote work was counted as when fulltime-working employees spent at least 6 h at home between 9 a.m. and 5 p.m. on a weekday. They find that teleworkers travel more on average if they commute to work than on a day working from home.

However, it could be that this result is observed due to the modeling approach, because being at home for eight hours also excludes traveling for other purposes such as leisure or shopping during that time.

Allen et al. (2015: 61) suggest isolating the effect of telework on travel patterns from the impact of flextime. Hence, in the analyses that follow, flextime will be included. Additionally, flextime in itself may be a helpful tool for studying congestion. While telework cannot replace commuting in some cases, flextime could help to distribute traffic more evenly throughout the day, which might mitigate rush hour traffic jams. An analysis by He (2013) of the two most congested areas in California shows that flextime workers were less likely to depart before or during peak-period and more likely to start their way to work after the morning rush hour. Not every remote worker works from home all day; there are hybrid workers who work only a part of the day from home. Although the commute is not replaced, part-time telework still offers the advantage of avoiding rush hour if people work from home for a number of hours and commute to the workplace afterwards (Lyons and Haddad, 2008). A study by Haddad et al. (2009) from the UK compares part-day teleworking with full-day teleworking and concludes that the former is more common and indeed promotes earlier departures from the work place.

A study by Asgari and Jin (2018) tests whether regular and non-regular (occasional) remote workers compared to on-site workers use their schedule flexibility to postpone the start of their commute to miss the peak of congestion in the New York Metropolitan region. Using a hazard function model, they show that compared to on-site workers, teleworkers are more likely to commute in the less-crowded midday period instead of the morning peak time. A study by Lachapelle et al. (2018) analyzes the effect of different remote working arrangements on travel time and peak-period traffic using the 2005 Canadian General Social Survey. A special feature of this study is that it was measured directly, whether a person worked only remotely, only on-site or combined working remotely and on-site during the survey period. They find that working from home the whole workday is associated with a reduction of the overall travel time by on average 13 min. Generally, private motorized rush hour trips compared to mid-day trips are less likely for teleworkers. One exception to this is the morning peak-period journey taken by whole-day remote workers, which is not significantly avoided, mainly due to the need to transport children, e.g. to school, by a particular time of the day. The studies from the Seoul Metropolitan Area (Kim et al., 2015; Kim, 2017) also indicate that teleworkers more often avoid peak period travel and that their departure times are more dispersed on days they commute compared to office-based workers. The work from Sweden (Elldér, 2020) reveals that full-day remote workers are more likely to avoid rush-hour traffic in general compared to those who do not telework. In Switzerland, two pilot studies find that there is potential for flextime to reduce peak-period travel (Ecoplan, 2015; Weichbrodt et al., 2013); however, these are limited to some specific companies and restricted to specific geographical areas.

This literature review concludes that there is more recent evidence suggesting a complementary impact of telework on travel (e.g. Chakrabarti, 2018; Hu and He, 2016; Kim et al., 2015; Kim, 2017; Zhu, 2012; Zhu and Mason, 2014) rather than a substitution effect (e.g. Elldér, 2020; Mokhtarian et al., 2004). However, most studies agree that there is a positive impact of flexible working arrangements on traffic distribution throughout the day. Reduction effects of flexible working arrangements are often based on the simulation of different scenarios or theoretical modeling (see Hook et al., 2020) or limited samples (e.g. Mokhtarian et al., 2004; He, 2013). Moreover, many results regarding commuting behavior rely only on one-way distances, travel times, beeline distances or projections. However, people do not necessarily have only two commutes (e.g. some may drive home for lunch). Furthermore, it is only an assumption that people usually take the shortest route – for instance if a longer route is faster it may be more appealing. Therefore, actual commuting and travel distances derived from large scale data need to be analyzed. As systematic and representative research for Switzerland on this topic is scarce, this paper adds to the literature.

The theoretical framework of this paper follows a behavioral approach. It is assumed that travel behavior is an individual choice, which consists of different alternatives of which people select the alternative most beneficial for them (e.g. Domencich and McFadden, 1975; Salomon, 1985). There are various empirical applications following the behavioral framework to answer questions such as when travel will take place, which route is chosen, which mode of transport is preferred, and which determinants are relevant for these choices (e.g. Davidov et al., 2003; Domencich and McFadden, 1975; Franzen, 1997; Moore et al., 1984; Preisendörfer, 2000).

In many cases, commuting to work is a necessary component of gainful employment. However, commuting to work is usually unpaid, takes time, and can entail direct costs (such as costs for fuel or a public transportation ticket). Additionally, it comes along with opportunity costs, as the time used for commuting cannot be used for something else such as leisure. If the individual utility of gainful employment is optimized, it is expected that commuting to work will be reduced as much as possible. Moreover, as already explained, empirical research agrees that telework indeed reduces commuting. Hence, the first hypothesis of this study is that people who have the opportunity to do some of their work from home will take advantage of this and thus avoid commuting.

H1. Flexible working arrangements reduce the work-related distance traveled.

However, the commuting time saved could be used for other journeys. Furthermore, telework might eliminate the possibility of efficiently combining other activities with the commute. Thus, there is only an environmental benefit of remote work if the saved commute on home office days is not completely compensated by or even exceeded with trips for other purposes. This is especially important with regard to motorized private transport. Research has shown that remote workers tend to live further away from the workplace compared to on-site workers, which can outweigh the number of kilometers saved on office days (Hook et al., 2020). Moreover, many studies found a travel-inducing and complementary effect for non-work trips (e.g. Chakrabarti, 2018; Kim, 2017; Zhu and Mason, 2014), although some did not (e.g. Elldér, 2020; Mokhtarian et al., 2004). Because of these inconclusive results, the second research hypothesis is formulated to test the initial idea that flexible working arrangements could reduce traffic.

H2. Flexible working arrangements also reduce the total distance traveled (implying that there are no compensation effects in non-work travel).

Finally, a similar argument as that in H1 is made with regard to flextime. Although commuting may be inevitable for some people, they can still try to maximize the utility of their work route by minimizing travel time (Moore et al., 1984). When driving during peak time, congestion and traffic jams can entail stress, less comfort, or a higher mileage because of stop-and-go traffic. Moreover, the journey time is likely to be longer than if it occurred outside of rush hour. Additionally, empirical findings suggest that flextime and telework favor a more even distribution of traffic during the day (e.g. Asgari and Jin, 2018; Elldér, 2020; He, 2013). Although part-day remote work does not replace the commute, it at least allows the avoidance of peak period travel (Haddad et al., 2009; Lachapelle et al., 2018). Accordingly, it is hypothesized that people who have a flexible work schedule are more likely to commute outside of rush hour.

H3. Flexible working arrangements increase the likelihood of commuting outside of rush hour.

3. Data and methods

3.1. Data

The data used in this paper is the most recent available Swiss Mobility and Transport Microcensus (MTMC) from 2015 by the Swiss Federal Statistical Office and Swiss Federal Office for Spatial Development ARE (2017a). The MTMC is a micro-data trend survey on mobility behavior and attitudes of the Swiss population, which started in 1974 and is repeated every 5 years since then. Since 1994 it is conducted via Computer-assisted telephone interview (CATI) using a random sample of the Swiss resident population starting from age 6. In 2015, there was a response rate of 53% resulting in 57,900 interviews (Swiss Federal Statistical Office and Swiss Federal Office for Spatial Development ARE, 2017b). The data set contains detailed route recording of all ways traveled by a person on one specific target day. In addition, further relevant information about these routes – such as distance, duration, start and end place and time, mode of transportation, and purpose – is collected. Apart from this, the data set contains socio demographic and economic information about the respondents as well as various household characteristics. Although there is some information about the whole household, only one person out of each household is the target person whose traffic behavior is recorded. The target days are equally distributed throughout the whole year. Thus, the data are the best available source for testing the research hypotheses in Switzerland.

Besides these main data, which are conducted for each respondent, four additional modules covering supplementary topics were randomly assigned with different probabilities. For this study, the third module in particular is of great importance, as it contains questions about flexible forms work. The module was assigned to about 30% of respondents (Swiss Federal Statistical Office and Swiss Federal Office for Spatial Development ARE, 2017b). This means that not all working respondents received these questions about flexible working arrangements. However, since all modules were assigned randomly, missing values concerning telework and flextime are completely at random. Therefore, the results are unbiased. Since regular working and commuting practices are of interest here, all analyses are carried out for people who are gainfully employed (not in training), aged between 18 and 65 years, because the latter is the regular retirement age for males in Switzerland. Moreover, only routes traveled within the country are taken into account. Hence, the sample size drops considerably to about 8700 observations (see Fig. S1 in supplementary material). Descriptive results are weighted using the weighting coefficient provided in the data set.

3.2. Independent variables – telework and flextime

This paper focuses on two flexible working arrangements, which could help to relieve traffic. In the MTMC, respondents had been asked if they are able to do some of their work from home, which is a specific form of telework. Respondents, who answered this question with “yes”, or “sometimes”, were then asked to what extent (in % of full-time-equivalent). Since some of them choose not to work from home, a variable was built that represents actual telework usage. That is to say, the MTMC only records whether a person generally teleworks (e.g. working remotely 20% of the working time), while there is no information whether an individual actually teleworked on the target day. Therefore, group comparisons of teleworkers compared to those who never telework are carried out at the macro level. Since the questionnaire explicitly asks about working from home (and not from other places like a café or a train), the MTMC captures a specific kind of the telework; hence, these two terms will be used interchangeably. In the following, people who always work remotely (100% of their workload) are called full-time teleworkers, while the mixture between working from home and on-site during the workweek is designated as hybrid work.

The second form of flexible working arrangements considered is flextime. Respondents had been asked to what extent they can organize their own working time. The four answering categories in 2015 were the following: predetermined start and end time of working hours, predetermined core time, fixed number of working hours per week or month, and completely flexible working hours. Since even core work time could have a positive impact on traffic, flextime will be dichotomized into non-flexible (the first category), and flexible, that is collapsing the other three categories. See Table S1 in the supplementary material for descriptive information about all variables used in this study as well as an overview of how they were constructed.

3.3. Dependent variables – travel behavior

To test hypotheses 1 to 3, eight travel-related dependent variables are used. In the MTMC, every recorded route is assigned to a (main) purpose, such as work, shopping, use of services, business activity, leisure activity, or accompanying trips.[1] Based on this classification, there will be three kinds of travel: the commute, everything except the commute – referred to as non-work-travel, and the total travel, which is the sum of both. For each travel indicator the number of kilometers traveled via all routes, with the corresponding purpose, are totaled to record the overall distance traveled. It should be noted that individuals who did not commute or drive at the target day, still are included in the analyses with a value of zero. This is particularly important since these zero values are meaningful and represent special travel patterns. For instance, zero kilometers commuted are observed when a person only worked remotely on the target day. Zero non-work travel can occur if somebody only commuted or did not leave the house at all. Finally, zero kilometers driven by motorized private transport can indicate that an individual only covered distances by walking, cycling or using public transport. Hence, these data they do not rely on any prior travel-related assumptions, which generates a precise measure of the actual distances traveled. This approach is reasonable as it also depicts specific travel patterns. E.g., people do not necessarily take only one trip to and from work. Some might drive home for lunch, which would result in more kilometers commuted. Only considering one-way commuting distances would lead to a distorted picture in this case. Another benefit is that this approach also captures trip chaining adequately. Each individual outbound trip of a chained journey is labeled with the purpose of the activity at the destination. The final part of a chained journey is the return trip. This way home is labeled with the purpose of the main activity, i.e., the activity that took up the most time. Hence, chaining the commute with other trips usually results in a smaller distance covered for the work route, since the purpose of travel is split between work and non-work. Such cases could hardly be captured by any other approach. In conclusion, considering actual behavior, that is how much had been traveled for what reasons, is most suitable to test the impact of flexible working arrangements on traffic.

Additionally to the distances, the main mode of transport is recoded for every trip. Motorized private transport (MPT), namely driving with own car or motorcycle, is the most energy-consuming mode of transportation. Therefore, a reduction of travel by MTP is needed in order to observe any beneficial impact of telework on the environment. Hence, the total distances traveled by MPT are additionally presented for all three types of travel. Accordingly, the total distances traveled with all modes are called person kilometers traveled (PKT), and distances covered with motorized private transport are referred to as vehicle kilometers traveled (VKT).

Finally, two dummy variables are constructed for commuting by MPT during morning and evening peak time respectively. Here, the

[1] In the MTMC, all trips (outbound and return) are assigned to a purpose. The purpose for any outbound trip is based on the activity at the destination. The assignment of purposes to ways home is based on the purpose of the previous activities. In the simplest case of only two ways, the trip home is assigned to the same purpose as the outbound trip.

dummy variable approach is suitable for evaluating whether people use their flexibility to drive outside the peak period, because it has the advantage of considering all work routes taken by a single person. Additionally, it is possible to investigate morning rush hour commuting separately from the evening rush hour commute, which had previously been found to be an important distinction (Lachapelle et al., 2018). The rush-hour dummy variable is coded as 1 if at least one journey commuted by MPT starts and/or ends between 7:15 a.m. to 8:15 a.m. for the morning peak period or between 5 p.m. to 6:30 p.m. for the evening rush hour (cf. Swiss FEDRO - Federal Roads Office, 2020). There are almost 2400 people who actually commuted via MPT on the target day for whom information on flexible working arrangements is available.

3.4. Control variables

Three main types of variables are considered as control variables for hypothesis testing: sociodemographic and economic, mobility-related, and job-related variables. These variables are of theoretical interest, available in the MTMC and have been found to be important in other studies investigating travel patterns and flexible working arrangements (e.g. Elldér, 2020; He, 2013; Moore et al., 1984; Ravalet and Rérat, 2019; Walls et al., 2007; Zhu, 2012; Zhu and Mason, 2014). Accordingly, age, gender, education, income, and type of household (family status and children), and nature of residential area (city, agglomeration, rural area) are included. Considering travel behaviors as decisions, different mobility-related factors can offer opportunities or impose restrictions regarding the travel choices. Hence, vehicle accessibility and the holding of public transport subscriptions are taken into consideration. Finally, the following characteristics of job and workplace are also taken into account: being employed vs. self-employed, working full-time or part-time, job classification (International Standard Classification of Occupations (ISCO)), and nature of workplace area. When testing H1 to H3, the day of the week is also controlled for in order to catch common differences between weekdays and weekends.

3.5. Statistical models

The research hypotheses are tested by comparing the groups of teleworkers vs. on-site workers in multivariate regression models. OLS regression models on the distances traveled are calculated applying robust standard errors to test H1 and H2. Telework and flextime are included in all regression models simultaneously in order to isolate their effects on the different travel indicators (Allen et al., 2015: 61). As has been done in other studies (e.g. Elldér, 2020; Hu and He, 2016; Zhu, 2012), and because the distances are right skewed, they are logged.[2] Therefore, the OLS regression coefficients (β) are interpreted as percentage changes in the travel indicators using this calculation: (exp(β) – 1) * 100%. For every kind of travel, there are separate regression models analyzing PKT and VKT respectively.[3] The total distance commuted on the target day is the dependent travel behavior used to test H1. As in other studies (e.g. Asgari and Jin, 2018; Zhu, 2012) people who always work from home represent a special case, because they do not have a commuting distance per definition. Therefore, these full-time teleworkers will be excluded from the analyses testing H1 (commuting behavior). However, since this type of workplace condition is important for the total travel behavior working full-time from home is included as a specific type of telework when testing H2. H2, addressing possible rebound effects, is tested in two steps. First, the impact of flexible working arrangements on non-work traffic is calculated to identify potential induced travel. Since the main question is whether enough people reduce travel based on telework to be reflected in the aggregate (Mokhtarian, 1991b), the impact of flexible working arrangements on the total distance traveled is calculated as a second step. Finally, to test H3, all commutes on the target day are evaluated with regard to the time at which they took place. For this, two logistic regression analyses are applied, for the morning and evening commutes respectively. In order to be able to estimate the influence of flexible working arrangements on the different mobility behaviors in as unbiased a way as possible, the previously described control variables are taken into account in all regression models. In the course of this, variance inflation factors (VIFs) were calculated to test for multicollinearity among the independent variables. The mean VIF is 1.9, which is reasonable; and no single VIF is noticeably large.

4. Results

The majority of participants in the labor market cannot telework in Switzerland (68%). Of workers, who could work from home, 11.3% decide to not take up this option. Full-time teleworkers working solely from home make up only 2.5% of all respondents. The most common form of telework is hybrid work: 26.2% of all workers combine working from the workplace with working from home during the workweek. Altogether, 28.7% actually work from home, while 71.3% do not work remotely at all. Non-flexible working – i.e. start and finish times are predetermined – is, with 41.5%, the most common type of work schedules in Switzerland. Predetermined core time offers more flexibility and is used by 15.9% of employed respondents. Even more people (18.4%) have only a contractually agreed number of working hours per week or month, but can decide for themselves when they want to work. Finally, 24.3% of the respondents have completely flexible working hours, which means they can fully decide on their working timings and number of hours. Thus, almost three fifths of the respondents can at least to some extent decide their own working hours, and about two fifth of the people in the data set do not have any flexibility over their schedule. In conclusion, there is a bigger share of temporal flexibility than in terms of spatial flexibility for jobs in Switzerland.

On average, workers cover a total distance of 45.6 km per day. This distance is made up of an average of 15 km for commuting and 30.6 km of trips for other purposes. The larger share of non-work travel also highlights the importance of considering effects of flexible working arrangements on non-work travel. The data shows that 35% of labor market participants commute during the morning rush hour, while 43% drive during evening peak periods.

4.1. Flexible working arrangements and distances traveled

Table 1 presents the results of OLS regression models on the distance traveled for work (a), for purposes other than work (b), as well as for the total distance covered (c). The left side of each travel indicator shows estimates of distance covered with all modes of transport (PKT), whereas the right side depicts distance driven by motorized private transport (VKT). First, as expected, hybrid work is statistically significant associated with less kilometers commuted. Model 1 shows that hybrid workers commute on average 21% less with all modes of transport compared to on-site workers (coefficient = −0.235). Remote workers also commute 14.6% less by motorized private transport (Model 2, coefficient = −0.158). However, there is no statistically significant effect of flextime on the distance commuted.

Less time spent commuting offers more free time to travel for other reasons such as leisure or shopping. Indeed, hybrid workers travel 21.5% more for non-work purposes (Model 3, coefficient = 0.195), and

[2] There are people, who did not commute or travel on the target day, thus, having zero PKT/VKT. It is of great importance to consider these cases when transforming the dependent variables. For this purpose, 1 km is added to each distance, and the variable is logged afterwards. Since the natural logarithm of 1 equals 0, the new transformed variable still represents individuals, who did not travel, adequately with a value of zero.

[3] Additionally, as a robustness check, tobit regression models were calculated to account for censoring at zero kilometers. Since the conclusions are the same as for the OLS regression models, these results are not presented.

Table 1
OLS regression on logged distances traveled.

	(a) Commute		(b) Non-work travel		(c) Total travel	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	PKT	VKT	PKT	VKT	PKT	VKT
Flexible working arrangements						
Hybrid work (i.e. part-time telework) (ref. = on-site work)	−0.235***	−0.158***	0.195***	0.151**	−0.001	0.015
Full-time telework (ref. = on-site work)			0.149	−0.022	−0.374**	−0.464**
Flextime (ref. = no flextime)	0.002	−0.035	0.121**	0.065	0.091*	0.0288
Full-time work (ref. = part-time work)	0.399***	0.306***	−0.270***	−0.199***	0.042	0.045
Employed (ref. = self-employed)	0.256***	0.148*	−0.123	−0.150*	0.091	−0.004
Women (ref. = men)	−0.236***	−0.112**	−0.065	−0.127*	−0.209***	−0.171***
Age	−0.003	−0.002	−0.009***	−0.008***	−0.008***	−0.007***
Income (in thousand CHF)	0.027**	0.031***	0.036***	0.042***	0.039***	0.050***
Year of education	0.004	−0.016*	−0.016	−0.024**	−0.001	−0.021*
Type of household (ref. = single person)						
Couple	0.052	0.033	−0.169**	−0.124	−0.075	−0.036
Couple with child(ren)	0.103	0.104*	−0.128*	−0.004	0.032	0.099
Single-parent with child(ren)	0.122*	0.139	−0.051	0.159	0.023	0.219*
Other (e.g. shared flat)	0.165	0.033	0.049	0.049	0.129	0.101
Area of home (ref. = rural community)						
Agglomeration	−0.112*	−0.145**	0.030	−0.108	−0.146**	−0.211***
City	−0.192**	−0.280***	−0.131*	−0.359***	−0.286***	−0.507***
Area of workplace (ref. = rural community)						
Agglomeration	0.082	0.048	0.029	0.058	0.076	0.074
City	0.034	−0.187**	−0.096	−0.110	0.003	−0.194**
Car availability (ref. = no car)						
Always	0.144	0.494***	0.377***	0.884***	0.287**	1.148***
By prior arrangement	−0.058	0.051	0.169	0.359**	0.065	0.360***
Public transport subscription	0.123**	−0.362***	−0.021	−0.339***	0.123***	−0.500***
Weekend (ref. = weekdays)	−1.731***	−1.217***	0.532***	0.447***	−0.407***	−0.235***
Constant	1.728***	1.396***	2.511***	1.831***	3.207***	2.318***
Number of observations	6587	6587	6767	6767	6767	6767
R^2	0.266	0.209	0.046	0.075	0.065	0.124

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. PKT = Person kilometers traveled by all modes of transport. VKT = Vehicle kilometers traveled by motorized private transport. All models controlled for the type of occupation (ISCO; results not presented). Coefficient's (β) interpretation in percentage-changes: (exp(β) – 1) * 100%.

they have 16.3% higher VKT driven by motorized private transport (Model 4, coefficient = 0.151) compared to individuals who never telework. Hence, a rebound effect of part-time remote work on non-work travel can be observed. Interestingly, people who always work from home do not significantly differ from on-site workers in the amount of non-work travel. Flextime workers cover 12.9% greater distances by all modes of transport compared to non-flextime workers (Model 3, coefficient = 0.121). However, they do not have statistically significantly more VKT (Model 4).

The total distances traveled show that hybrid workers do not differ statistically significantly from individuals, who always work on-site (Models 5 and 6). Accordingly, saved commutes are offset with non-work journeys resulting in a zero impact of occasional telework on travel behavior overall. In comparison, people who always work from home travel for non-work purposes as much as those who never telework (Models 3 and 4). Since full-time teleworkers do not have to commute, their total distances result in fewer PKT and VKT compared to on-site workers (Models 5 and 6). Interestingly, they drive even less by car or motorcycle (Model 6, −37.1%, coefficient = −0.464) than they travel less with all modes of transport (Model 5, −31.2%, coefficient = −0.374). Flextime does not statistically significantly affect the VKT (Model 6).

Furthermore, full-time workers as compared to part-time workers have more work-related travel on the one hand, but less non-work travel on the other hand. However, there are no differences regarding the total distances traveled. This can probably be attributed to the fact that full-time workers have more time restrictions due to their job. In addition, people living or working in cities, as compared to rural areas, drive less on average, which could be explained by the fact that in cities the distances that need to be covered to fulfill different needs such as work, shopping, and leisure, are shorter. Moreover, owners of a public transport subscription generally drive less by motorized private transport compared to individuals who do not own a subscription (Models 2, 4, and 6). However, one could argue that people's decision to purchase a public transport subscription could be based on their teleworking practices, which could in turn be related to their travel behavior. To ensure that none of the key findings was biased by the inclusion of public transport subscription, all six models were run without this variable as a robustness check. Neither the main results of the models nor the significance tests changed substantially. All previously presented conclusions remained unchanged. Finally, as expected, individuals commute less on weekends, but travel more for non-work purposes. In total, they drive on average 20.9% less on weekends (Model 6, coefficient = −0.235).

4.2. Flexible working arrangements and congestion relief

Finally, H3 assumes that flexible working arrangements can help to reduce congestion. Table 2 displays the results of two logistic regression models analyzing the effect of flexible working arrangements on rush hour commuting. The coefficients presented are odds ratios. Hence, 1 indicates no effect, while an odds ratio bigger (smaller) than 1 represents a positive (negative) impact. First of all, differentiating between morning and evening peak time offers different insights. Contrary to the assumption, the data suggests that flextime workers are more likely to commute during morning peak time compared to non-flexible workers (odds ratio = 1.3). No difference is found between hybrid workers compared to on-site workers for the morning commute. Nevertheless, in line with H3, hybrid workers are less likely to drive during evening peak time (odds ratio = 0.7). There is no statistically significant effect of flextime on evening peak period travel. Furthermore, full-time workers are more likely to commute during the evening commute compared to part-time workers, probably because the latter can finish work before the evening rush hour. Moreover, it shows that single parents are more likely to commute during the morning rush hour. This could indicate

Table 2
Logistic regression on commuting during morning and evening rush hour respectively by motorized private transport (i.e. car or motorcycle).

	Morning rush hour commute	Evening rush hour commute
Flexible working arrangements		
Flextime (ref. = no flextime)	1.298**	1.149
Hybrid work (i.e. part-time telework) (ref. = on-site work)	1.148	0.702**
Full-time work (ref. = part-time work)	0.947	1.549***
Employed (ref. = self-employed)	0.917	1.234
Women (ref. = men)	1.561***	1.149
Age	0.991*	0.999
Income	1.030	0.965
Year of education	1.055**	0.982
Type of household (ref. = single person)		
Couple	1.118	1.003
Couple with child(ren)	1.289	1.075
Single-parent with child(ren)	1.698*	1.201
Other (e.g. shared flat)	1.076	1.043
Residential area of home (ref. = rural community)		
Agglomeration	0.902	0.990
City	0.736*	0.715**
Residential area of workplace (ref. = rural community)		
Agglomeration	1.211	0.843
City	1.105	0.858
Weekend (ref. =weekdays)	0.603*	0.3999***
Number of observations	2367	2367

Note: Coefficients = odds ratios. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. All models controlled for the type of occupation (ISCO; results not presented).

that they combine taking children to (pre)school with their commute, which is in line with the findings of Lachapelle et al. (2018).

5. Summary and discussion

The aim of this study is to investigate the potential of the digitalization of the labor market for reductions in traffic and congestion relief. Teleworkers are still in the minority with a share of less than 30%. Most of them are hybrid workers, i.e. mix working from the workplace and from home, and only a small minority always works from home. Interestingly, 11% of respondents who have the possibility to work from home some of the time, are not using this option. According to the MTMC flextime is quite common in Switzerland, offering temporal flexibility to three fifths of the Swiss workers. Three hypotheses concerning the impact of flexible working arrangements on different aspects of commuting and general travel behavior are empirically tested using the most recent nationwide micro level transport data (MTMC) from 2015 in Switzerland.

Research hypothesis H1 assumes that flexible working arrangements cause a reduction in work-related mobility behavior. The empirical results show that hybrid work is associated with fewer kilometers being commuted by both all modes of transport and motorized private transport. This can be due to three reasons: First, some respondents are actually working a whole workday from home, and thus, fully replace the commute. Second, some workers typically drive home for lunch and return to the workplace afterwards, so that even half-day home office has a travel reducing effect. Third, people are efficiently chaining the journey to work with trips for other purposes. There is no statistically significant effect of flextime. Overall, hypothesis 1 is partly supported, at least with respect to telework.

Hypothesis H2 postulates a reduction in total mobility. The empirical results show that hybrid work is associated with larger distances of non-work-related travel. This is in line with most research finding a complementary effect of telework. However, the commute is not overcompensated for, since the results show a non-significant impact on total travel. So in this study, less commuting and more non-work travel add up to a neutral impact of hybrid work on total mobility. This is in contrast to the other studies, which found a complementary effect of telework (e.g. Chakrabarti, 2018; de Vos et al., 2018; Kim et al., 2015; Zhu and Mason, 2014), and also differs from work finding a travel reduction (Elldér, 2020). Because this is a cross-sectional study, it cannot be assessed, whether there is unobserved heterogeneity. It could be that hybrid workers make more non-work trips because they are generally more active people. After all, telework offers time slots to travel to leisure activities. The distinction between people always working from home and doing hybrid work turned out to be particularly important. Although statistically significant effects of full-time remote working on overall travel had been found, this is not true for the more common hybrid work. Altogether, H2 needs to be rejected. The results suggest that the occasional usage of flexible working arrangements does not lead to a reduction in traffic.

The third hypothesis, assuming a more even distribution of traffic through flexible working arrangements, gains two interesting insights. First, it is useful to distinguish between morning and evening rush hours. Second, evidence on the effect on flexible working arrangements is mixed. Surprisingly, flextime workers are even more likely to depart during morning rush hour. An explanation for this could be that people who can work flexibly care less when exactly they arrive, and thus they may not mind encountering traffic in the morning. However, teleworkers are less likely to travel during evening peak-time. An explanation could be that people tend to work remotely in the morning or for half a day. This is also in line with most people in Switzerland only executing a small part of their workload from home. Hence, even if they commuted to work on that day, they would still be able to avoid traveling during the evening rush hour. Another possibility could be that they chain their commute with trips for other purposes, which is usually more efficient than doing these trips separately. Overall, H3 is partly supported, suggesting that only telework could affect evening traffic.

In summary, this study shows that the provision of flexible working arrangements by itself does not lead to a reduction in traffic, and if at all, there is only small potential for traffic redistribution. The strength of this study is that it uses a behavioral approach that is based on the most recent nation-wide data for Switzerland considering actual distances traveled. Therefore, it is particularly reliable compared to studies using one-way distances, air-line distances or travel times. Furthermore, this work presents a comprehensive picture of the overall effect of telework because it does not exclude specific groups of people such as part-time workers or self-employed individuals. This study is also particularly useful in showing connections between commutes and non-work trips and how these lead to a neutral impact of telework on the total distance traveled. Moreover, this research isolates the impact of remote work from effects of flextime. In addition, this work shows the benefits of a separate consideration of morning and evening commutes to study the effect of flexible working arrangements. However, this study also has a number of limitations and raises questions for further research. One issue concerns the data itself, because flexible working arrangements were only surveyed for a random subsample of 30% of all respondents. Additionally, only a general indicator for telework could be used instead of a direct measure that captures the actual usage of remote work on the target day. While this general indicator provides interesting insights into the macro level impact of telework on travel, it also leaves some questions unanswered. In particular, the general indicator cannot show differences in the teleworking practices on a working day, while the direct measure allows to distinguish workers who telework the complete day from workers who combine working remotely and on-site on one workday. These two teleworking practices could have different effects on travel behavior as work from Sweden shows (Elldér, 2020). Thus, understanding these practices and their macro level consequences is an important subject for future research. Furthermore, a direct telework indicator would make it possible to separate not being at the workplace due to sickness or vacation from remote work. This could be illuminative

as these reasons might lead to different travel behavior as well. Data from the MTMC showed that not all people who could work from home, actually do so. The same could be true for flextime offers, whose usage had not been recorded in the MTMC. In addition, this study is not able to evaluate effects of flexible working arrangements on traffic that arise over the course of a longer period of time, because only one day was surveyed. This could be important, because trips forgone on home-based days could be caught up during the working week, as work in Great Britain by de Abreu e Silva and Melo (2018) demonstrates. Their study also highlights different outcomes for single and two worker households, which could not be considered in this paper. Since this paper already finds induced non-work travel for teleworking individuals, considering the household's travel could even show an increase of the total distances covered, as other work shows (e.g. Kim, 2017).

Further empirical micro level research is advised, explicitly distinguishing between the possibility and utilization of flexible working arrangements. A subsample of about 2100 people in the MTMC was asked how often they experience traffic jams on their way to work and what they do if they run into congestion on their commutes. Only about 40% of the respondents faced congestion at least once a month. The most common strategy for dealing with it was to do nothing but schedule in time for the congestion (36%). Thirty-one percent simply chose another, probably less crowded, route. In the end, there are 22% that state they would depart earlier or later, which indicates at least some willingness to use flextime in order to avoid congestion. This highlights that (theoretically promising) measures will only be successful, first, if people see a problem that needs to be addressed, and second, if they contribute by actually using opportunities for flexibility.

Finally, there have been fewer traffic jams in 2020 compared to 2019 (−34%, Swiss Federal Statistical Office and Swiss Federal Roads Office FEDRO, 2021) in Switzerland, probably driven by the imposed obligation to work from home due to the coronavirus pandemic. To what extent this will lead to a lasting increase in the spread of flexible working arrangements and whether the altered travel behavior due to home-based working and lockdowns is beneficial for traffic reduction needs to be investigated in future studies.

Funding

This work was supported by the Swiss National Science Foundation (SNSF). Grant number: 188866. The funding source had no involvement in the preparation of this paper.

Declaration of Competing Interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jtrangeo.2022.103390.

References

de Abreu e Silva, J., Melo, P.C., 2018. Does home-based telework reduce household total travel? A path analysis using single and two worker British households. J. Transp. Geogr. 73, 148–162. https://doi.org/10.1016/j.jtrangeo.2018.10.009.
Allen, T.D., Golden, T.D., Shockley, K.M., 2015. How effective is telecommuting? Assessing the status of our scientific findings. Psychol. Sci. Public Interest 16 (2), 40–68. https://doi.org/10.1177/1529100615593273.
Andreev, P., Salomon, I., Pliskin, N., 2010. Review: state of teleactivities. Transp. Res. C 18, 3–20.
Asgari, H., Jin, X., 2018. An evaluation of part-day telecommute impacts on work trip departure times. Travel Behav. Soc. 12, 84–92. https://doi.org/10.1016/j.tbs.2017.04.002.
Black, W.R., 2001. An unpopular essay on transportation. J. Transp. Geogr. 9, 1–11.
Chakrabarti, S., 2018. Does telecommuting promote sustainable travel and physical activity? J. Transp. Health 9, 19–33.
Davidov, Eldad, Schmidt, Peter, Bamberg, Sebastian, 2003. Time and money: an empirical explanation of behaviour in the context of travel-mode choice with the German microcensus. Eur. Sociol. Rev. 19 (3), 267–280.
Domencich, T.A., McFadden, D., 1975. Urban travel demand. In: A Behavioral Analysis. North-Holland, Amsterdam.
Ecoplan, 2015. Verkehrsinfrastrukturen smarter nutzen dank flexibler Arbeitsformen. Entlastungspotentiale für die Hauptverkehrszeiten am Beispiel der Region Bern, Bern. https://www.ecoplan.ch/de/projekte.
Elldér, E., 2020. Telework and daily travel: new evidence from Sweden. J. Transp. Geogr. 86, 102777 https://doi.org/10.1016/j.jtrangeo.2020.102777.
Franzen, A., 1997. Umweltbewusstsein und Verkehrsverhalten: Empirische Analysen zur Verkehrsmittelwahl und der Akzeptanz umweltpolitischer Massnahmen. Rüegger Verlag, Zürich.
Haddad, H., Lyons, G., Chatterjee, K., 2009. An examination of determinants influencing the desire for and frequency of part-day and whole-day homeworking. J. Transp. Geogr. 17, 124–133.
He, S.Y., 2013. Does flexitime affect choice of departure time for morning home-based commuting trips? Evidence from two regions in California. Transp. Policy 25, 210–221. https://doi.org/10.1016/j.tranpol.2012.11.003.
Hook, A., Court, V., Sovacool, B.K., Sorrell, S., 2020. A systematic review of the energy and climate impacts of teleworking. Environ. Res. Lett. 15, 093003.
Hu, L., He, S., 2016. Association between telecommuting and household travel in the Chicago metropolitan area. J. Urban Plan. Dev. 142 (3), 04016005.
Keller, M., 2019. Staukosten Schweiz 2015. Swiss Federal Office for Spatial Development ARE, Bern. https://www.are.admin.ch/are/de/home/medien-und-publikationen/publikationen/verkehr/staukosten-schweiz-2015-schlussbericht.html.
Kim, S.-N., 2017. Is telecommuting sustainable? An alternative approach to estimating the impact of home-based telecommuting on household travel. Int. J. Sustain. Transp. 11 (2), 72–85.
Kim, S.-N., Choo, S., Mokhtarian, P.L., 2015. Home-based telecommuting and intra-household interactions in work and non-work travel: a seemingly unrelated censored regression approach. Transp. Res. A 80, 197–214.
Lachapelle, U., Tanguay, G.A., Neumark-Gaudet, L., 2018. Telecommuting and sustainable travel: reduction of overall travel time, increases in non-motorised travel and congestion relief? Urban Stud. 55, 2226–2244.
Lane, B.W., 2019. Revisiting 'an unpopular essay on transportation:' the outcomes of old myths and the implications of new technologies for the sustainability of transport. J. Transp. Geogr. 81, 102535 https://doi.org/10.1016/j.jtrangeo.2019.102535.
Lyons, G., Haddad, H., 2008. Commute replacement and commute displacement the rise of part-day home working. Transp. Res. Rec. 2082, 1–7. https://doi.org/10.3141/2082-01.
Meissner, J.O., Weichbrodt, J., Hübscher, B., Baumann, S., Klotz, U., Pekruhl, U., Gisin, L., Gisler, A., 2016. Flexible neue Arbeitswelt. In: Eine Bestandsaufnahme auf gesellschaftlicher und volkswirtschaftlicher Ebene. vdf Hochschulverlag AG an der ETH-Zürich, Zürich. https://doi.org/10.3929/ethz-a-010659566.
Mokhtarian, P., 1991a. Defining telecommuting. Transp. Res. Rec. 1305, 273–281.
Mokhtarian, P., 1991b. Telecommuting and travel: state of the practice, state of the art. Transportation 18 (4), 319–342.
Mokhtarian, P.L., Collantes, G.O., Gertz, C., 2004. Telecommuting, residential location, and commute-distance traveled: evidence from state of California employees. Environ. Plan. A 36, 1877–1897.
Moore, A.J., Jovanis, P.P., Koppelman, F.S., 1984. Modeling the choice of work schedule with flexible work hours. Transp. Sci. 18, 141–164. http://www.jstor.org/stable/25768126.
Perch-Nielsen, S., von Felten, N., Henzen, C., Meissner, J., Sprenger, M., Bieri, M., Arvanitis, S., Seliger, F., Ley, M., 2014. Auswirkungen neuer Arbeitsformen auf den Energieverbrauch und das Mobilitätsverhalten von Arbeitnehmenden. KOF Stud. 48 https://doi.org/10.3929/ethz-a-010699193. Zürich.
Preisendörfer, P., 2000. Strukturell-situationale Gegebenheiten als Bestimmungsfaktoren der Verkehrsmittelwahl. Soz. Welt 51, 487–501.
Ravalet, E., Rérat, P., 2019. Teleworking: decreasing mobility or increasing tolerance of commuting distances? Built Environ. 45, 582–602. https://doi.org/10.2148/benv.45.4.582.
Salomon, I., 1985. Telecommunications and travel: substitution or modified mobility? J. Transp. Econ. Policy 19 (3), 219–235.
Salomon, I., 1986. Telecommunications and travel relationships: a review. Transp. Res. A 20 (3), 223–238.
Swiss Federal Council, 2021. Switzerland's long-term climate strategy. Bern. https://unfccc.int/documents/268092.
Swiss Federal Department of the Environment, Transport, Energy and Communications DETEC and Swiss Federal Roads Office FEDRO, 2018. Steigender Verkehr auf den Nationalstrassen. Faktenblatt, Bern, 17.1.2018.
Swiss Federal Office for Spatial Development ARE, 2016. Transport Outlook 2040 - Development of Passenger and Freight Transport in Switzerland. Swiss Federal Office for Spatial Development. Bern: 812.104.e.
Swiss Federal Office for the Environment FOEN, 2021. Greenhouse Gas Emissions in Switzerland. Development in CO2 Equivalents and Emissions by Sector. KL013, Bern. https://www.bafu.admin.ch/bafu/en/home/topics/climate/in-brief.html.
Swiss Federal Roads Office FEDRO, 2019. Roads and Traffic 2019 – Developments, Facts, Figures. Annual publication of the Federal Roads Office, Bern. https://www.astra.admin.ch/astra/en/home/documentation/facts-and-figures/archive.html.
Swiss Federal Statistical Office, 2021. Pendlermobilität in der Schweiz 2019 - Mit einer Vertiefung zur Länge der Arbeitswege. Neuchâtel. Swiss Federal Statistical Office. BFS-Nummer 1351–1900.

Swiss Federal Statistical Office and Swiss Federal Roads Office FEDRO, 2021. Stau: Staubelastung auf dem Nationalstrassennetz. Bern. Swiss Federal Statistical Office and Swiss Federal Roads Office FEDRO. BFS-Nummer gr-d-11.03.03-stau.

Swiss FEDRO - Federal Roads Office, 2020. Verkehrsentwicklung und Verkehrsfluss 2019 (V1.00). Bern. https://www.astra.admin.ch/astra/de/home/themen/nationalstrassen/verkehrsfluss-stauaufkommen/verkehrsfluss-nationalstrassen.html.

Swiss FSO - Federal Statistical Office, 2020. Bruttowertschöpfung nach Branchen. https://www.bfs.admin.ch/bfs/de/home/statistiken/querschnittsthemen/wohlfahrtsmessung/gueter/oekonomische-gueter/branchenstruktur.assetdetail.14447498.html.

Swiss FSO - Federal Statistical Office and Swiss ARE - Federal Office for Spatial Development, 2017a. Dataset: Mobility and Transport Microcensus 2015. Data request via. https://www.are.admin.ch/are/de/home/mobilitaet/grundlagen-und-daten/mzmv/datenzugang.html.

Swiss FSO - Federal Statistical Office and Swiss ARE - Federal Office for Spatial Development, 2017b. Verkehrsverhalten der Bevölkerung. Ergebnisse des Mikrozensus Mobilität und Verkehr 2015. Neuchâtel and Bern: BFS-Nummer 840–1500.

de Vos, D., Meijers, E., van Ham, M., 2018. Working from home and the willingness to accept a longer commute. Ann. Reg. Sci. 61, 375–398.

United Nations Framework Convention on Climate Change UNFCCC, 2015. Adoption of the Paris Agreement Report No. FCCC/CP/2015/L9/Rev.1. United Nations Framework Convention on Climate Change.

Walls, M., Safirova, E., 2004. A Review of the Literature on Telecommuting and Its Implications for Vehicle Travel and Emissions. Research Papers in Economics, Discussion Paper 04–44, pp. 1–23.

Walls, M., Safirova, E., Jiang, Y., 2007. What drives telecommuting? Relative impact of worker demographics, employer characteristics, and job types. Transp. Res. Rec. 111–120 https://doi.org/10.3141/2010-13.

Weichbrodt, J., Sprenger, M., Steffen, M.H., Tanner, A., Meissner, J.O., Schulze, H., 2013. WorkAnywhere. In: SBB AG und Swisscom AG (Ed.), Mehr Produktivität und Zufriedenheit der Mitarbeitenden sowie Entlastung der Verkehrsinfrastruktur dank mobil-flexibler Arbeitsformen. https://irf.fhnw.ch/handle/11654/4994.

Zhu, P., 2012. Are telecommuting and personal travel complements or substitutes? Ann. Reg. Sci. 48, 619–639. https://doi.org/10.1007/s00168-011-0460-6.

Zhu, P., 2013. Telecommuting, household commute and location choice. Urban Stud. 50, 2241–2459.

Zhu, P., Mason, S.G., 2014. The impact of telecommuting on personal vehicle usage and environmental sustainability. Int. J. Environ. Sci. Technol. 11, 2185–2200. https://doi.org/10.1007/s13762-014-0556-5.

Work flexibly, travel less? The impact of telework and flextime on mobility behavior in Switzerland

Supplementary material

Fig. S1. Formation of analysis subsample.

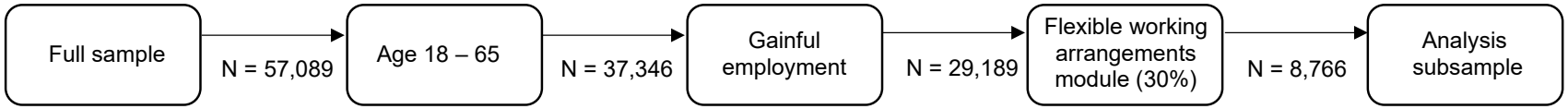


Table S1. Descriptive information of variables for the analysis subsample

Variable	Description / answering categories	Obs.	Min.	Max.	Mean / share	SD
Independent variables: telework and flextime						
Telework	• No telework = 0 (no possibility to work from home or choosing not to do so, that is 0% of workload working from home) • Part-time telework / hybrid work = 1 (possibility to do home office and choose to work less than 100% from home) • Always telework = 2 (individuals, who work 100% of their workload from home)	8737	0	2	0: 71.3% 1: 26.2% 2: 2.5%	
Flextime	• Non-flexible work = 0 (predetermined start and end of the workday) • Flexible work = 1 (predetermined core time, Fixed number of working hours per week/month, completely flexible working hours)	8724	0	1	0: 41.5% 1: 58.5%	

Dependent variables: travel behavior						
Commute PKT	Natural log of the sum of all kilometers commuted on the target day by all modes of transport	8766	0	6.3	1.38	1.62
Commute VKT	Natural log of total distance commuted on the target day by motorized private transport (car, motorcycle, and moped)	8766	0	5.9	0.93	1.48
Non-work travel PKT	Natural log of total distance travelled for all purposes other than work on the target day by all modes of transport	8766	0	6.8	2.19	1.65
Non-work travel VKT	Natural log of total distance for all purposes other than work on the target day by motorized private transport	8766	0	6.8	1.60	1.75
Total travel PKT	Natural log of total distance travelled (commute + non-work travel) on the target day by all modes of transport	8766	0	6.8	2.98	1.44
Total travel VKT	Natural log of total distance commuted on the target day by motorized private transport	8766	0	6.8	2.15	1.82
Control variables						
Full-time work	Part-time work = 0 (reference category), full-time work = 1 (90-100% of full-time equivalent)	8561	0	1	0: 34.9% 1: 58.5%	
Type of employment	Self-employed = 0 (reference category), employed = 1	8766	0	1	0: 12.7% 1: 87.3%	
Gender	Male = 0 (reference category), Female = 1	8766	0	1	0: 52.3% 1: 47.7%	
Age	In years	8766	18	65	43.65	12.03
Income	Household Equivalent Income in 1000 Swiss Francs (income is calculated using the mid value of class interval divided by the square root of the household size)	7591	0.44	17	5.90	2.57
Education	In years (calculated according to the educational attainment)	8731	0	17.5	12.45	2.94
Type of household	• Single-person = 0 (reference category) • Couple = 1 • Couple plus child(ren) = 2 • Single-parent plus child(ren) = 3 • Other (e.g. shared flat) = 4	8755	0	4	0: 13.8% 1: 27.4% 2:48.4% 3: 6.3% 4: 4.1%	

Area of home	• Rural community = 0 (reference category) • Agglomeration = 1 • City = 2	8766	0	2	0: 22.3% 1: 46.3% 2: 31.4%
Area of workplace	• Rural community = 0 (reference category) • Agglomeration = 1 • City = 2	8666	0	2	0: 17.2% 1: 36.0% 2: 46.9%
Car availability	• No car available = 0 (reference category) • Car always available + possession of a valid driver's license = 1 • Car available after prior arrangement + possession of a valid driver's license = 2	8078	0	2	0: 4.5% 1: 78.4% 2: 17.3%
Public transport subscription	No public transport subscription = 0, owning a public transport subscription (which includes the Swiss "Generalabonnement" – a flat rate for the whole public transport in Switzerland - or a half-fare card, or a regional travel pass) = 1	8766	0	1	0: 47.8% 1: 52.2%
Weekend	Weekdays (Monday – Friday) = 0, weekend (Saturday, Sunday) = 1	8766	0	1	0: 70.5% 1: 29.5%
Type of occupation	International Standard Classification of Occupations (ISCO 2008) • Armed Forces Occupations = 0 (excluded due to small sample size) • Managers = 1 • Professionals, Scientists = 2 • Technicians and associate professionals = 3 • Clerical support workers = 4 • Service and sales workers = 5 • Skilled agricultural, forestry and fishery workers = 6 • Craft and related trades workers = 7 • Plant and machine operators and assemblers = 8 • Elementary occupations = 9	8721	0	9	0: 0.1% 1: 11.0% 2: 24.9% 3: 20.3% 4: 8.2% 5: 15.0% 6: 2.2% 7: 11.0% 8: 3.6% 9: 3.8%

Note: Obs. = number of observations, min = minimum, max = maximum, SD = standard deviation. Results of the independent and dependent variables are weighted.

3.3 Artikel 4: Work flexibly, travel more healthily? How telework and flextime affect active travel in Switzerland

Die vierte veröffentlichte Forschungsarbeit im Rahmen dieser Dissertation befindet sich auf den Seiten 76 – 91.

Zitation: Wöhner, Fabienne, 2023. Work flexibly, travel more healthily? How telework and flextime affect active travel in Switzerland *Transportation Research Part A: Policy and Practice* 174, 103748.
DOI: https://doi.org/10.1016/j.tra.2023.103748

Transportation Research Part A 174 (2023) 103748

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Work flexibly, travel more healthily? How telework and flextime affect active travel in Switzerland

Fabienne Wöhner

Institute of Sociology, University of Bern, Fabrikstrasse 8, 3012 Bern, Switzerland

ARTICLE INFO

Keywords:
Active travel
Walking and cycling
Telecommuting
Flextime
Switzerland

ABSTRACT

The impact of flexible working arrangements, such as telework and flextime, on daily travel demand is widely discussed. Although there is no evidence that flexible working arrangements reduce traffic in Switzerland, they still might be beneficial for the environment and public health if they are associated with more active travel (i.e. walking and cycling). Hence, the aim of this study is to investigate the influence of telework and flextime on various active travel patterns as well as possible benefits for public health. Most studies agree on a positive association between telework and active travel. However, these studies mostly rely on spatial flexibility (i.e. working remotely), and do not consider temporal flexibility (i.e. flextime). This study is the first to include different extents of working schedule flexibility in order to analyze active travel behavior. Active mode choices and travel durations are analyzed using the 2015 Swiss Mobility and Transport Microcensus (MTMC) – a nationwide representative micro-data travel survey. The results of this study indicate that telework is not associated with the likelihood of using active modes of transport overall; however, teleworkers walk and cycle more for leisure purposes as compared to on-site workers. Furthermore, the analyses show that flextime (particularly core time) users are more likely to use active modes of transport as compared to people who have a predetermined working schedule, which is mainly attributed to the fact that flextime users walk more. In order to indicate some health benefits, flexible working arrangements are analyzed concerning traveling actively for 30 minutes or more per day. This threshold refers to the recommendation of the World Health Organization concerning health-enhancing amounts of physical activity. The analyses reveal that telework and flextime (core time) are significantly associated with a health-enhancing amount of active travel. Another important finding of this study is that the Body Mass Index (BMI) and the weather condition should be included as control variables in studies that aim to analyze the direct effect of flexible working arrangements on active travel behavior. Overall, this study shows the importance of both spatial and temporal flexibility for choosing active modes of transport. The latter finding in particular is important for future research and policy decisions, as until now the impact of telework on active travel has been the main consideration, without recognizing flextime.

1. Introduction

The ongoing digitalization of the labor market continuously promotes flexible working arrangements, such as telework and flextime. In Switzerland, employees and employers gained much experience with flexible working arrangements due to home office

E-mail address: fabienne.woehner@unibe.ch.

https://doi.org/10.1016/j.tra.2023.103748
Received 9 October 2022; Received in revised form 13 April 2023; Accepted 12 June 2023
Available online 30 June 2023

obligations wherever possible during the COVID-19 pandemic. Hence, they might become more and more important as they spread in the near future. Flexible working arrangements are broadly discussed as possible drivers of less and more evenly distributed traffic – hence, being beneficial for the environment. However, with a few exceptions (e.g. Elldér, 2020), there is no traffic-reducing effect of telework in various countries around the world (e.g. Chakrabarti, 2018; de Vos et al., 2018, Kim, 2017; Zhu and Mason, 2014). Even in Switzerland, data before COVID-19 showed no evidence that telework reduces motorized private transport overall (Ravalet and Rérat, 2019; Wöhner, 2022). This is interesting as Switzerland provides a well-developed public transport system and economically focuses on the tertiary sector, which generally offers good opportunities for flexible working arrangements. Despite these results, flexible working arrangements could still have an important impact on travel behavior as they might promote forms of active travel, such as walking or cycling.

Accordingly, the aim of this study is to analyze the relationship between flexible working arrangements and active mobility from a behavioral perspective in Switzerland. In the Swiss context, telework and flextime are well-established forms of flexible working arrangements; thus, both are taken into account. Telework is generally defined as working from somewhere other than the workplace. In the context of this study, telework refers to working remotely from home for part of the workday or the complete day. In 2015, already more than one-fourth of the workforce can use telework in Switzerland (see Section 5.1). Flextime means that the working hours are not completely predetermined, so the worker enjoys some degree of scheduling flexibility. In Switzerland, three-fifth of workers can decide to some extent on their working hours (see section 5.1). In the following, different kinds of working schedule flexibility are considered. Although both temporal and spatial flexibility is available to many workers at the same time, this is not the case for everyone. Therefore, this study aims to isolate these two aspects. Using empirical multivariate analyses based on actual travel behavior, this study evaluates the potential of promoting flexible working arrangements to increase active travel. Before elaborating on the association between working flexibly and traveling actively, it is useful to briefly outline the importance of active travel research.

In Switzerland, 41.2% of the population was overweight in 2012, which cost Switzerland more than 8 billion CHF (Schneider and Venetz, 2014). It also became apparent that overweight and obesity increased during the last two decades. Moreover, it was revealed that the costs associated with overweight and obesity had tripled within 10 years (Schneider and Venetz, 2014). In order to address overweight and the accompanying diseases, the World Health Organization (WHO) recommends at least 150 to 300 minutes (min) of moderate-intensity physical activity per week, preferably in 10+ minutes bouts, for adults (World Health Organization, 2010). Regular physical activity is beneficial for health and generally helps prevent many diseases because it strengthens muscles, immune system, and cardiovascular system (e.g. Furie and Desai, 2012; Pucher et al., 2010; Warburton et al. 2006; WHO, 2010). Using active modes of transport offers a useful opportunity to be physically active and helps to meet the health-enhancing WHO recommendations (e.g. Buehler et al., 2011; de Nazelle et al., 2011; Gibson-Moore, 2019; Stewart et al., 2016; Wanner et al., 2012; Panik et al., 2019). Therefore, traveling actively is not only beneficial for the individuals themselves but adds to public health as well (e.g. Merom et al., 2010; Laverty et al., 2013; Saunders et al., 2013; Tajalli and Hajbabaie, 2017, Winters et al., 2017). Moreover, it is the most environmentally friendly kind of travel as compared to motorized private transport and public transport. Hence, it is subject to research and policymaking to identify promoters and barriers to traveling actively.

There is a significant amount of research on different policies and interventions in order to increase active travel, such as financial incentives, providing personalized information, or specific programs in companies (e.g. Martin et al., 2012; de Nazelle et al., 2011; Petrunoff et al., 2016; Sulikova and Brand, 2022, Winters et al., 2017). However, such measures are often limited to small areas or single companies or are expensive and might be difficult to implement broadly. Because of that, this study follows a more general approach. If it is revealed that flexible working arrangements and active mobility are empirically associated, this insight could provide a starting point for large-scale policy measures to promote active travel behavior.

There are various arguments as to why the possibility of work time flexibility and working remotely might affect active travel, mainly relating to people's increased spatial and temporal flexibility during the day. Usually, the daily structure of a working person is largely determined by the job. People who work from home spend less time commuting. Assuming there is some certain basic need/desire to be mobile, the commuting time saved is likely to be reinvested in other purposes, such as running errands, leisure, or physical activities, including walking and cycling (Black, 2001; Chakrabarti, 2018; Lachapelle et al., 2018). Moreover, the saved time when not commuting on teleworking days can be used to travel via slower modes of transport for other trip purposes (Elldér, 2022). Furthermore, the commute is often combined with trips for other purposes; however, when working remotely, this is not possible anymore. Therefore, it seems obvious that people will execute daily needs closer to home (e.g. Pendyala et al. 1991; Lachapelle et al., 2018; Saxena and Mokhtarian, 1997). Such shorter distances, in turn, could often be managed well by walking or cycling (Mokhtarian, 1991). Flextime, which is deciding to at least some degree one's own working time schedule, lowers time constraints. This breaks up the largely given temporal structure of the day due to gainful employment. Hence, reduced time pressure makes it possible to use slower modes of transport, for instance to commute to work. Moreover, flextime might offer additional opportunities for active travel, for instance when breaks can be decided independently, during which workers can go for a walk to relax. This could contribute to reaching a sufficient amount of physical activity.

These considerations lead to the following questions in the context of this study. Do flexible workers use more modes of active travel as compared to on-site workers? Can job flexibility contribute to a more active lifestyle? Is there variation in terms of trip purpose? Are there different conclusions between walking and cycling? Do flexible working arrangements contribute to public health?

Previous research on this topic is scarce and leaves some insightful aspects out of consideration. There are only a few recent empirical studies, addressing the research questions using reliable micro-level data and multivariate statistical analyses. These studies will be described in further detail in the next section. They mainly conclude that telework is indeed associated with more active travel. This paper considers five specific aspects, which have rarely been addressed in the other studies to date. First, this study takes the impact of flextime into account, which is neglected in almost all other studies. Including flextime is useful as it addresses the temporal

aspect concerning active travel. This is also in line with the suggestion of Allen et al. (2015: 61) to isolate the effect of telework from flextime, as both might lead to different conclusions. Second, there is often no distinction made between different modes of transport used while traveling actively. The current study consists of separate analyses for walking and cycling, which has only been done once before and indeed led to different results (Elldér, 2022). Third, to obtain a general picture of the association between flexible working arrangements and active travel, various indicators concerning active travel behavior are considered. These include travel times, trip purposes, and health-enhancing amounts of active travel, where the latter two have only been addressed rarely. Fourth, another feature of this study is that it controls for the Body Mass Index (BMI) to estimate the direct effect of flexible working arrangements on active travel. Only one other study considered this variable before, but that study analyzed only a vague measure of active travel behavior. However, BMI is an important variable, because active travel can be differently exhausting depending on the level of BMI, and missing this aspect could lead to biased conclusions. Finally, the weather is included in all analyses as a control variable. It is surprising that this indicator is most of the time not integrated into active travel research. However, it is especially important for studies using one-day travel diaries as weather conditions might evidently influence both the decision to work from home and to walk or cycle.

The research questions are tested using the 2015 Swiss Mobility and Transport Microcensus (MTMC) – a rich nationwide representative micro-data trend survey on mobility behavior and attitudes. This database allows for the analysis of the impact of telework and flextime on different aspects of active travel behavior, such as walking and cycling and health-enhancing usage of active modes of travel, controlling for relevant background variables.

The remainder of this article is split into five sections. In the next section, previous studies that examine the relationship between flexible forms of work and active travel are reviewed. The research hypotheses are presented in section 3. Thereafter, section 4 describes the data, the operationalization, and the analytical strategy used to answer the research question. Following this, the results are given. The final section of the paper closes with a conclusion and discussion of the results.

2. Literature review

Active travel is executed when "the sustained physical exertion of the traveller directly contributes to their motion" (Cook et al., 2022: 154). This includes various forms of non-motorized travel such as walking and cycling, but also, inlineskating, swimming, skateboarding or the usage of manual wheelchairs (Cook et al., 2022). Although active travel is more than just walking and cycling, these two modes of transport are the most widespread for active commuting and active mobility in general. Accordingly, this study considers both types when analyzing the impact of flexible working arrangements on active travel.

Since the 1970s, there has been an extensive discussion about the impact of flexible working arrangements on travel patterns, mainly focusing on the question of whether working remotely reduces traffic (see Hook et al., 2020 for a recent review). However, only very few recent, empirical, micro-level studies analyze the association between flexible working arrangements and active travel behavior. Most of these few studies are based in North America (the U.S. and Canada), with the remainder based in Europe (the UK and Sweden).

Starting with research from North America, work by Chakrabarti (2018) analyzes multiple travel and activity indicators using the US National Household Travel Survey from 2009. A distinction is made between occasional and regular telework and flextime is controlled. Results show that regular teleworkers complete more walking trips during one week as compared to non-teleworkers, while no effect is found for occasional telework. In addition, another analysis shows that teleworkers are more likely to walk/cycle for at least one mile on their remote working days as compared to teleworkers on on-site days. Furthermore, the study investigates the association of telework with health-enhancing levels of physical activity (30+ minutes). Here, physical activity includes active traveling as well as exercising. Teleworkers as compared to on-site workers are more likely to be sufficiently active (i.e. 30+ minutes/day), and teleworkers are more likely to reach the recommended amount of physical activity on remote days than on days in the office. Unfortunately, one cannot assess the contribution of active travel to reaching sufficient physical activity here. Furthermore, Chakrabarti (2018) controls for temporal flexibility and finds that the possibility of deciding on the start of one's workday is associated with more trips walked during one week, and a higher likelihood of being physically active for at least 30 min on the target day.

Work from Wang and Ozbilen (2020) analyzes data from the Central Puget Sound Region Travel Survey in the State of Washington (US) from 2017 applying machine learning. The dependent variable is the share of time spent traveling via active modes of transport during the survey period. They use a continuous measure of telework – that is, the daily duration of telework in minutes. Results show that the duration of telework is positively associated with the duration of active travel. Looking more deeply, there is a gradual increase in the share of travel time from 0.18 to 0.26 when the duration of telework increases from 0 to 420 min. A study by Ozbilen et al. (2021) researches on the reported duration of trips traveled with active modes of transport (walking and cycling) also using data from the Central Puget Sound Region from 2017. Again, a continuous measure of telework is used – while also including a dummy variable of whether the individual's job allows telework. They do not find an effect of the duration of telework on the time traveled actively; however, individuals with a teleworkable job travel longer with active modes of transport as compared to individuals with a non-teleworkable job. The results are somewhat complicated to interpret, but it appears that the dichotomous telework indicator shows a positive relation with active travel, but there is no additional continuous effect of telework. Thus, it might be concluded that these results are still in line with other studies finding a positive association of telework and active travel behavior. Research by Sener and Reeder (2014) uses the Texas (US) add-on sample data from the 2009 National Household Travel Survey to estimate simultaneously physically active activities and active travel behavior. They find that individuals who work from home are more likely to travel by active modes of transport as compared to on-site workers. Moreover, they included flextime in their analyses, measured as the possibility to decide on the start of the working hours. Indeed, working schedule flexibility is positively associated with a higher likelihood

of traveling actively. Work from Canada conducted by Lachapelle et al. (2018) investigates the relationship between telework and health-enhancing amounts of active travel using a dichotomous indicator for 30+ minutes of walking and cycling on the target day as the dependent variable. They analyze the Canadian General Social Survey from 2005 and restrict the sample to residents of urban areas because they expect it unlikely that walking and cycling occur in rural areas. Their results show that working only from home as compared to working only on-site is associated with 77% higher odds of meeting the recommended amount of physical activity through active travel. Other research in Canada on active travel behavior was done as part of a master's thesis written by Garden (2012) using the TRANS origin–destination survey in the National Capital Region in the fall of 2005. The outcome variable is a binary measure of whether a trip during a one-day period was covered via walking/ cycling or another mode of transport. Results indicate that teleworkers are more likely to take trips via active modes of transport as compared to regular workers.

Turning to Europe, a study from the UK carried out by de Abreu e Silva and Melo (2018) analyzes the National Travel Survey from 2005 to 2012 with respect to different travel indicators, including the number of trips and the distance traveled with active modes of transport (walking and cycling). A strength of this study is that it uses weekly data and considers the frequency of telework (albeit only as an ordinal indicator). They show that frequent telework correlates with more frequent and further active travel. However, this is only the case for single-worker households and not for households in which two individuals are gainfully employed. Another study from the UK, carried out by Caldarola and Sorrell (2022), uses the English National Travel Survey from 2005 to 2019 to investigate the impact of medium- and high-frequency telework on various travel patterns, including active travel. They use weekly travel data, consider individual and household travel, and also conduct separate analyses for commuting, non-work travel and business trips. Results show that medium-frequency telework is associated with more frequent and longer active travel for private purposes (commuting and non-work travel). Furthermore, high-frequency teleworkers travel further for non-work purposes by active modes of transport as compared to non-teleworkers. In addition, they observe intra-household dependencies of household members' telework practice on total active travel usage of the whole household. A study from Sweden by Elldér (2022) uses the National Travel Survey from 2011 to 2016 to investigate the association of telework with various walking and cycling indicators. The strengths of the study are that it analyzes walking and cycling behavior separately and that it considers a direct measure of telework, so that it is clear whether teleworkers, actually worked remotely during the day or not. Hence, this allows telework and non-telework days to be distinguished. In general, the results show that teleworkers walk more but cycle less. This result is robust for different measures of active travel, including whether the mode of transport was used at all, the number of trips made, and the time spent traveling actively. That is interesting, as telework status is associated differently with walking and cycling. This means that combining both could hide important differences. Taking a deeper look, teleworkers walk more for service and leisure on days on which they work remotely only. This is in line with the previous argument that daily needs might be fulfilled closer to home and by slower modes of transport as time saved from the commute is reinvested. Using the same Swedish dataset, earlier work by Elldér (2020) finds that teleworkers are more likely to only walk and cycle, and not use other modes of transport, on teleworking days. Although this insight does not allow conclusions to be drawn about the amount of active travel behavior, it is still informative in terms of sustainability.

3. Hypotheses

The literature review clearly found that telework is indeed positively associated with more active travel. This result is interesting because the studies used various indicators to measure the two key concepts and were conducted in different contexts. Furthermore, it is noticeable that only two studies integrated flextime in their analyses. This is surprising as many studies argue for increased temporal flexibility due to telework, but do not look at the temporal component explicitly. Only two studies (Chakrabarti, 2018; Sener and Reeder, 2014) include the respondent's opportunity to decide on the start of the workday in their models. It turns out that schedule flexibility is positively associated with active travel behavior. However, neither study used a continuous measure of active travel such as the time walked/cycled, and also missed other extents of working schedule flexibility such as completely flexible working hours. Thus, there is still a need for further research on flextime and active travel behavior. As the daily structure is usually determined by the job, telework and flextime help to reduce the temporal constraints. This enables workers who have flexible working arrangements to use slower modes of transport, such as walking and cycling. Moreover, saved commutes from teleworkers might be reinvested in trips for other purposes closer to home. These shorter distances might then be executed more easily using active modes of transport. Thus, the following research hypothesis emerges:

H1: Telework and flextime promote active travel.

Most studies dealing with active travel consider only a few behavioral aspects, for instance whether people walk or cycle at all. In particular, the purpose of walking and cycling trips often remains unaddressed. Only three studies consider the purpose of active travel trips. One study from Canada includes the purpose as a control variable to explain active travel mode choice and observes differences in the likelihood of walking and cycling (Garden, 2012). Results show, for instance, that trips are more likely to be made via active modes of transport for recreational purposes as compared to medical purposes (reference category). A study from the UK made different analyses for commutes and non-work travel (Caldarola and Sorrell, 2022). They find no evidence that telework increases active commuting, but that telework is associated with more non-work active travel. The third study considering trip purposes is from Sweden and distinguished between trips to commute and for leisure and maintenance purposes (Elldér, 2022). The results revealed that telework is associated with more walking for maintenance purposes, but less cycling to work. This study is also the only one that has conducted separate analyses for walking and cycling so far (Elldér, 2022). However, this approach seems to be promising for future insights, as the results differed. Based on the empirical results, this study seeks to test whether there are also different findings

depending on the mode of transport and trip purpose in the Swiss context:

H2: The association between flexible working arrangements and active travel differs across trip purposes and the mode of transport.

It is often argued that active travel might be beneficial for the environment and for public health. Some studies investigate the impact of telework on the time traveled with active modes of transport, which is informative but is not yet sufficient to make statements about public health policies. Only two studies analyze this aspect directly using a binary indicator for 30+ minutes of active travel and physical activity respectively. One study (Lachapelle et al., 2018) shows that full-day telework helps people to meet a health-enhancing amount of active travel; however, the sample was restricted to urban areas only, which could have influenced the results. The other study (Chakrabarti, 2018) has limited explanatory power, as it investigates the impact of flexible working arrangements on physical activity (active travel and exercising) and, therefore, the relevance of active travel can only be guesstimated. However, the results at least suggest a positive impact of working flexibly on active travel. If telework and flextime create more temporal flexibility and thus lead to more active travel, this might help people to achieve the recommended level of physical activity. Moreover, there is evidence that active travel is likely to add to the amount of physical activity instead of replacing other kinds of exercise (Panik et al., 2019). Accordingly, the next research hypothesis addressing possible benefits for public health is as follows:

H3: Telework and flextime help to reach health-enhancing amounts of active travel per day.

Finally, two further important aspects will be addressed that have been neglected in the other studies. First, no study included the weight or BMI of respondents. This is remarkable as there is much research on the relationship between active travel and weight/BMI (e.g. Dons et al., 2018; Habinger et al., 2020; Kroesen and de Vos, 2020; Wanner et al., 2012). The decision to walk or cycle is often day dependent. Hence, active travel is likely to be influenced by weight, as it is more exhausting to travel actively for people with higher BMIs, and might thus be a less appealing mode of transport. In order to estimate the direct effect of flexible working arrangements on active travel behavior, the BMI needs to be controlled – especially in cross-sectional data or one-day travel diaries. Second, the weather was only considered in one study, which revealed an impact of weather conditions, such as a decreased likelihood of less walking and cycling when it rained (Garden, 2012). However, some other studies include the month (Sener and Reeder, 2014) or the season (Chakrabarti, 2018). The neglecting of weather is surprising since it seems obvious that the decision to walk or cycle also depends on the weather. Hence, the weather conditions seem particularly important for data based on one-day travel diaries. Accordingly, to estimate the direct effect of telework on active travel, one needs to control for the weather as this variable might be a confounder that influences both whether remote work is done as well as whether active modes of transport are used. As these two aspects might be important for future research on active travel behavior, a fourth hypothesis is formulated:

H4: BMI and weather are associated with active travel behavior.

4. Data and methods

4.1. Data

The data used in this paper is the most recent available Swiss Mobility and Transport Microcensus (MTMC) from 2015, which was conducted by the Swiss Federal Statistical Office and the Swiss Federal Office for Spatial Development ARE (2017a). The MTMC is a micro-level trend survey documenting the travel behavior and attitudes of a random sample of the Swiss resident population starting from age six. The data collection period covers a whole year (14 months) and the survey is repeated every five years. Respondents report a travel diary of one randomly selected target day via computer-assisted telephone interview. It contains detailed route recording of all ways traveled and further relevant information about these routes – such as distance, duration, mode of transportation, and purpose. Additionally, sociodemographic and economic information about the respondents is collected. Apart from this, the survey includes various characteristics of the target person's household; however, only one person out of each household is the target person whose travel behavior is recorded. The response rate of the MTMC in 2015 was 53%, leading to 57,900 travel diaries (Swiss Federal Statistical Office and Swiss Federal Office for Spatial Development ARE, 2017b).

A special feature of the MTMC is that, in addition to these main data, special topics are also collected in the form of additional randomly assigned modules. Module 2 is particularly relevant for this study. This module deals with active travel and the occupational situation. Here, both flexible working arrangements are recorded and in-depth questions about walking and cycling are asked. It should also be emphasized that BMI is part of the module, which is an important control variable in studying active travel. The module was randomly assigned to 30% of respondents (Swiss Federal Statistical Office and Swiss Federal Office for Spatial Development ARE, 2017b). Because of this, the sample size is reduced but no selection bias is expected due to the randomization.

In summary, the MTMC offers a random sample of the total Swiss population, uses accurate methods to record travel behavior, and collects additional relevant variables. Thus, the MTMC is the best available source for analyzing the impact of flexible working arrangements on active travel in Switzerland. Because of this topic, all analyses are carried out for people who are gainfully employed (not in training). The sample is also restricted to respondents aged between 18 and 65 years, because the latter is the regular retirement age for males in Switzerland. In the following, only trips traveled within the country are taken into account. Because only 30% of all respondents received module 2 and due to the substantiated sample restrictions, the number of cases drops considerably to about 8700

Table 1
Descriptive information of variables for the analysis subsample.

Variable	Description / answering categories	Obs.	Min.	Max.	Mean / share	SD
Independent variables: telework and flextime						
Telework	• No telework = 0 (no possibility to work from home or choosing not to do so, that is 0% of workload working from home; reference category)	8737	0	1	0: 71.3%	
	• Telework / hybrid work = 1 (possibility to do home office and choose to work from home)				1: 28.7%	
Flextime	• Fixed working hours = 0 (predetermined start and end of the workday; reference category)	8724	0	3	0: 41.5%	
	• Core time = 1				1: 15.9%	
	• Fixed number of working hours = 2				2: 18.4%	
	• Flexible working hours = 3				3: 24.2%	
Dependent variables: travel behavior						
Traveled actively	• Did not walk/cycle = 0 (reference category)	8767	0	1	0: 40.2%	
	• Walked and/or cycled = 1				1: 59.8%	
Active travel duration	Natural log of total time traveled via active modes of transport	8767	0	6.6	2.10	1.88
Walked	• Did not walk = 0 (reference category)	8767	0	1	0: 45.4%	
	• Walked = 1				1: 54.6%	
Walking duration	Natural log of time walked	8767	0	6.6	1.86	1.84
Cycled	• Did not cycle = 0 (reference category)	8767	0	1	0: 89.6%	
	• Cycled = 1				1: 10.4%	
Cycling duration	Natural log of time cycled	8767	0	6.3	0.36	1.10
Walking to work	• Did not walk to or from work = 0 (reference category)	8767	0	1	0: 81.6%	
	• Walked to or from work = 1				1: 18.4%	
Cycling to work	• Did not cycle to or from work = 0 (reference category)	8767	0	1	0: 87.1%	
	• Cycled to or from work = 1				1: 12.9%	
Walking for leisure	• Did not walk for leisure = 0 (reference category)	8767	0	1	0: 68.7%	
	• Walked for leisure = 1				1: 31.3%	
Cycling for leisure	• Did not cycle for leisure = 0 (reference category)	8767	0	1	0: 87.9%	
	• Cycled for leisure = 1				1: 12.1%	
Walking for shopping	• Did not walk for doing shopping = 0 (reference category)	8767	0	1	0: 80.9%	
	• Walked for doing shopping = 1				1: 19.1%	
Cycling for shopping	• Did not cycle for doing shopping = 0 (reference category)	8767	0	1	0: 89.7%	
	Cycled for doing shopping = 1				1: 10.3%	
Active travel: 30 + minutes	• Did not walk/cycle for at least 30 min = 0 (reference category)	8767	0	1	0: 66.2%	
	• Walked/cycled for at least 30 min = 1				1: 33.8%	
Active travel: 30 + minutes in at least 10-minute bouts	• Did not walk/cycle for at least 30 min = 0 (reference category)	8767	0	1	0: 78.2%	
	• Walked/cycled for at least 30 min = 1				1: 27.8%	

(*continued on next page*)

Table 1 (*continued*)

Variable	Description / answering categories	Obs.	Min.	Max.	Mean / share	SD
Control variables						
Full-time work	• Part-time work = 0 (reference category) • Full-time work = 1 (90–100% of full-time equivalent)	8561	0	1	0: 34.9% 1: 58.5%	
Gender	• Male = 0 (reference category) • Female = 1	8767	0	1	0: 52.3% 1: 47.7%	
Age	In years	8767	18	65	43.65	12.03
Income	Household equivalent income in 1000 Swiss Francs (income is calculated using the mid value of class interval divided by the square root of the household size)	7592	0.44	17	5.90	2.57
Education	In years (calculated according to the educational attainment)	8732	0	17.5	12.45	2.94
Children	• Having no underage children = 0 (reference category) • Having underage children = 1	8767	0	1	0: 61.8% 1: 38.2%	
Area of home	• Rural community = 0 (reference category) • Agglomeration = 1 • City = 2	8767	0	2	0: 22.3% 1: 46.3% 2: 31.4%	
Public transport subscription	• No public transport subscription = 0 (reference category) • Owning a public transport subscription (which includes the Swiss "Generalabonnement" – a flat rate for the whole public transport in Switzerland - or a half-fare card, or a regional travel pass) = 1	8767	0	1	0: 47.8% 1: 52.2%	
Car availability	• No car available = 0 (reference category) • Car available and possession of a valid driver's license = 1	8079	0	2	0: 4.5% 1: 95.5%	
BMI	Body Mass Index	8649	12.9	68.4	24.5	4.04
Weather	• Unpleasant weather conditions (fog, rain, snow, hot, frosty, very unstable) = 0 (reference category) • Pleasant weather conditions (sunny, nice, cloudy) = 1	8665	0	1	0: 43.3% 1: 56.7%	
Weekend	• Weekdays (Monday – Friday) = 0 • Weekend (Saturday, Sunday) = 1	8767	0	1	0: 70.5% 1: 29.5%	
Not leaving the house at all	• No, left the house on the target day = 0 • Yes, stayed at home all day = 1	8767	0	1	0: 92.7% 1: 7.3%	

Note: Obs. = number of observations, min = minimum, max = maximum, SD = standard deviation. Results of the independent and dependent variables are weighted.

observations (see Fig. S1 in the supplementary material). All descriptive results refer to the restricted sample of regular labor market participants and are weighted using the weighting coefficient provided in the MTMC data set.

4.2. Independent variables – Telework and flextime

This paper focuses on two flexible working arrangements, which could combine well with active travel behavior: telework and flextime. In the MTMC, workers were asked if they are able to do some of their work from home, so other kinds of telework such as working from a café are not considered. Respondents, who could work remotely were then asked to what extent (in percentage of full-time-equivalent). Since some of them choose not to work remotely, a variable was built that represents actual telework usage. It is important to say that the MTMC only records whether a person generally teleworks (e.g. working remotely 20% of the working time), but does not capture whether an individual actually teleworked on the target day. Hence, the analytical results are based on group comparisons evaluating differences between teleworkers with those who never telework. The second form of flexible working arrangement considered is working schedule flexibility, i.e. flextime. This study stands out because it considers four different kinds of working hours organization: predetermined start and end time of working hours (i.e. no flextime), predetermined core time, a fixed number of working hours per week or month, and completely flexible working hours. The last three categories lose the time constraints due to gainful employment to different extents, and thus they all are included separately. Please see Table 1 for an overview of how all variables used in this study were constructed, as well as descriptive information on them.

4.3. Dependent variables – Active travel behavior

In order to test the three research hypotheses, 14 dependent variables are used to capture a variety of active travel patterns. The MTMC records the exact route and the mode of transport that was used for the individual stages of all trips on the target day. H1, hypothesizing a positive impact of flexible working arrangements on active travel, is tested using two different kinds of variables. First, there are dummy variables that indicate the usage of active modes of transport. They are set to 1 if a respondent walked or cycled on the target day for more than 0.1 km. This threshold is used to make sure that actual active travel is captured, in contrast to situations in which individuals might walk to the parking lot or take a few steps to change trains, for instance. The binary indicators are 0 if a respondent did not travel actively (e.g. only used motorized private transport or public transport). Furthermore, they are also 0 when individuals did not leave the house on the target day at all, so that no cases get lost and that there is no selection bias due to working remotely. Second, the duration (in minutes) of all trips traveled actively is totaled up. Again, respondents who did not leave the house or only traveled by car and public transport are included with a value of 0, and distances shorter than 0.1 km are coded as 0 min of active travel. According to work from Sweden (Elldér, 2022), it is essential to analyze the modes of active travel separately, as they might lead to different outcomes and conclusions. Following this, the analyses are carried out for walking only, cycling only, and total active travel (i.e. walking and cycling). H2 seeks to explore the associations between flexible working arrangements and the purposes for which different active modes of transport are used. Accordingly, there will be six binary variables, addressing commuting, active travel for leisure reasons, and shopping trips, each built separately for walking and cycling respectively. Again, distances shorter than 0.1 km are coded with a value of 0. In order to test H3, which addresses the health benefits of active travel, two binary indicators are created. The first variable is 1 for individuals who travel actively (by bike and on foot) for at least 30 min on the target day. This threshold is chosen because of the WHO recommendation that recommends at least 150 min of physical activity per week (World Health Organization, 2010). Based on a typical work week with five working days for full-time employees, this results in an average of 30 min of active travel per day. Furthermore, the threshold of 30 min is harmonized with previous studies analyzing active travel and public health (e.g. Buehler et al., 2011; Lachapelle et al., 2018; Merom et al., 2010). The second indicator takes into account that longer periods of travel are even more health-enhancing as compared to multiple but very short stages of active travel. According to the WHO, physical activity should be practiced in bouts of at least 10 min duration (World Health Organization, 2010). As has been done in previous studies (e.g. Buehler et al., 2011), a binary indicator for sufficient active travel is generated that excludes active travel trips shorter than 10 min but still sums up to at least 30 min of walking and/or cycling.

4.4. Control variables

The aim of this study is to analyze the association of telework and flextime with different active travel patterns. It is therefore essential to control for possible confounders, which are variables that might affect both the presence of flexible working arrangements and active travel behaviors. Hypothesis H4 considers BMI and weather as important factors in active travel research. The BMI is calculated using self-reported height and weight. The weather condition on the target day is incorporated into the statistical models as a binary variable that distinguishes pleasant (i.e. sunny, nice, cloudy) from unpleasant (i.e. fog, rain, snow, hot, frosty, and very unstable) weather conditions for active travel. The weather data comes from the MTMC. The respondents stated what the weather was like for them on the target day. If at least one unpleasant condition, such as fog or snow, was mentioned, the binary indicator is set to unpleasant. Using weather data directly from the MTMC has the advantage that the respondents can indicate the weather at all the different locations that they encounter or are relevant, which is relevant to their travel decision-making.

Furthermore, five other types of control variables are taken into account. First, there is an important job characteristic to consider. Full-time and part-time work need to be included, in order to disentangle the effect of temporal flexibility due to flextime from impacts due to fewer working hours. Second, the following sociodemographic characteristics of the respondents are included: gender, age (in years), household equivalent income (in thousand Swiss Francs), education (in years), and having underage children. Third, different

levels of the built environment are controlled by including the area of residence (the three categories are rural area, agglomeration, and city). Fourth, some travel-related indicators are considered, as they can offer alternatives or impose restrictions regarding active travel behaviors. These are holding a public transport subscription, and having a private car available. Finally, an important characteristic of the survey day is controlled. A binary indicator for weekends is included, in order to catch common differences to regular weekdays. Besides BMI and weather, whose inclusion in the analyses is a novelty of this study, all included control variables were found to be important in the previous studies reviewed.

4.5. Statistical models

The research hypotheses are tested by comparing the groups of teleworkers vs. on-site workers, and the different groups of working schedules (flextime) in multivariate regression models. The key variables of interest – telework, and flextime - are simultaneously included in all regression models in order to isolate their effects on the different active travel indicators (Allen et al., 2015). In the course of this, the previously described control variables are taken into account in order to estimate the direct effect of telework and flextime on active travel behavior.

H1 assumes that flexible working arrangements contribute to more use of active modes of travel. To test this hypothesis, three different aspects of active travel are considered: (a) active travel overall, (b) walking, and (c) cycling. Each of these groups includes two analyses: one logistic regression model, measuring whether the mode of transport was used at all, and one ordinary least squares (OLS) regression model, analyzing the time spent traveling actively. The latter is measured continuously. Since these durations are right-skewed, they are logged, as has been done in previous studies (e.g. Elldér, 2022). The value of duration is 0 for individuals who did not travel actively. To not lose these important cases, one minute is added to the durations before transforming it. As the natural logarithm of 1 equals 0, the new variable still represents workers who did not walk or cycle adequately with 0. Because of the transformation of the dependent variable, the OLS regression coefficients (β) are interpreted as percentage changes using this calculation: (exp(β) – 1) * 100%. Moreover, robust standard errors were applied to calculate the OLS regression models. The variance inflation factors (VIFs) of these models – testing for multicollinearity among the independent variables – are not noticeably large and the mean VIF is 1.30, which is reasonable. The second hypothesis seeks to explore associations between flexible working arrangements and different purposes for active travel. Six binary logit models are computed for walking and cycling respectively to (d) commute to work, (e) pursue leisure, and (f) do shopping. H3 addresses the possible benefits of flexible working arrangements for public health. In order to test this hypothesis, two logistic regression analyses are carried out for traveling actively for at least 30 min, and for traveling 30+ minutes in 10-minute bouts, respectively. The fourth hypothesis concerns the importance of weather conditions and BMI in active travel research. H4 is tested indirectly since these two indicators are included as control variables in all models.

5. Results

5.1. Descriptive results

Starting with some descriptive results, the data shows that 59.8% of Swiss labor market participants travel actively in one day. Moreover, the results demonstrate that walking (54.6%) is more common than cycling (10.4%) in Switzerland. Having a deeper look, the data shows that the average time spent traveling actively is about 31 min per day, of which 26 min are walked and only 5 min are cycled. Looking at the purposes for active travel, it becomes apparent that most people walk and cycle for leisure (34.8%). The second most important purpose for traveling actively is commuting (23%), followed by walking and cycling for shopping (21.5%). 33.8% of workers travel actively for at least 30 min on the target day. The travel of slightly fewer people – 27.8% – consists of trips that lasted at least 10 min and summed up to a minimum of 30 min. Thus, there are about 5% of labor market participants who travel actively for at least 30 min, but whose total duration of active travel is made up of several shorter stages. Finally, a few brief words are said about the spread of flexible forms of work in Switzerland. The majority of participants in the Swiss labor market cannot telework (68%). Interestingly, of all individuals who could work from home, 11.3% decide to not take up this option. Overall, this results in 28.7% of workers practicing telework, while 71.3% work on-site only. Looking at flextime, the most common type of working schedule organization is non-flexible working, i.e. the start and finish times of work are predetermined. The working times are fixed for 41.5%; however, this also indicates that almost three-fifths of workers can decide to some extent on their working times. 15.9% of labor market participants have a predetermined core time, which means that they can decide on the start of their working day within a given period. 18.4% benefit from even more temporal flexibility, as they have only a contractually agreed number of working hours per week or month. Finally, 24.2% of workers have completely flexible working hours. Overall, more labor market participants have temporal than spatial flexibility in their jobs in Switzerland. Furthermore, it becomes apparent that in Switzerland all combinations of temporal and spatial flexibility are present. For instance, there are teleworkers who cannot decide on their working hours, and there are also individuals who cannot work from home but can decide on their working day completely autonomously. However, it is most common that on-site workers do not have flexible working hours, and that teleworkers can fully decide on their working hours (see Table S1 in the supplementary material).

5.2. Flexible working arrangements and active travel usage

Table 2 presents the results of the regression models for active travel via (a) walking and cycling, (b) walking only, and (c) cycling only. In each case, the logistic regression is on the left, and the OLS regression is on the right. The coefficients presented for the logistic

regressions are odds ratios (OR). First, contrary to expectations, there is no statistically significant impact between telework and active travel; however, flextime is associated with active travel behavior. Workers, who can decide on the start of their working days (i.e. having core time) are more likely to use active modes of transport (model 1, OR = 1.23), and also travel 25.6% longer using active modes (model 2, β = 0.228) as compared to workers with fixed working hours. A further insight is that this is due to more (model 3, OR = 1.203) and 23% longer walking (model 4, β = 0.207), while no effect is found for cycling. Interestingly, individuals who can fully decide on their working hours cycle less (model 5, OR = 0.77; model 6, β = −0.086) as compared to workers with fixed working hours; however, there is no significant impact on active travel overall. Furthermore, results show that full-time work, the availability of a car, and an increasing BMI lead to less active travel, while education, denser infrastructure, a public transport subscription, and pleasant weather correlate positively with active travel behavior. Regarding the weather condition, the separate analysis of walking and cycling is informative. It shows that in pleasant weather people cycle more often and longer, and individuals also walk longer. However, there is no statistically significant effect of pleasant weather on the likelihood to walk at all. One reason for this could be that there are certain routes that must be walked in all weather conditions, such as the way to the public transportation stop. At the same time, the positive effect of good weather on the duration of walking suggests that the weather is indeed relevant for additional or "voluntary" distances covered on foot, such as going for a walk or walking to the supermarket. Additionally, people are less likely to use active modes of transport on weekends as compared to weekdays. The question might arise whether the group of individuals who did not leave the house at all is overrepresented in the group of teleworkers and if that could affect the results. A *t*-test shows that there is no statistically significant difference in the share of people who stayed at home all day between teleworkers and on-site workers (t = −1.46, p = 0.143, N = 8737). As a robustness check, all six models were also calculated without individuals who did not leave the house at all on the target day, which reduces the sample size by 439 cases (results not presented). No differences are found concerning the key variables telework and flextime. Furthermore, including telework and flextime in separate models did not change the main results.

5.3. Flexible working arrangements and active travel trip purposes

Next, Table 3 displays the results of the likelihood to walk and cycle respectively, separated for commutes, leisure purposes, and shopping trips. The coefficients presented in Table 3 are odds ratios. This separation into different purposes provides some different insights. Teleworkers are statistically significantly more likely to walk and cycle for recreational reasons (model 9, OR = 1.215; model

Table 2
Logistic and OLS regressions on active travel, walking and cycling behavior.

	(a) Active travel		(b) Walking		(c) Cycling	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Binary indicator (OR)	Duration (β)	Binary indicator (OR)	Duration (β)	Binary indicator (OR)	Duration (β)
Flexible working arrangements						
Telework (ref. = no telework)	1.039	0.054	1.043	0.0617	1.019	0.011
Flextime (ref. = fixed working hours)						
Core time	1.230**	0.228***	1.203*	0.207**	1.133	0.049
Fixed number of working hours	1.032	0.075	1.018	0.066	0.886	−0.017
Flexible working hours	0.952	0.003	1.002	0.054	0.770*	−0.086*
Full-time work (ref. = part-time work)	0.850*	−0.234***	0.904	−0.177**	0.757**	−0.100**
Women (ref. = men)	1.153*	0.086	1.263***	0.203***	0.653***	−0.156***
Age	0.998	0.002	0.998	0.001	1.005	0.002
Income (in thousand CHF)	0.995	−0.009	1.000	−0.007	0.973	−0.006
Years of education	1.037***	0.028**	1.027**	0.0177*	1.053***	0.019***
Children (ref. = no children)	0.968	−0.020	0.959	−0.040	1.083	0.031
Area of home (ref. = rural community)						
Agglomeration	1.236***	0.185**	1.224**	0.169**	1.222	0.050
City	1.782***	0.476***	1.604***	0.356***	1.877***	0.210***
Public transport subscription (ref. = no subscription)	1.847***	0.549***	1.662***	0.450***	2.136***	0.209***
Car availability (ref. = no car)	0.649**	−0.441***	0.725*	−0.361**	0.946	−0.076
BMI	0.977***	−0.027***	0.982**	−0.018**	0.935***	−0.019***
Weekend (ref. = weekdays)	0.795***	0.019	0.846**	0.076	0.644***	−0.111***
Pleasant weather (ref. = unpleasant weather)	1.154**	0.213***	1.065	0.125**	1.289**	0.106***
Constant		2.142***		1.785***		0.569***
Number of observations	6744	6744	6744	6744	6744	6744

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Coefficients of binary indicators = odds ratios (OR). Coefficients of duration = β; interpretation of β-coefficients in percentage-changes: (exp(β) – 1) * 100%.

10, OR = 1.403), and they are more likely to go shopping on foot (model 11, OR = 1.214). In contrast, no association is observed between core time work and active commuting and active leisure travel. However, workers with fully flexible working hours are more likely to commute to work on foot (model 7, OR = 1.232).

Some interesting conclusions emerge from the control variables. Car availability correlates with less commuting by active modes of transport. Additionally, the built environment seems to matter for executing regular needs, such as commuting and shopping: individuals living in cities are more likely to commute and shop on foot as compared to those living in rural areas. Also, older, higher educated, and full-time working people are more likely to cycle to work. Holding a public transport subscription promotes walking to work too. In general, a higher income decreases the likelihood of traveling by bike. On weekends, workers are less likely to commute on foot but are more likely to commute by bike. No correlation between BMI and purpose-dependent active travel behavior is found. However, this makes sense, since walking and cycling might be more exhausting for individuals with a high BMI in general, and not only when they are walking or cycling for recreational purposes for instance. No statistically significant association is observed between the weather condition and active travel for leisure purposes. However, these non-significant coefficients show at least a positive coefficient as expected. Surprisingly, good weather conditions are associated negatively with walking to work and with walking and cycling to do shopping. It might be that individuals avoid slower modes of transport for daily necessities on sunny days to save time for other recreational activities.

5.4. *Flextime working arrangements and health-enhancing active travel*

H3 hypothesizes that flexible working arrangements help people to reach a health-enhancing amount of active travel. Table 4 reports the results of two logistic regression models analyzing the impact of telework and flextime on 30 + minutes of active travel (model 13) and 30+ minutes of active travel in at least 10-minute bouts (model 14). The coefficients presented are odds ratios. Results show a statistically significant association between telework and the recommended amount of active travel (model 14, OR = 1.147). Interestingly, teleworkers are not more likely to travel for at least 30 min as compared to on-site workers (model 13), but it seems that they differ in terms of stage duration (i.e. they possibly travel for longer episodes). Furthermore, the results show a positive impact of working schedule flexibility on health-enhancing active travel. Individuals who can decide on the start and end of their working hours are more likely to walk and cycle sufficiently (OR = 1.2 and 1.225, respectively). Only having a fixed number of working hours as compared to a predetermined start and end of the work day also correlates with a higher likelihood of traveling actively for at least 30 min (model 13, OR = 1.178). Full-time workers are less likely to walk and cycle sufficiently, as are individuals for whom a car is available and who have higher BMIs. In contrast, health-enhancing active travel is more likely for workers who live in cities as compared to rural areas, and who hold a public transport subscription. Additionally, older and more educated people are more likely to

Table 3
Logistic regressions on walking and cycling separated by trip purposes.

	(d) Commute		(e) Leisure		(f) Shopping	
	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Walking	Cycling	Walking	Cycling	Walking	Cycling
Flexible working arrangements						
Telework (ref. = no telework)	1.082	1.124	1.215**	1.403***	1.214*	1.171
Flextime						
(ref. = fixed working hours)						
Core time	0.965	0.872	0.964	0.887	0.952	0.730*
Fixed number of working hours	1.031	0.903	1.045	0.990	0.931	0.859
Flexible working hours	1.232*	0.965	1.094	1.103	1.097	1.085
Full-time work	1.453***	0.936	0.891	0.858	0.920	0.802*
(ref. = part-time work)						
Women (ref. = men)	1.141	0.895	1.217**	0.930	1.365***	1.119
Age	1.002	1.008*	1.005	1.000	0.998	1.008*
Income (in thousand CHF)	0.998	0.943***	0.984	0.957*	0.975	0.938***
Years of education	1.018	1.045**	1.017	1.017	1.003	1.029
Children (ref. = no children)	0.897	0.888	0.929	0.883	0.893	0.838
Area of home (ref. = rural community)						
Agglomeration	1.037	1.027	1.013	0.966	1.170	1.092
City	1.217*	1.212	0.979	1.133	1.348**	1.051
Public transport subscription	1.151*	1.137	1.029	1.110	0.991	1.092
(ref. = no subscription)						
Car availability (ref. = no car)	0.727*	0.705*	0.939	0.788	0.726*	0.889
BMI	1.003	0.993	0.995	0.998	1.011	1.008
Weekend (ref. = weekdays)	0.785***	1.251**	1.937***	2.388***	1.274***	1.955***
Pleasant weather	0.865*	0.969	1.051	1.040	0.863*	0.828*
(ref. = unpleasant weather)						
Number of observations	6744	6744	6744	6744	6744	6744

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Coefficients = odds ratios (OR).

Table 4
Logistic regression on health-enhancing active travel behavior.

	Active travel: 30 + minutes	Active travel: 30 + minutes in at least 10-minute bouts
	Model 13	Model 14
Flexible working arrangements		
Telework (ref. = no telework)	1.101	1.147*
Flextime (ref. = fixed working hours)		
Core time	1.200*	1.225*
Fixed number of working hours	1.178*	1.086
Flexible working hours	1.046	1.008
Full-time work (ref. = part-time work)	0.725***	0.701***
Women (ref. = men)	1.045	0.986
Age	1.005*	1.006*
Income (in thousand CHF)	0.996	0.985
Years of education	1.025*	1.009
Children (ref. = no children)	1.018	0.987
Area of home (ref. = rural community)		
Agglomeration	1.148	1.081
City	1.451***	1.352***
Public transport subscription (ref. = no subscription)	1.546***	1.252***
Car availability (ref. = no car)	0.604***	0.783
BMI	0.970***	0.971***
Weekend (ref. = weekdays)	1.240***	1.546***
Pleasant weather (ref. = unpleasant weather)	1.319***	1.338***
Number of observations	6744	6744

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Coefficients = odds ratios (OR).

travel actively for at least 30 min per day. It is also more likely for labor market participants to walk and cycle sufficiently on weekends than on weekdays, and when the weather conditions are pleasant. The latter finding is in line with the results seen in Table 2. As a robustness check, both models are calculated without individuals who stayed at home all day (results not presented). No differences are found concerning the key variables telework and flextime. As a further robustness analysis, telework and flextime are included separately in the models. This does not change the main findings (results not presented).

6. Conclusion and discussion

The aim of this study is to analyze the association between telework/flextime and active travel behavior in order to gain insights into possible impacts on public health and the environment. The results show that both flexible working arrangements and active travel are quite common in Switzerland. H1 assumed that telework and flextime increase active travel and the results show that telework correlates with more walking for leisure and shopping purposes. In addition, teleworkers are more likely to cycle for recreational purposes as compared to on-site workers. Furthermore, flextime, more precisely core time, is associated with more and further active travel, which is mainly covered by foot. In summary, the empirical evidence for Switzerland only supports H1 partly. Despite the positive impacts of flexible working arrangements, it needs to be mentioned that the results do not show up in all respects of active travel patterns. For instance, telework is only found to affect leisure and shopping trips, but no association was found when looking at active travel behavior overall. H1 is also contradicted to some extent by the fact that only certain flextime arrangements correlate with active travel, and that workers with completely flexible working hours cycle less. The analyses in this study stressed the importance of traveling actively for leisure and shopping purposes, while no association was found for the ways to and from work. Accordingly, it is advised to approach active travel broadly, in contrast to focusing on impacts on the commute only. Furthermore, the analyses revealed that core time affects walking but not cycling in Switzerland. Therefore, the association between flexible working arrangements and active travel patterns differs across trip purposes and mode of transport, meaning H2 is supported. From this, it can be derived that different active modes of transport and various conceptualizations of active travel patterns (e.g. considering travel reasons) contribute to a more detailed understanding of active travel behavior and the underlying mechanisms. This finding is important for modeling approaches in future studies, as well as for targeted measures from policymakers. Next, analyses reveal that telework and flextime (especially core time) help people to reach a health-enhancing amount of active travel per day, which supports H3, and this might be an important insight for public health authorities. Finally, H4 addressed the significance of including BMI and weather conditions in active travel research. The analyses suggest that higher BMIs correlate with less active travel overall, less walking and cycling, and a lower likelihood of reaching 30+ minutes of active travel per day. The effect of BMI did not vary between trip purposes, but this was not necessarily expected. Because of the first finding, which is in this case the more important one, it is

concluded that there is support for H4. Furthermore, the weather conditions have mainly a significant positive influence on active travel behavior, and thus, represent a potential confounder when analyzing the relationship of active travel with flexible working arrangements. However, it is important to note that there is a need for more detailed research concerning the trip purposes, as these results here are somewhat contradictory and inconclusive. Anyways, it is advisable to take the weather into account. Even if no weather data is collected in travel diaries, it could be a good idea to feed weather data externally. In summary, H4 is supported: BMI and weather conditions are associated with active travel. What is more, the results show that public transportation subscriptions correlate positively with active travel behaviors. This could indicate that the development of public transport infrastructure is not only beneficial for the environment but also for public health. In summary, the conclusions of this study are largely consistent with the other studies, while at the same time setting new priorities such as the consideration of flextime, or the inclusion of BMI and weather conditions as important control variables.

Next, the limitations of this study and some open questions for further research are discussed. This study uses cross-sectional data; accordingly, the impacts of telework and flextime on active travel cannot be interpreted causally. There could be some selection effects; for instance, generally more active people could have sorted themselves into jobs with flexible working arrangements. Another possible explanation could be dog-ownership, as telework allows taking care of pets and is empirically associated with more walking for leisure purposes. Hence, this study cannot be used to draw conclusions about the effectiveness of promoting flexible working arrangements for more active travel. However, in combination with the theoretical considerations, the observed associations may at least indicate what policies could be considered. Then, the efficiency of such policies needs to be tested in future research using panel or experimental data. Furthermore, the results of this study are based on one-day travel diaries of only one member per household. This fact could hide some interesting findings, as work from studies using household data demonstrated some intra-household effects (e.g. Caldarola and Sorrell, 2022). Moreover, as only one-day travel diaries were used, no conclusions could be drawn about effects over a work week, consisting of both remote and on-site working days for the same individuals. In addition, this study only used a general indicator of telework and flextime, thus only allowing group comparisons of teleworkers and flextime workers as compared to regular workers on aggregate. More detailed analyses of the underlying mechanisms are possible if, first, longer periods of time are observed and, second, if it is clear whether someone teleworked or used their working schedule flexibility on the target day(s). This study aims to address possible benefits for public health. However, this study only considers active travel behavior and leaves some questions open with regard to total levels of physical activity. It could not be analyzed to what extent active travel contributes to the daily amount of physical activity. It might be the case that flexible working arrangements promote more exercise, as work from Texas showed (Sener and Reeder, 2014), but they could also replace other kinds of physical activity. Although active travel is only part of all physical activities, the analyses provide at least the insight that core time and telework correlate with more active travel.

This study stands out because it uses the most recent nationwide available data for Switzerland to analyze different active travel patterns and consequences while controlling for relevant and new aspects. First, previously mostly neglected flextime was included as another flexible working arrangement that could positively impact active travel, as it loosens the time constraints imposed by gainful employment. The results are in favor of this argument. This study is the first to include different extents of schedule flexibility. Interestingly, it was core time as compared to fixed working hours that showed the most important impact on the usage of active modes of transport and for reaching sufficient amounts of physical activity. This is surprising, as core time only adds small temporal flexibility as compared to fully flexible working hours for instance. This insight is especially important for policy decisions because it reveals that even small opportunities to decide on the structure of one's day could have relevant impacts for public health. Second, BMI was included in this study and was found to be negatively associated with active travel behavior. This result cannot be interpreted causally but it might indicate that the physical condition on the target day might influence the decision to travel actively and, if so, for how long. It could indeed be that this is due to more efforts in walking and cycling but could also point to different habits. There is a need for future research with regard to the causality, as there are studies that argue that more active travel reduces the BMI in the long term (e.g. Dons et al., 2018) but also those that suggest that it is rather the BMI that determines decisions to travel actively (e.g. Kroesen and de Vos, 2020). Furthermore, the BMI itself is a somewhat simplified concept, as it does not differentiate between fat and muscles, and because it might be biased across different socio-demographics. However, it is quite feasible and can be easily captured in travel surveys, as many people know their height and weight. In this study, the usage of the BMI should not be problematic, because the models include many relevant variables as controls. Still, there is potential for future travel research that considers alternative concepts or additional control variables. In summary, the results suggest that the BMI (or some comparable concept) is an important control variable that should be considered in studies that aim to analyze the direct effect of flexible working arrangements on active travel patterns. Third, analyzing walking and cycling behavior separately leads to different insights. This is in line with research from Sweden that found contradictory impacts of telework on walking and cycling behavior respectively (Elldér, 2022). Furthermore, it becomes apparent that all studies, including this one, only considered walking and/or cycling. However, there is a variety of other active modes of transport, such as skateboards, kick scooters, or skates, whose association with flexible working arrangements has not been analyzed yet. Finally, the literature review also revealed that these large-scale studies based on representative micro-level data are only conducted in North America and Europe, so studies in other parts of the world will be important in the future. Additionally, flexible working arrangements are already quite well-established in Switzerland. But this is not yet the case for several countries around the world. It is supposable that the association between telework/ flextime and active travel behavior is similar in many countries – independently of the spread of flexible working arrangements. However, this is an empirical question that needs to be clarified in future studies. Moreover, this study used data from before the COVID-19 pandemic. Further research is needed in order to investigate if a lasting change in the spread of flexible working arrangements and the use of active modes of transport occurred as a result of the pandemic, and whether the conclusions drawn from this study still hold.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

This work was supported by the Swiss National Science Foundation (SNSF). Grant number: 188866. The funding source had no involvement in the preparation of this paper.

Appendix A. Supplementary material

Supplementary material to this article can be found online at https://doi.org/10.1016/j.tra.2023.103748.

References

Allen, T.D., Golden, T.D., Shockley, K.M., 2015. How effective is telecommuting? Assessing the status of our scientific findings. Psychol. Sci. Public Interest 16 (2), 40–68.
Black, W.R., 2001. An unpopular essay on transportation. J. Transp. Geogr. 9, 1–11.
Buehler, R., Pucher, J., Merom, D., Bauman, A., 2011. Active Travel in Germany and the U.S. Contributions of Daily Walking and Cycling to Physical Activity. Am. J. Prev. Med. 41 (3), 241–250.
Caldarola, B., Sorrell, S., 2022. Do teleworkers travel less? Evidence from the English National Travel Survey. Transport. Res. A: Pol. Pract. 159, 282–303.
Chakrabarti, S., 2018. Does telecommuting promote sustainable travel and physical activity? J. Transp. Health 9, 19–33.
Cook, S., Stevenson, L., Aldred, R., Kendall, M., Cohen, T., 2022. More than walking and cycling: What is "active travel"? Transp. Policy 126, 151–161.
de Abreu e Silva, J., Melo, P.C.,, 2018. Does home-based telework reduce household total travel? A path analysis using single and two worker British households. J. Transp. Geogr. 73, 148–162.
de Nazelle, A., Nieuwenhuijsen, M.J., Antó, J.M., Brauer, M., Briggs, D., Braun-Fahrlander, C., Cavill, N., Cooper, A.R., Desqueyroux, H., Fruin, S., Hoek, G., Int Panis, L., Janssen, N., Jerrett, M., Joffe, M., Andersen, Z.J., van Kempen, E., Kingham, S., Kubesch, N., Leyden, K.M., Marshall, J.D., Matamala, J., Mellios, G., Mendez, M., Nassif, H., Ogilvie, D., Peiró, R., Pérez, K., Rabl, A., Ragettli, M., Rodríguez, D., Rojas, D., Ruiz, P., Sallis, J.F., Terwoert, J., Toussaint, J.-F., Tuomisto, J., Zuurbier, M., Lebret, E., 2011. Improving health through policies that promote active travel: A review of evidence to support integrated health impact assessment. Environ. Int. 37 (4), 766–777.
de Vos, D., Meijers, E., van Ham, M., 2018. Working from home and the willingness to accept a longer commute. Ann. Reg. Sci. 61, 375–398.
Dons, E., Rojas-Rueda, D., Anaya-Boig, E., Avila-Palencia, I., Brand, C., Cole-Hunter, T., de Nazelle, A., Eriksson, U., Gaupp-Berghausen, M., Gerike, R., Kahlmeier, S., Laeremans, M., Mueller, N., Nawrot, T., Nieuwenhuijsen, M.J., Orjuela, J.P., Racioppi, F., Raser, E., Standaert, A., Int Panis, L., Götschi, T., 2018. Transport mode choice and body mass index: cross-sectional and longitudinal evidence from a European-wide study. Environ. Int. 119, 109–116.
Elldér, E., 2020. Telework and daily travel: new evidence from Sweden. J. Transp. Geogr. 86, 102777.
Elldér, E., 2022. Active travel and telework in Sweden: teleworkers walk more, but cycle less. Transp. Res. D: Transp. Environ. 109, 103362.
Furie, G.L., Desai, M.M., 2012. Active transportation and cardiovascular disease risk factors in U.S. adults. Am. J. Prev. Med. 43 (6), 621–628.
Garden, B., 2012. Telecommuting travel behavior: Examining the influence of work status on distance and mode choice in the National Capital Region. Open Access Dissertations and Theses. McMaster University Paper.
Gibson-Moore, H., 2019. UK chief medical officers' physical activity guidelines 2019: What's new and how can we get people more active? Nutr. Bull. 44 (4), 320–328.
Habinger, J.G., Chávez, J.L., Matsudo, S.M., Kovalskys, I., Gómez, G., Rigotti, A., Sanabria, L.Y.C., García, M.C.Y., Pareja, R.G., Herrera-Cuenca, M., Zimberg, I.Z., Guajardo, V., Pratt, M., Bolados, C.C., Valenzuela, C.F., Marques, A., Peralta, M., Leme, A.C.B., Fisberg, M., Werneck, A.O., Silva, D.R.d., Ferrari, G., on behalf of the ELANS Study Group, 2020. Active transportation and obesity indicators in adults from Latin America: ELANS Multi-Country Study. Int. J. Environ. Res. Public. Health 17(19), 6974.
Hook, A., Court, V., Sovacool, B.K., Sorrell, S., 2020. A systematic review of the energy and climate impacts of teleworking. Environ. Res. Lett. 15, 093003.
Kim, S.-N., 2017. Is telecommuting sustainable? An alternative approach to estimating the impact of home-based telecommuting on household travel. Int. J. Sustain. Transp. 11 (2), 72–85.
Kroesen, M., De Vos, J., 2020. Does active travel make people healthier, or are healthy people more inclined to travel actively? J. Transp. Health 16, 100844.
Lachapelle, U., Tanguay, G.A., Neumark-Gaudet, L., 2018. Telecommuting and sustainable travel: reduction of overall travel time, increases in non-motorised travel and congestion relief? Urban Stud. 55, 2226–2244.
Laverty, A.A., Mindell, J.S., Webb, E.A., Millett, C., 2013. Active travel to work and cardiovascular risk factors in the United Kingdom. Am. J. Prev. Med. 45 (3), 282–288.
Martin, A., Suhrcke, M., Ogilvie, D., 2012. Financial incentives to promote active travel. An evidence review and economic framework. Am. J. Prev. Med. 43(6), e45–e57.
Merom, D., van der Ploeg, H.P., Corpuz, G., Bauman, A.E., 2010. Public health perspectives on household travel surveys. Active travel between 1997 and 2007. Am. J. Prev. Med. 39 (2), 113–121.
Mokhtarian, P., 1991. Telecommuting and travel: State of the practice, state of the art. Transportation 18 (4), 319–342.
Ozbilen, B., Wang, K., Akar, G., 2021. Revisiting the impacts of virtual mobility on travel behavior: an exploration of daily travel time expenditures. Transp. Res. A: Pol. Pract. 145, 49–62.
Panik, R.T., Morris, E.A., Voulgaris, C.T., 2019. Does walking and bicycling more mean exercising less? Evidence from the U.S. and the Netherlands. J. Transp. Health 15, 100590.
Pendyala, R.M., Goulias, K.G., Kitamura, R., 1991. Impact of telecommuting on spatial and temporal patterns of household travel. Transportation 18, 383–409.
Petrunoff, N., Rissel, C., Wen, L.M., 2016. The effect of active travel interventions conducted in work settings on driving to work: a systematic review. J. Transp. Health 3 (1), 61–76.
Pucher, J., Buehler, R., Bassett, D.R., Dannenberg, A.L., 2010. Walking and cycling to health: a comparative analysis of city, state, and international data. Am. J. Publ. Health 100 (10), 1986–1992.
Ravalet, E., Rérat, P., 2019. Teleworking: Decreasing mobility or increasing tolerance of commuting distances? Built Environ. 45, 582–602.
Saunders, L.E., Green, J.M., Petticrew, M.P., Steichbach, R., Roberts, H., 2013. What are the health benefits of active travel? A systematic review of trials and cohort studies. PLoS ONE 8 (8), e69912.
Saxena, S., Mokhtarian, P.L., 1997. The impact of telecommuting on the activity spaces of participants. Geogr. Anal. 29 (2), 124–144.

Schneider, H., Venetz, W., 2014. Cost of obesity in Switzerland 2012. Studie im Auftrag des BAG. Federal Office for Public Health, Bern.
Sener, I.N., Reeder, P.R., 2014. An integrated analysis of workers' physically active activity and active travel choice behavior. Transp. Res. A: Policy Pract. 67, 381–393.
Stewart, G., Anokye, N.K., Pokhrel, S., 2016. Quantifying the contribution of utility cycling to population levels of physical activity: an analysis of the Active People Survey. J Public Health (Oxf) 38 (4), 644–652.
Sulikova, S., Brand, C., 2022. Do information-based measures affect active travel, and if so, for whom, when and under what circumstances? Evidence from a longitudinal case-control study. Transp. Res. A: Policy Pract. 160, 219–234.
Swiss Federal Statistical Office and Swiss Federal Office for Spatial Development ARE, 2017a. Dataset: Mobility and Transport Microcensus 2015. Bundesamt für Statistik und Amt für Raumentwicklung, Bern.
Swiss Federal Statistical Office and Swiss Federal Office for Spatial Development ARE, 2017b. Verkehrsverhalten der Bevölkerung. Ergebnisse des Mikrozensus Mobilität und Verkehr 2015. Neuchâtel and Bern: BFS-Nummer: 840–1500.
Tajalli, M., Hajbabaie, A., 2017. On the relationships between commuting mode choice and public health. J. Transp. Health 4, 267–277.
Wang, K., Ozbilen, B., 2020. Synergistic and threshold effects of telework and residential location choice on travel time allocation. Sustain. Cities Soc. 63, 102468.
Wanner, M., Götschi, T., Martin-Diener, E., Kahlmeier, S., Martin, B.W., 2012. Active transport, physical activity, and body weight in adults: a systematic review. Am. J. Prev. Med. 42 (5), 493–502.
Warburton, D.E., Nicol, C.W., Bredin, S.S., 2006. Health benefits of physical activity: the evidence. Can. Med. Assoc. J. 174 (6), 801–809.
Winters, M., Buehler, R., Götschi, T., 2017. Policies to promote active travel: evidence from reviews of the literature. Curr. Envion. Health Rep. 4, 278–285.
Wöhner, F., 2022. Work flexibly, travel less? The impact of telework and flextime on mobility behavior in Switzerland. J Transp. Geogr. 102, 103390.
World Health Organization, 2010. Global Recommendations on Physical Activity for Health. World Health Organization, Geneva.
Zhu, P., Mason, S.G., 2014. The impact of telecommuting on personal vehicle usage and environmental sustainability. Int. J. Environ. Sci. Technol. 11, 2185–2200.

Work flexibly, travel more healthily? How telework and flextime affect active travel in Switzerland

Supplementary material

Figure S1. Formation of analysis subsample.

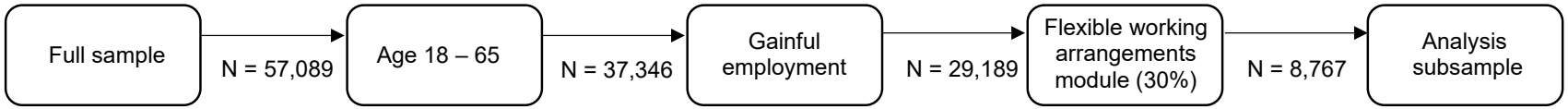


Table S1. Crosstabulation of flextime stratified by telework (in percent, weighted).

N = 8,706	No telework	Telework
Fixed working hours	49.9%	20.7%
Core time	16.1%	15.1%
Fixed number of working hours	18.3%	18.7%
Flexible working hours	15.7%	45.5%
Total	100%	100%

4 Fazit

Diese Dissertation liefert vier empirische Forschungsarbeiten zum Verhalten der Bevölkerung im Kontext verschiedener aktueller gesellschaftlicher Herausforderungen aus den Bereichen öffentliche Gesundheit, Klimawandel und Verkehr.

Die Coronapandemie war eine Bedrohung für die öffentliche Gesundheit und um dieser zu begegnen, wurden verschiedene Schutzmassnahmen wie das Social-Distancing verordnet. Weil COVID-19 für jüngere und gesunde Personen meist weniger gefährlich war, ist die Befolgung des Appells, zu Hause zu bleiben, ein kostspieliger Beitrag zum Kollektivgut „Virusverbreitung stoppen“. Aufgrund dessen wurde die Frage untersucht, unter welchen Bedingungen junge Erwachsene zum Schutz der Gesamtbevölkerung die Social-Distancing-Massnahme einhalten. Zu den wichtigsten inhaltlichen Erkenntnissen der beiden Forschungsarbeiten zählt zum einen, dass vor allem Personen mit einem Umfeld, das sich ebenfalls an den Social-Distancing-Appell hält, ihren Beitrag zum Kollektivgut „Virusverbreitung stoppen“ leisten. Zum anderen ist bedeutsam, dass sich Individuen, welche die verschiedenen Schutzmassnahmen befürworten, auch stärker an den Social-Distancing-Appell halten. Mithilfe von zwei Panelanalysen kann zudem gezeigt werden, dass dieser Zusammenhang zwischen der Einstellung gegenüber der Schutzmassnahmen und dem Social-Distancing-Verhalten kausal interpretiert werden kann. Im Rahmen der Dissertation wurde argumentiert, dass gewisse Unsicherheiten darüber bestehen, wie Menschen auf verordnete Massnahmen und Veränderungen reagieren. Hier kann mithilfe von Panel-Daten aus dem zweiten Lockdown eine gewisse „Coronamüdigkeit“ bei den jungen Erwachsenen gezeigt werden, denn es hat sowohl die anfänglich hohe Akzeptanz für die verschiedenen Schutzmassnahmen abgenommen, als auch das Trittbrettfahren beim Social-Distancing zugenommen. Dies verdeutlicht die Wichtigkeit davon, kontinuierlich sozialwissenschaftliche Beiträge zum Krisenmanagement zu leisten, um das Wissen über die Verhaltensweisen immer wieder aktualisieren und adäquat einzuschätzen. Sowohl inhaltlich als auch methodisch ist der folgende Befund besonders wertvoll: Viele Faktoren, die in anderen Forschungsarbeiten als relevant für das Schutzverhalten identifiziert wurden (wie z.B. die Risikowahrnehmung oder das Vertrauen), wirkten in dieser Studie nicht direkt auf das Verhalten, sondern wurden ausschliesslich über die Einstellung zu den Schutzmassnahmen vermittelt. Die erhöhte die Akzeptanz von Schutzmassnahmen spiegelt sich dann wiederum in einer strikteren Befolgung des Social-Distancings wider. Deswegen, und weil gezeigt wurde, dass dieser Zusammenhang kausal ist, können sich hilfreiche Überlegungen für den Umgang mit zukünftigen Notlagen der öffentlichen Gesundheit ergeben. So könnte beispielsweise das Krisenmanagement explizit auf die Förderung einer positiven Einstellung abgestimmt werden, um die Kooperationsbereitschaft zu erhöhen, anstatt nur an

Verhaltensnormen zu appellieren.

Die beiden Publikationen im Rahmen des SNF-Projekts liefern eine systemische Evaluation des Potenzials der Flexibilisierung des Arbeitsmarktes auf das Mobilitätsverhalten in der Schweiz. Diese Forschung ist besonders für den Umgang mit den gesellschaftlichen Herausforderungen hinsichtlich des Klimawandels und des steigenden Verkehrsaufkommens, aber auch der öffentlichen Gesundheit, nützlich. Es wurden verschiedene Aspekte der alltäglichen Mobilität auf Basis von den umfangreichsten und zuverlässigsten Daten, die in der Schweiz verfügbar sind, analysiert. Einer der wichtigsten Befunde ist, dass Home-Office-Arbeit nicht mit Reduktionen in der Verkehrsnachfrage einhergeht. Obwohl Telearbeitende weniger pendeln, wird die gesparte Zeit in andere Mobilitätszwecke, wie Einkaufen oder Freizeit, reinvestiert. Diese Arbeit liefert folglich einen verkehrsrelevanten empirischen Nachweis des Reboundeffekts bei der Home-Office-Nutzung. Demzufolge kann zum heutigen Stand kein Potenzial zur Abmilderung des Klimawandels durch weniger verkehrsbedingte Treibhausgasemissionen aufgrund von Home-Office-Arbeit erwartet werden. Die aktuellen Befunde lassen allerdings noch offen, ob die erhofften Effekte der Telearbeit auf die Mobilität in Kombination mit anderen Massnahmen wie Strassennutzungsgebühren oder City-Maut erreicht werden können. Dies ist ein wichtiger Gegenstand zukünftiger Forschung und betont abermals die Bedeutung kontinuierlicher empirischer Beiträge aus den Sozialwissenschaften, um die Umwelt- und Verkehrsproblematiken besser zu verstehen und zu adressieren. Weitere Erkenntnisse aus den Mobilitätsstudien sind, dass flexible Arbeitsformen wie Home-Office und Gleitzeit Vorteile für die Volkswirtschaft mit sich bringen könnten. Einerseits sind geringere Staukosten denkbar, denn Home-Office-Arbeitende pendeln während der Abendverkehrsspitze seltener mit dem Auto. Andererseits könnten Telearbeit und Gleitzeit dazu beitragen, die Gesundheitskosten zu senken. Der Grund dafür ist, das zeitliche Flexibilität im Arbeitsalltag in Form eines Kernarbeitszeitmodells mit häufigeren und längeren Fusswegen verbunden ist. Ausserdem könnten Telearbeit und Gleitzeit zur öffentlichen Gesundheit beitragen, weil sie mit höherer Wahrscheinlichkeit ein gesundheitsförderndes Mass an aktiver Fortbewegung (30+ Minuten) pro Tag ermöglichen. Der zentralste methodische Beitrag dieser Dissertation ergibt sich dabei aus der Berücksichtigung der zeitlichen Komponente der Flexibilisierung des Arbeitsmarktes (Gleitzeit bzw. „flextime“), die in der vorherigen Forschung oft ausser Acht gelassen wurde. Die Analyse der Gleitzeiteffekte ist nicht nur inhaltlich aufschlussreich, sondern erlaubt es auch, die räumlichen Einflüsse der Telearbeit von der zeitlichen Komponente zu trennen (Allen et al. 2015). Obwohl bei der Forschung zu den Auswirkungen der Home-Office-Arbeit auf den Verkehr oft implizit von einer zeitlichen Flexibilisierung ausgegangen wird, ist dies nicht zwingend der Fall. So haben in der Schweiz immerhin 20,7% der Telearbeitenden fest vorgegebene Arbeits-

zeiten, also keinerlei zeitliche Flexibilität. Es wurde bereits mehrmals betont, dass das menschliche Verhalten teilweise nicht einfach zu prognostizieren ist. Beispielsweise ergab sich ein unerwarteter Befund hinsichtlich der Gleitzeit: Erwerbstätige mit zeitlicher Flexibilität fahren sogar häufiger während der Morgenverkehrsspitze mit dem Auto zur Arbeit. Dies ist überraschend, denn intuitiv würde davon ausgegangen werden, dass die Verkehrsspitze, wenn es die Rahmenbedingung erlaubt, auch gemieden wird. Auch hinsichtlich der Telearbeit lässt sich feststellen, dass die Schaffung von Rahmenbedingungen nicht impliziert, dass diese auch genutzt werden. So entscheiden sich in der Schweiz mehr als 11% von den Erwerbstätigen, die Telearbeit nutzen dürften, gegen diese Option. Die weiteren Erkenntnisse und die verwendeten methodischen Herangehensweisen, die in zukünftiger Forschung angewendet werden könnten, sind vielfältig. Die erste Verkehrsstudie zeigt beispielsweise, dass es bei der Analyse der Verkehrsnachfrage wichtig ist, die Personen, die ausschliesslich im Home-Office arbeiten, herauszurechnen oder das separate Analysen der Morgen- und Abendverkehrsspitze zu unterschiedlichen Schlussfolgerungen führen. Ausserdem könnte auch die intuitiv nachvollziehbare Präsentation des Reboundeffekts und seinen Auswirkungen auf Gesamtverkehrsnachfrage zukünftig in Analysen in anderen Ländern eingesetzt werden. Hinsichtlich der Forschung zur aktiven Mobilität hat die Arbeit gezeigt, dass der Body-Mass-Index und die Wetterbedingungen als Kontrollvariablen Einzug in die weitere Forschungspraxis finden sollten. Zudem könnten die gesamten Projektergebnisse für die Planung und Durchsetzung nachhaltige und gesunder Verkehrsformen hilfreich sein. Die Forschungsarbeiten basieren auf Daten von vor der COVID-19-Pandemie. Für die zukünftige Forschung bleibt offen, ob sich die pandemiebedingte verstärkte Nutzung des Home-Office und der Einfluss des Coronavirus auf das Verkehrsverhalten (z.B. Vermeidung des öffentliches Verkehrs) auch langfristig widerspiegeln werden.

Alles in allem liefert diese Dissertation neue inhaltliche Befunde im Hinblick auf ausgewählte gesellschaftliche Herausforderungen und schliesst bestehende Forschungslücken für die Schweiz. Die Arbeit zeigt zudem auf, dass das menschliche Verhalten oft überraschende Aspekte bereithält und deswegen kontinuierliche empirische Verhaltsforschung für die Entwicklung politischer Massnahmen und Prognosen essenziell ist. Darüber hinaus tragen die Untersuchungen durch ihr methodisches Vorgehen zum kumulativen Forschungsprozess bei, denn die innovativen Herangehensweisen könnten auch in zukünftiger Forschung verwendet werden.

„Das eigene Zuhause kann der schönste oder der schrecklichste Ort der Welt sein.“

Walter Ludin,
Schweizer Journalist, Redakteur, Buchautor und
Mitglied des franziskanischen Kapuzinerordens

Schlusswort

Zusammenfassend hat sich die vorliegende Dissertation mit verschiedenen Aspekten des Zuhausebleibens beschäftigt. Zum einen wurde die Einhaltung des Social-Distancing-Appells, der forderte, so viel wie möglich zu Hause zu bleiben, während der Coronapandemie untersucht. Hier lässt sich das Zitat von Walter Ludin auf die Lockdowns und das Gefühl, über viele Wochen zu Hause eingesperrt zu sein, übertragen. Diese lange Zeit zu Hause war sicherlich für viele Personen herausfordernd – wenn nicht gar „schrecklich“ – und dennoch befolgten gerade zu Beginn viele junge Erwachsene diesen Aufruf zum Wohle der Gesamtbevölkerung. Zum anderen wurde der Einfluss von häufigerem Zuhausebleiben – im Zuge einer sich wandelnden Arbeitswelt – auf das Mobilitätsverhalten analysiert. Diesbezüglich spiegelt Walter Ludins Zitat den Wunsch vieler Arbeitnehmenden wider, einen Teil ihrer Erwerbsarbeit aus dem eigenen Home-Office „am schönsten Ort der Welt“ zu erledigen. Insgessamt sind die Gründe für vermehrtes Zuhausebleiben also sehr ambivalent und genau so vielschichtig sind die Konsequenzen, die sich daraus ergeben.

5 Literaturverzeichnis

Allen, T.D., Golden, T.D., Shockley, K.M., 2015. How effective is telecommuting? Assessing the status of our scientific findings. Psychological Science in the Public Interest 16(2), 40–68.

Andreev, P., Salomon, I., Pliskin, N., 2010. Review: state of teleactivities. Transportation Research Part C: Emerging Technologies 18, 3–20.

Bundesamt für Gesundheit BAG, 2020. COVID-19: Empfehlungen für die Bevölkerung. Stand: 06.03.2020. Verfügbar über: https://www.newsd.admin.ch/newsd/ message/attachments/60564.pdf (zuletzt abgerufen am 31.07.2023).

Bundesamt für Gesundheit BAG, 2020-2022. So schützen wir uns - Coronavirus Kampagenarchiv. Abrufbar über: https://bag-coronavirus.ch/kampagnen/ (zuletzt abgerufen am 31.07.2023).

Bundesamt für Gesundheit BAG, Schweizerische Konferenz der kantonalen Gesundheitsdirektorinnen und -direktoren GDK, 2016. Nationale Strategie Prävention nichtübertragbarer Krankheiten (NCD-Strategie) 2017–2024. Bern: Bundesamt für Gesundheit BAG, Schweizerische Konferenz der kantonalen Gesundheitsdirektorinnen und -direktoren GDK. Verfügbar über: www.bag.admin.ch/ncd (zuletzt abgerufen am 31.07.2023).

Bundesamt für Raumentwicklung ARE, 2022. Schweizerische Verkehrsperspektiven 2050 - Schlussbericht. Bern: Bundesamt für Raumentwicklung ARE. Verfügbar über: www.are.admin.ch/verkehrsperspektiven (zuletzt abgerufen am 31.07.2023).

Bundesamt für Statistik, 2021. Pendlermobilität in der Schweiz 2019 - Mit einer Vertiefung zur Länge der Arbeitswege. Neuchâtel: Bundesamt für Statistik. BFS-Nummer: 1351–1900.

Bundesamt für Statistik, 2022. Bruttowertschöpfung nach Branchen. BFS-Nummer: gr-d-04.02.03.01-iwm. Bern: Bundesamt für Statistik. Verfügbar über: https://www.bfs.admin.ch/bfs/de/home/statistiken/querschnittsthemen/wohlfahrtsmessung/gueter/oekonomische-gueter/branchenstruktur.assetdetail.23184450.html (zuletzt abgerufen am 31.07.2023).

Bundesamt für Statistik, 2023. Internetzugang der Haushalte. Bern: Bundesamt für Statistik. BFS-Nummer: ind-d-30109. Verfübar über: https://www.bfs.admin.ch/asset/de/ind-d-30109 (zuletzt abgerufen am 31.07.2023).

Bundesamt für Statistik, Bundesamt für Raumentwicklung ARE, 2017. Datensatz: Mikrozensus Mobilität und Verkehr 2015. Datenzugang über: https://www.are. admin.ch/are/de/home/mobilitaet/grundlagen-und-daten/mzmv/datenzugang.html (zuletzt abgerufem am 31.07.2023).

Bundesamt für Statistik, Amt für Raumentwicklung ARE, 2023. Mobilitätsverhalten der Bevölkerung. Ergebnisse des Mikrozensus Mobilität und Verkehr 2021. Neuchâtel: Bundesamt für Statistik. BFS-Nummer: 840-2100.

Bundesamt für Strassen ASTRA, 2019. Strassen und Verkehr 2019 - Entwicklungen, Zahlen, Fakten. Bern: Bundesamt für Raumentwicklung. Verfügbar über: https://www.astra.admin.ch/astra/de/home/dokumentation/strassen-verkehr/archiv.html (zuletzt abgerufen am 31.07.2023)

Bundesamt für Strassen ASTRA, 2021. Strassen und Verkehr 2020 - Entwicklungen, Zahlen, Fakten. Bern: Bundesamt für Raumentwicklung. Verfügbar über: https://www.astra.admin.ch/astra/de/home/dokumentation/strassen-verkehr/archiv.html (zuletzt abgerufen am 31.07.2023)

Bundesamt für Strassen ASTRA, 2022. Strassen und Verkehr 2022 - Entwicklungen, Zahlen, Fakten. Bern: Bundesamt für Raumentwicklung. Verfügbar über: https://www.astra.admin.ch/astra/de/home/dokumentation/strassen-verkehr.html (zuletzt abgerufen am 31.07.2023)

Bundesamt für Umwelt BAFU, 2023. Kenngrössen zur Entwicklung der Treibhausgasemissionen in der Schweiz 1990–2021. Verfügbar über: www.bafu.admin.ch/latest-ghg-inventory (zuletzt abgerufen am 31.07.2023).

Bundesrat, 2021. Langfristige Klimastrategie der Schweiz. Verfübar über: https://unfccc.int/process/the-paris-agreement/long-term-strategies (zuletzt abgerufen am 31.07.2023).

Bundesrat, 2023. Auswirkungen der Covid-19-Pandemie auf die Kostenträger im Gesundheitswesen Schlussbericht des Bundesrates in Erfüllung des Postulates 20.3135 SGK-SR vom 21. April 2020. Verfübar über: https://www.bag.admin.ch/bag/de/ home/das-bag/publikationen/ bundesratsberichte.html (zuletzt abgerufen am 31.07.2023).

Cook, S., Stevenson, L., Aldred, R., Kendall, M., Cohen, T., 2022. More than walking and cycling: What is "active travel"? Transport Policy 126, 151–161.

Creutzig, F., Jochem, P., Edelenbosch, O.Y., Mattauch, L., van Vuuren, D.P., McCollum, D., Minx, J., 2015. Transport: A roadblock to climate change mitigation? Science 350, 911-912.

Creutzig, F., Roy, J., Lamb, W.F., 2018. Towards demand-side solutions for mitigating climate change. Nature Climate Change 8, 260–263.

Dubois, G., Sovacool, B., Aall, C., Nilsson, M., Barbier, C., Herrmann, A., Bruyère, S., Andersson, C., Skold, B., Nadaud, F., Dorner, F., Moberg, K.R., Ceron, J.P., Fischer, H., Amelung, D., Baltruszewicz, M., Fischer, J., Benevise, F., Louis, V.R., Sauerborn, R., 2019. It starts at home? Climate policies targeting household consumption and behavioral decisions are key to low-carbon futures. Energy Research & Social Science 52, 144-158.

Elldér, E., 2020. Telework and daily travel: new evidence from Sweden. Journal of Transport Geography 86, 102777.

Elldér, E., 2022. Active travel and telework in Sweden: teleworkers walk more, but cycle less. Transportation Research Part D: Transport and Environment 109, 103362.

Fernandes, P., Vilaça, M., Macedo, E., Sampaio, C., Bahmankhah, B., Bandeira, J.M., Guarnaccia, C., Rafael, S., Fernandes, A.P., Relvas, H., Borrego, C., Coelho, M.C., 2019. Integrating road traffic externalities through a sustainability indicator. Science of the Total Environment 691, 483-498.

Franzen, A., Wöhner ,F., 2021a. Coronavirus risk perception and compliance with social distancing measures in a sample of young adults: Evidence from Switzerland. PLoS ONE 16(2), e0247447.

Franzen, A., Wöhner, F., 2021b. Fatigue during the COVID-19 pandemic: Evidence of social distancing adherence from a panel study of young adults in Switzerland. PLoS ONE 16(12), e0261276.

He, S.Y., 2013. Does flexitime affect choice of departure time for morning home-based commuting trips? Evidence from two regions in California. Transp. Policy 25, 210–221.

Hertwich, E.G., Peters, G.P., 2009. Carbon Footprint of Nations: A Global, Trade-Linked Analysis. Environmental Science & Technology 43(16), 6414-6420.

Hook, A., Court, V., Sovacool, B.K., Sorrell, S., 2020. A systematic review of the energy and climate impacts of teleworking. Environmental Research Letters 15, 093003.

IPCC - Intergovernmental Panel on Climate Change, 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (hrsg.)]. Geneva: Intergovernmental Panel on Climate Change.

IPCC - Intergovernmental Panel on Climate Change, 2023. Climate Change 2023: Synthesis Report. Summary for Policymakers. A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (hrsg.)]. Geneva: Intergovernmental Panel on Climate Change.

Ivanova, D., Stadler, K., Steen-Olsen, K., Wood, R., Vita, G., Tukker, A., Hertwich, E.G., 2015. Environmental Impact Assessment of Household Consumption. Journal of Industrial Ecology 20(3), 526-536.

Ivanova, D., Barrett, J., Wiedenhofer, D., Macura, B., Callaghan, M., Creutzig, F., 2020. Quantifying the potential for climate change mitigation of consumption options. Environmental Research Letters 15, 093001.

Iyer, G., Ou, Y., Edmonds, J., Fawcett, A.A., Hultman, N., McFarland, J., Fuhrman, J., Waldhoff, S., McJeon, H., 2022: Ratcheting of climate pledges needed to limit peak global warming. Nature Climate Change 12, 1129-1135.

Keller, M., 2019. Staukosten Schweiz 2015. Bern: Bundesamt für Raumentwicklung ARE. Verfügbar über: https://www.are.admin.ch/are/de/home/medien-und-publikationen/publikationen/verkehr/staukosten-schweiz-2015-schlussbericht.html (zuletzt abgerufen am 29.07.2023).

Ling, G.H.T., Ho, C.M.C., 2020. Effects of the Coronavirus (COVID-19) Pandemic on Social Behaviours: From a Social Dilemma Perspective. Technium Social Sciences Journal 7(1), 312-320.

Matthes, K.L., Floris, J., Hartmann, C., Burnier, M., Bochud, M., Bührer, T.W., Reber, E., Stanga, Z., Gültekin, N., Zwahlen, M., Bender, N., Staub, K., 2020. Das Gewicht der Schweiz. Eine quantitative Synthesestudie zum Body Mass Index und Bauchumfang sowie den damit verbundenen Kofaktoren bei erwachsenen Männern und Frauen in der Schweiz. Verfübar über: https://www.bag.admin.ch/bag/de/ home/das-bag/publikationen/ forschungsberichte/forschungsberichte-ernaehrung-bewegung.html (zuletzt abgerufen am 31.07.2023).

McKay, D.I.A., Staal, A., Abrams, J.F., Winkelmann, R., Sakschwski, B., Loriani, S., Fetzer, I., Cornell, S.E., Rockström, J., Lenton, T.M., 2022. Exceeding 1.5°C global warming could trigger multiple climate tipping points. Science 377, eabn7950.

Meissner, J.O., Weichbrodt, J., Hübscher, B., Baumann, S., Klotz, U., Pekruhl, U., Gisin, L., Gisler, A., 2016. Flexible neue Arbeitswelt. In: Eine Bestandsaufnahme auf gesellschaftlicher und volkswirtschaftlicher Ebene. Zürich: vdf Hochschulverlag AG an der ETH-Zürich.

Merom, D., van der Ploeg, H.P., Corpuz, G., Bauman, A.E., 2010. Public health perspectives on household travel surveys: Active travel between 1997 and 2007. American Journal of Preventive Medicine 39 (2), 113–121.

Mokhtarian, P., 1991. Telecommuting and travel: state of the practice, state of the art. Transportation 18(4), 319–342.

Mokhtarian, P.L., Salomon, I., 2001. How derived is the demand for travel? Some conceptual and measurement considerations. Transportation Research Part A: Policy and Practice 35, 695-719.

Mokhtarian, P.L., Salomon, I., Redmond, L.S., 2001. Understanding the demand for travel: It's not purely „Derived". Innovation: The European Journal of Social Science Research 14(4), 355-380.

Mueller, N., Rojas-Rueda, D., Cole-Hunter, T., de Nazelle, A., Dons, E., Gerike, R., Götschi, T., Panis, L.I., Kahlmeier, S., Nieuwenhuijsen, M., 2015: Health impact assessment of active transportation: A systematic review. Preventive Medicine 76, 103-114.

Nivette, A., Ribeaud, D., Murray, A., Steinhoff, A., Bechtiger, L., Hepp, U., Shanahan, L., Eisner, M., 2021. Non-compliance with COVID-19-related public health measures among young adults in Switzerland: Insights from a longitudinal cohort study. Social Science & Medicine 268, 113370.

Rudert, S.C., Janke, S., 2021. Following the crowd in times of crisis: Descriptive norms predict physical distancing, stockpiling, and prosocial behavior during the COVID-19 pandemic. Group Processes & Intergroup Relations 25(7), 1819–1835.

Salomon, I., 1986. Telecommunications and travel relationships: a review. Transportation Research Part A 20(3), 223–238.

Santos, G., Behrendt, H., Maconi, L., Shirvani, T., Teytelboym, A., 2010. Part I: Externalities and economic policies in road transport. Research in Transportation Economics 28, 2–45.

Saunders, L.E., Green, J.M., Petticrew, M.P., Steinbach, R., Roberts, H., 2013. What Are the Health Benefits of Active Travel? A Systematic Review of Trials and Cohort Studies. PLoS ONE 8(8): e69912.

Saxena, S., Mokhtarian, P.L., 1997. The impact of telecommuting on the activity spaces of participants. Geographical Analysis 29 (2), 124–144.

Schneider, H., Venetz, W., 2014. Cost of obesity in Switzerland 2012. Studie im Auftrag des BAG. Bern: Bundesamt für Geszundheit BAG.

Schweizerische Eidgenossenschaft, 2020a. Verordnung 2 über Massnahmen zur Bekämpfung des Coronavirus (COVID-19) vom 13. März 2020. AS Referenz: 2020 773. Verfügbar über: https://www.fedlex.admin.ch/eli/oc/2020/141/de (zuletzt abgerufen am 31.07.2023).

Schweizerische Eidgenossenschaft, 2020b. Verordnung 2 über Massnahmen zur Bekämpfung des Coronavirus (COVID-19). Änderung vom 16. März 2020. AS Referenz: AS 2020 783. Verfügbar über: https://www.fedlex.admin.ch/eli/oc/2020/144/de (zuletzt abgerufen am 31.07.2023).

Schweizerische Eidgenossenschaft, Schweizerische Konferenz der kantonalen Gesundheitsdirektorinnen und -direktoren (GDK), Gesundheitsförderung Schweiz. Massnahmenplan zur Nationalen Strategie Prävention nichtübertragbarer Krankheiten (NCD-Strategie) 2017–2024, Bern, 2016.

Sorrell.S., 2007. The Rebound Effect: an assessment of the evidence for economy-wide energy savings from improved energy efficiency. A report produced by the Sussex Energy Group for the Technology and Policy Assessment function of the UK Energy Research Centre. (ISBN: 1-903144-0-35)

UNFCCC - United Nations Framework Convention on Climate Change, 2015. Adoption of the Paris Agreement Report No. FCCC/CP/2015/L9/Rev.1. United Nations Framework Convention on Climate Change.

Van Bavel, J.J., Baicker, K., Boggio, P.S., Capraro, V., Cichocka, A., Cikara M., Crockett, M.J., Crum, A.J., Douglas, K.M., Druckman, J.N., Drury, J., Dube, O., Ellemers, N., Finkel, E.J., Fowler, J.H., Gelfand, M., Han, S., Haslam, S.A., Jetten, J., Kitayama, S., Mobbs, D., Napper, L.E., Packer, D.J., Pennycook, G., Peters, E., Petty, R.E., Rand, D.G., Reicher, S.D., Schnall, S., Shariff, A., Skitka, L.J., Smith, S.S., Sunstein, C.R, Tabri, N., Tucker, J.A., van der Linden, S., van Lange, P., Weeden, K.A., Wohl, M.J.A., Zaki, J., Zion, S.R., Willer, R., 2020. Using social and behavioural science to

support COVID-19 pandemic response. Nature Human Behaviour 4: 460–471.

WHO - World Health Organization, 2010. Global Recommendations on Physical Activity for Health. Geneva: World Health Organization (ISBN: 9789241599979).

WHO - World Health Organization, 2020a. WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. Abgerufen über: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—11-march-2020 (zuletzt abgerufen am 31.07.2023).

WHO - World Health Organization 2020b: Coronavirus disease 2019 (COVID-19) Situation Report – 73 (2 April 2020). World Health Organization. Verfügbar über: https://apps.who.int/iris/handle/10665/331686 (zuletzt abgerufen am 31.07.2023).

WHO - World Health Organization, 2021. Looking back at a year that changed the world: WHO's response to COVID-19. Geneva: World Health Organization.

WHO - World Health Organization, 2023. WHO Director-General's opening remarks at the media briefing – 5 May 2023. Abgerufen über: https://www.who.int/news- room/speeches/item/who-director-general-s-opening-remarks-at-the-media-briefing—5-may-2023 (zuletzt abgerufen am 31.07.2023).

Wieser, S., Tomonaga, Y., Riguzzi, M., Firscher, B., Telser, H., Pletscher, M., Eichler, K., Trost, M., Schwenkglenks, M., 2014. Die Kosten der nichtübertragbaren Krankheiten in der Schweiz - Schlussbericht. Bern: Bundesamt für Gesundheit.

Wöhner, F., 2022. Work flexibly, travel less? The impact of telework and flextime on mobility behavior in Switzerland. Journal of Transport Geography 102, 103390.

Wöhner, F., 2023. Work flexibly, travel more healthily? How telework and flextime affect active travel in Switzerland. Transportation Research Part A: Policy and Practice 174, 103748.

Woodcook, J., Banister, D., Edwards, P., Prentice, A.M., Roberts, T., 2007. Energy and transport. Lancet 370, 1078-1088.

Danksagung

Zum Schluss möchte ich mich bei allen bedanken, die mich bei meinem Promotionsvorhaben unterstützt haben. Zuallererst spreche ich meinem Betreuer Prof. Dr. Axel Franzen grossen Dank aus. Er stand mir fortlaufend zur Seite und hat mir durch seine hilfrechen Hinweise und sein ehrliches Feedback geholfen, mich weiterzuentwickeln und voranzukommen. Ausserdem hat er mich ermuntert, mein Wissen in verschiedenen Summer Schools zu erweitern und meine Arbeit auf unterschiedlichen Konferenzen zu diskutieren. Ohne seine kontinuierliche Unterstützung wäre diese Dissertation nicht möglich gewesen. Ebenfalls danke ich Prof. Dr. Roger Berger für die motivierenden Gespräche und dafür, dass er sich als mein Zweitgutachter zur Verfügung gestellt hat. Dank gebührt auch meinen Kollegen und Kolleginnen für das Schaffen eines positiven Promotionsumfelds. Dankeschön an die UniBern Forschungsstiftung und die IMG Stiftung für die finanzielle Förderung meiner Teilnahme an verschiedenen Summer Schools im In- und Ausland. Die dort gerlenten Inhalte konnten gewinnbringend in dieser Dissertation angewandt werden. Ausserdem danke ich dem Bundesamt für Statistik und dem Amt für Raumentwicklung ARE für die Bereitstellung der Daten und für das Intersse an meinen Forschungsergebnissen. Dem Mensa-Team spreche ich meinen Dank für die feine Verpflegung und die freundlichen Begegnungen aus. Meinen Freundinnen und Freunden aus der Schweiz, aus Leipzig, aus dem PC-Pool und aus meiner Heimat bin ich für ihre aufbauenden, motivierenden und inspirierenden Worte dankbar. Ein besonderes Dankeschön gilt meinen Eltern, meiner Oma und meiner Schwiegerfamilie für ihre liebevolle Unterstützung und dafür, dass sie immer an mich glauben. Schliesslich danke ich von Herzen meinen Partner Christian, der während meiner Promotion immer hinter mir stand und mich mit viel Geduld ermutigt hat, über mich hinauszuwachsen.

Selbstständigkeitserklärung

Ich erkläre hiermit, dass ich diese Arbeit selbstständig verfasst und keine anderen als die angegebenen Quellen benutzt habe. Alle Koautorenschaften sowie alle Stellen, die wörtlich oder sinngemäss aus Quellen entnommen wurden, habe ich als solche gekennzeichnet. Mir ist bekannt, dass andernfalls der Senat gemäss Artikel 36 Absatz 1 Buchstabe o des Gesetzes vom 5. September 1996 über die Universität zum Entzug des aufgrund dieser Arbeit verliehenen Titels berechtigt ist.

Bern, 8. August 2023

Fabienne Wöhner