The Taming of the Flu

Spatial patterns of influenza-like illness and the challenges and opportunities in immunisation on a city level

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Nina Goldman

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The geographic contribution. The geographic contribution to this project consisted of a large-scale household survey carried out in collaboration with the above-mentioned institutions. It was distributed across ten urban quarters of Basel, making this the largest influenza survey conducted in Switzerland to date. The survey helped to understand the spatial patterns of influenza-like illness (ILI) and vaccinated individuals within an urban context, and to determine which factors influence an individual's likelihood of getting an ILI or being vaccinated. Additionally, it helped to find factors that may determine an individual's willingness to be vaccinated and in what ways vaccination behaviour varies among different population groups.

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Abstract

Seasonal influenza is a preventable, often underestimated infectious disease. In Switzerland, it causes between 1,000 and 5,000 hospitalizations and about 400-1,500 deaths annually. Vaccination is the most effective strategy to reduce virus transmission and decreases the severity of influenza, number of complications and deaths. Yet, public confidence of influenza vaccines is decreasing which leads to reductions in vaccination rates thereby limiting its effectiveness. Community variation in attitudes, beliefs and behaviours about influenza vaccination have been identified as an important issue, as well as the lack of comprehensive assessment of community opinions and behaviours related to vaccination. For this study, which is part of a large interdisciplinary project funded by the Swiss National Science Foundation, we distributed 30,000 questionnaires (return rate 27.2%) in ten urban quarters of Basel, making this the largest survey on influenza undertaken so far in Switzerland. We aimed to understand (1) the spatial patterns of influenza-like illness (ILI) and vaccinated individuals within an urban context, and to determine which factors influence an individual's likelihood of getting an ILI or being vaccinated, and (2) which factors may determine an individual's willingness to be vaccinated and in what ways vaccination behaviour varies among different population groups. This study could show that there is high spatial variability of vaccinated and sick individuals. The main barriers towards an influenza vaccination seem to be false ideas about the vaccination, how the immune system works and many feel the flu is not dangerous enough to vaccinate against it. Studying influenza is useful as it can also help to understand other pandemics, such as the current Covid-19 pandemic.

Executive summary

Influenza is a highly transmittable infectious disease causing acute respiratory infection and is often underestimated. In Switzerland, influenza causes between 1,000 and 5,000 hospitalisations and approximately 400-1,500 deaths annually both from the virus itself and from complications such as secondary bacterial infections. On a global scale factors such as global population growth, high population densities, high rates of urbanisation and the dramatic increase in human mobility all contribute to an increase in the spread of influenza. The last influenza pandemic swept the globe in 2009 (Influenza A/California/7/2009 H1N1) but the current Severe Acute Respiratory Syndrome Coronavirus Type 2 (SARS-CoV-2) pandemic is a strong reminder how fast infectious diseases can emerge and spread. Vaccination is the most effective strategy to reduce virus transmission and decreases the severity of influenza, number of complications and deaths. Yet, public confidence in influenza vaccines is decreasing which leads to reductions in vaccination rates thereby limiting its effectiveness. This study has a high and direct relevance for the population of Basel, because influenza infection is very common within the population and an infection is associated with high morbidity, mortality and health care costs. In addition, epidemic peaks can lead to an overstrain of medical institutions. Therefore, it is vital to lower the infection rates of influenza.

To this end, this study wanted to understand (1) the spatial patterns of influenza-like illness (ILI) and vaccinated individuals within an urban context, and to determine which factors influence an individual's likelihood of getting an ILI or being vaccinated, and (2) which factors may determine an individual's willingness to be vaccinated and in what ways vaccination behaviour varies among different population groups. To achieve this, 30,000 questionnaires (return rate 27.2%) were distributed in ten Basel quarters, making this the largest influenza survey conducted in Switzerland to date. The survey covered topics on incidences and severity of illness, health related behaviours, opportunities for exposure in close contact environments, aspects of the city environment, procurement of health information and personal data.

To achieve the aims a wide array of methods were combined. GIS-assisted disease mapping, GIS-assisted multilayer spatial analysis and the Kernel Density Estimates (KDE) were used to find spatial patterns of ILI and vaccinated individuals. Binary logistic regression analysis was conducted to find factors that influence an individual's likelihood of getting an ILI or being vaccinated. And descriptive analysis in the form of cross tabulations and frequency tables, including confidence intervals, were used to determine an individual's propensity to get vaccinated and study the vaccination behaviour of different population groups, especially the risk group and the vaccination target group.

Results showed, that both ILI and self-reported vaccination rates were highly variable on the quarter level, with high rates of ILI in quarters where the vaccination rate was low. Across the general population the vaccination rate for seasonal influenza was significantly below the vaccination aim set out by the Federal Office of Public Health (FOPH). Even the risk group, which had the highest vaccination rates, was far below the vaccination target. The most common stated reasons for not getting a vaccination, regardless of gender or population sub group, were strengthening their immune system with alternative means, not knowing why one should get vaccinated and not believing in its effectiveness. The respondents who were ≥65 years old, non-Swiss, health care workers or had a chronic illness were more likely to be vaccinated, whereas respondents who regularly engaged in physical activity or felt exposed to negative environmental influences at home were less likely to be vaccinated. Daily smoking was the only predictor that increased the likelihood of an ILI, whereas being vaccinated or 65 years or older decreased the likelihood. Alternative vaccination locations seem to be especially important for those without a general practitioner and for those who have never had an influenza vaccination. But still, the medical practice was the main place of vaccination across the study area and remains the most important vaccination location. This study further showed the importance of health professionals as vaccination propagators. They are also considered a reliable and trusted source for health-related information by a majority of the study population.

In conclusion, this study could show that there is high spatial variability of vaccinated and sick individuals. The main barriers towards an influenza vaccination seem to be false ideas about the vaccination, how the immune system works and many feel the flu is not dangerous enough to vaccinate against it. Putting disease incidences into a spatial context contributes to the understanding of transmission paths of influenza within urban populations. Therefore, studying influenza is useful as it can also help to understand other pandemics, such as the current Covid-19 pandemic. This study also filled many gaps concerning estimations of ILI in the general population as well as vaccination behaviour of the general population, the risk group and vaccination target group in an urban context. The findings of this study may provide the basis for developing tailored public health strategies, which target specific urban quarters by strengthening and enhancing vaccination recommendations.

Acronyms and Abbreviations

COVID19	Coronavirus Infectious Disease 2019
FOPH	Federal Office of Public Health (DE: Bundesamt für Gesundheit BAG)
FSO	Federal Statistical Office
GIS	Geographic Information System
ILI	Influenza-like illness
KDE	Kernel Density Estimation
OBSAN	Swiss Health Observatory
OLS regression	Ordinary least square regression
SARS-CoV2	Severe Acute Respiratory Syndrome Coronavirus Type 2
SES	Socio-economic status
WHO	World Health Organization

Glossary

Basel	refers to the city of Basel
Basel-City	refers to the canton of Basel-City
Influenza incidence	Number of cases per 100,000 inhabitants; based on the number of cases per doctor-patient contact
ILI	self-reported Influenza-like illness according to the WHO definition, defined as 1) measured fever of ≥ 38 ° C; 2) a cough; and 3) incapacitated for 1-10 days
Risk group	Persons with an increased risk of getting influenza, defined as individuals 65 years or older and/or having a specific chronic illness that puts them at higher risk
Target group	Risk group + individuals who work in health care, work with children, frequently visit hospital or retirement homes
Vaccine pharmacy	A pharmacy which allows pharmacists with additional training in vaccination to vaccinate their customers directly at the pharmacy. Basel-City started to implement this in May 2018.

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Part I – Introduction and Theoretical Background

“Healthy citizens are the greatest asset any country can have.”

- Winston Churchill, 1943

1 Introduction

Background. Globally, it is estimated that 1 billion people get influenza every year, of which 3-5 million need to be hospitalised of whom 290,000-650,000 ultimately die from influenza or its consequences (IULIANO ET AL. 2018). Within EU/EEA countries influenza has the highest disease burden, compared to 30 other human infectious diseases (CASSINI ET AL. 2018). Studying influenza is useful as it can help to understand other pandemics, such as the current COVID-19 pandemic. The geographic variation of seasonal influenza incidences has been studied at varying geographic scales ranging from global (BLOOM-FESHBACH ET AL. 2013; TAMERIUS ET AL. 2013), to country scale (YU ET AL. 2013) or the regional and city level (MAO, BIAN 2010; Rodríguez-Rieiro 2011). The influenza vaccine uptake has been examined for various population groups and different settings around the world (BISCH ET AL. 2011; MERECKIENE ET AL. 2008; LIN ET AL. 2011; MAK ET AL. 2010) and many have tried to understand why people are reluctant to accept an influenza vaccination (JARRETT ET AL. 2015; LARSON ET AL. 2014; SCHMID ET AL. 2017; STRELITZ ET AL. 2015).

Rarely if ever have geographic distribution patterns of influenza been studied in a city context although most people world-wide live in urban environments (WHO 2010). The spatial distribution of influenza may also be related to geographical patterns of vaccination preparedness and the occurrence of herd immunity in an urban population. Studying vaccination behaviour is complex and depends on the vaccine, place and the time in question (WHO 2014). There is a lack of studies which analyse the spatial variation of influenza-like illness on the city scale which also provide an in-depth analysis on the vaccination determinants and behaviour of the general population, the vaccination target group and the at-risk group. Studies on the city scale often just focus on one aspect of seasonal influenza, e.g. with the vaccination uptake of the general population or specific subgroups or try to find determinants for vaccine barriers or study its spatial distribution. Studying the vaccination behaviour of various population groups may also help estimating potential vaccination barriers for COVID-19 vaccination.

1.1 Objectives and research questions

This study addresses the geographic distribution of influenza and aspects of the vaccination behaviour of the general population, the vaccination target group and the risk group in the context of urban quarters. The study wants to understand

1. the distribution patterns of influenza, influenza-like illness and vaccinated individuals within an urban context, using Basel as an example city, and determine which factors influence the likelihood of individuals to get an ILI.

2. which factors may determine an individual's propensity to get vaccinated and in what ways does the vaccination behaviour of different population groups vary.

To achieve this, a household survey (see appendix) for the general population was composed, in cooperation with the participating departments, to capture information on influenza-like illness, vaccination uptake, health-related behaviours, perceptions of own health and preventive measures, obtaining and perceived helpfulness of health information as well as personal information of the respondents (for details see EGLI ET AL. 2019) and 5.1.1 below. Additional data from statistics office Basel-City are added to explore the built and social environment, from the University Hospital Basel to explore the spread of PCR-confirmed influenza incidents (seasons 2013/14-2017/18) and from the Institute for Social and Preventative Medicine in Berne to explore the association between the Swiss index of socio-economic position (Swiss-SEP) and influenza incidents. All datasets are available at block-level to enable an analysis of influenza-like illness on the smallest city scale. Table 1 provides an overview of the objectives, research questions, and the methodological approaches.

Table 1 Overview of the objectives, research questions and approaches (own visualisation)

Objectives	Operationalisation - Research Questions	Methodological approach
Objective 1 Understand the distribution patterns of influenza, influenza-like illness, and vaccinated individuals within an urban context, using Basel as an example city, and determine which factors influence the likelihood of individuals to get an ILI.	**1.1** What is the spatial variation of ILI and influenza across the study area?	• GIS-assisted disease mapping of ILI incidence and vaccination rates • GIS-assisted multilayer spatial analysis of index on socio-economic position and the Kernel Density Estimates (KDE) of influenza incidences • Binary logistic regression analysis using ILI and vaccination as the dependent variables
	1.2 Which factors predict the likelihood of an individual to get an influenza-like illness?	
	1.3 What is the spatial distribution of seasonal vaccination rates across the study area for the target group and the general population?	
	1.4 Which factors predict the likelihood that an individual gets a seasonal influenza vaccination?	
Objective 2 Understand which factors may determine an individual's propensity to get vaccinated and in what ways does the vaccination behaviour of different population groups vary.	**2.1** What are the main reasons for the risk group, target group and the general population to decide for or against getting a seasonal influenza vaccination?	• Statistical analysis using frequency tables and cross tabulations, including 95% confidence intervals, Pearson's Chi^2 test, Cramer-V, Phi
	2.2 What are the differences in vaccination experience, perceptions of own health and health related behaviours between the risk group, the target group, and the general population?	
	2.3 Where do the risk group, target group, and general population obtain health information, and how do these groups perceive the helpfulness of this information?	

1.2 Relevance

The study contributes in various ways to current geographical health research, in the form of theoretical and methodological findings. The research questions are relevant in several ways.

1.2.1 Relevance of combining health and place

Influenza transmissions in a city context are responsible for "critical chains of transmission outside of peak climatic conditions, altering the spatiotemporal geometry of herd immunity" (DALZIEL ET AL. 2018:75), which highlights the importance of studying the spread of influenza-like illnesses and vaccination behaviour an urban context. This type of study can be placed within a long research tradition of combining health and place. Geospatial data and methods can add value to health research by spatialising medical and health data. An early example of this was put forward by John Snow in 1854, when he mapped cholera incidences by the living address of the infected individuals in London (KISTEMANN ET AL. 2019). This helped to identify certain communal pumps as the disease sources and thereby prevent the further spread of cholera (VANDENBROUCKE 2013). For other diseases, such as tuberculosis and pertussis, the burden could also be reduced by exactly mapping their occurrences and analysing the spatial patterns (KISTEMANN ET AL. 2019). This also applies to the current COVID-19 pandemic, where some public health policies that aim at limiting its spread, are based on spatial analysis of disease incidence. This includes measures such as having mandatory quarantine for individuals that have travelled to certain regions or countries which have been classified as risk areas (FOPH 2020A) or by imposing cantonal rules on wearing face masks based on the disease prevalence in that canton (FOPH 2020B).

Factors that increase influenza spread. Putting disease incidences into a spatial context contributes to the understanding of transmission paths of influenza within urban populations and is therefore of greater relevance. In our fast-changing world, three main factors foster the spread and evolution of viruses, e.g. the influenza virus. First, global population growth and higher population densities, especially in urban areas, influence transmission paths in two ways (ANDERSON 2016:6). People living in a city usually have dense contact networks, which can serve as a highway for influenza viruses, propelling their spread (MEADE, EMCH 2010). Thereby larger cities often act as a node for surrounding smaller cities or rural areas, making them the source of disease infection (GRENFELL ET AL. 2001). Every time a virus is transmitted to another person it may mutate, which results in higher rates of virus evolutions in areas with high transmission rates because of confrontations with multiple evolutionary bottlenecks and due to the immune response of each individual (ANDERSON 2016:6).

Second, high rates of urbanisation influence the spread and evolution of new viruses. From the past, we know many infectious diseases affecting humans originate from close contact with livestock or wild animals (so called zoonotic diseases). These interactions can happen in two ways: firstly, in cities, as livestock is used to feed the population and secondly, as people move into wild animal habitats, due to the increased pressure for housing. Both increase close contact opportunities (ANDERSON 2016:6). In the Western world and Asia, the close proximity of intensive livestock farms to densely populated areas is especially prominent (ROBINSON ET AL. 2011; SMIT, HEEDERIK 2017).

Third, the mobility of many people has increased dramatically. With air travel, the time spent on a journey has massively decreased and is now often shorter than the incubation period of many infectious diseases (ANDERSON 2016:8). This increases the threat of pandemics, which became very clear with the fast spread of Influenza A (H1N1) in 2009 (GOG ET AL. 2014; FRASER ET AL. 2009) and the recent COVID-19 pandemic.

Health inequalities. Disease mapping can also show if there is an unequal distribution of health, which is important when managing limited resources and allocating them to the places that need them most. A geographic approach also helps to visually highlight spatial disparities, which is not possible with non-georeferenced data. It can bring unexpected findings to people outside the field and can also include social and environmental determinants of health. Already in 1986, the Ottawa Charter for Health Promotion acknowledged that equity and social justice, among other things, are prerequisites for good health. But promoting health should not be the sole responsibility of the health sector as there are many factors that can benefit or harm good health outcomes (WHO 1986). Health inequalities are discussed in more detail in chapter 2.2.4.

1.2.2 Relevance for public health

The UN estimates that the global population living in cities will increase from 30% in 1950 to 66% by 2050 (UN 2014). This new influx of people into urban areas brings new challenges in disease prevention for public health authorities and will become one of the most important global health issues of this century (WHO 2010A). Globally, it is estimated that 1 billion people get influenza every year, of which 3-5 million need to be hospitalised eventually resulting in 290,000–650,000 deaths (IULIANO ET AL. 2018). Influenza poses a particularly high burden for low- and middle-income countries, which have higher death rates as a result of influenza infection (IULIANO ET AL. 2018). For high-income countries most influenza-related deaths occur in the age group >65 years (THOMPSON ET AL. 2009).

It is important to study influenza and influenza-like illnesses on a city scale as it is a highly transmittable infectious disease causing acute respiratory infection and is associated with substantial morbidity, mortality, and health care costs (CHEN ET AL. 2015). In the temperate climate zones, it shows seasonal patterns during the winter months, whereas in the tropical zone it occurs throughout the year (SHAW, PALESE 2011; VIBOUD ET AL. 2006). In Switzerland, more people die from influenza or influenza-related illnesses than in traffic accidents, despite having a well-established health care system (FOPH 2017A; FSO 2019A). Everyone can get influenza, but some people are more at risk than others. Influenza viruses are most easily transmitted in crowded areas, such as schools, public transport and nursing homes. People sneezing or coughing without covering their mouth and nose, project droplets containing the influenza virus up to one metre. People in close proximity can get infected if they inhale these droplets. Special care should also be taken when touching surfaces many people have touched, as contaminated hands can also spread the virus (WHO 2019a).

The Swiss influenza burden. In Switzerland, the FOPH sees seasonal influenza as a serious disease, which leads to 112,000-275,000 annual doctors' consultations (FOPH 2017C), causes between 1,000 and 5,000 hospitalisations and approximately 400-1,500 deaths annually (FOPH 2017A). These high variations in consultation and hospitalisation numbers make it very difficult to quantify the cost caused by seasonal influenza, which is why there are no reliable estimates (GSCHWEND ET AL. 2018). The influenza associated deaths are mainly due to secondary infections and complications which arise after an influenza infection (GORDON, REINGOLD 2018:1-2). Approximately, 90% of all influenza-related deaths can be attributed to the over 65-age group (FOPH 2019a), which highlights their vulnerability. With the help of the voluntary Sentinella surveillance system, the FOPH estimated that around 3% of the Swiss population, who had flu-like symptoms, were taken care of by their family doctor (FOPH 2016A). Small children, pregnant women, elderly people and patients with a chronic disease or prolonged immunosuppression show an increased risk of a poorer clinical course (KUMAR ET AL. 2009; KUMAR ET AL. 2010; MACHADO 2005). High influenza burdens can result in high medical costs and indirect costs through large numbers of people missing work or school, leading to large productivity losses. During influenza peaks medical institutions can become overstrained (WHO 2018A).

Influenza viruses adapt rapidly to the host immune system and happen through genetic polymorphisms (mutations). Due to the constant change, the virus can escape the targeted immune response and thereby create an opportunity to spread, causing epidemics every winter. As the annual immunological protection induced in each host is bypassed through viral adaptation, the virus-specific immunity is only short-lived, the frequency of influenza cases does not only depend on an individual but also on the population (herd immunity) as a whole (ENCYCLOPAEDIA BRITANNICA 2020A).

Studies on Influenza-like illness are often concerned with the spread and monitoring of ILI (e.g. CHARAUDEAU ET AL. 2014; FRIESEMA ET AL. 2009), the evaluation of a surveillance system, analysing correlations between commuting patterns and ILI rates (CHARAUDEAU ET AL. 2014) and the impact of influenza on various population groups (GLEZEN ET AL. 2000). This project has a high and direct relevance for the population of Basel, because influenza infection is a very common problem within the population and an infection is associated with high morbidity, mortality and health care costs (CHEN ET AL. 2015). In addition, epidemic peaks can lead to medical institutions becoming overstrained (WHO 2018A). Therefore, it is vital to lower the infection rates of influenza.

The risk of pandemics. The last century has seen four influenza pandemics, which have led to millions of deaths worldwide (FANNING 2010). The Federal Office for Civil Protection (FOCP) conducted a comprehensive national risk analysis and identified the dangers of a lack of electricity and a pandemic as the two greatest risks for Switzerland (FOCP 2015). A report analysed what would happen if a pandemic hit Switzerland and concluded that there are many inconsistencies and weaknesses between the various cantonal and national authorities regarding cooperation (RÜFELI ET AL. 2018). Unfortunately, our interconnected world does not give authorities a lot of time to prepare, which became evident when the COVID-19 pandemic swept over Switzerland (BURKHARDT 2020). Identifying disease hotspots might help prepare for future epidemics and pandemics. It is also important to understand lay persons' perceptions regarding the difference between influenza and common cold as misperceptions can lead to reduced vaccination rates (MAYRHUBER ET AL. 2018) as some individuals might not perceive influenza to be a severe illness. Statements such as "I've got the flu" should be made with care, as this could lead to misperception of influenza by the public, which can affect vaccination rates. Despite the lack of confidence by some people concerning influenza vaccines, they are still the best strategy to decrease the disease burden within a population. It might come as no surprise that opposition towards vaccines in general grew almost immediately after their introduction to the general population and therefore is not a new phenomenon (WOLFE, SHARP 2002). This study can provide the basis for developing tailored public health strategies, which target specific urban quarters by strengthening vaccination recommendations and services to match the needs of the quarters.

1.2.3 Relevance of understanding vaccine hesitancy

Effective vaccines. Vaccination is the most effective strategy to reduce virus transmission, decreases the severity of influenza and a number of complications and deaths (WHO 2018A). Yet, public confidence in influenza vaccines is decreasing which leads to reductions in vaccination rates (POLAND 2010) thereby limiting the effectiveness of the vaccine. To produce effective vaccines accurate predictions of the circulating strains are needed in advance and as these are only predictions, they are sometimes wrong (FITCH 1997; NEHER 2014; STEINBRUCK 2014). The Swiss Sentinella system or the FluID of the WHO can identify the circulating strains and record the dynamics during an influenza epidemic (FOPH 2019B; WHO 2019B). The influenza season 2014/15 was an impressive example of a wrong prediction resulting in an observed vaccination effectiveness of only 23% (95% CI [0.08, 0.36]) in the USA (ECDC 2015). Mispredictions like these do not foster public confidence in flu vaccines. In addition, Haralambieva et al. (2015) found that age significantly influences influenza-specific humoral immunity, leading to disturbances of the immune system, which can negatively influence the vaccination response. This is inauspicious, as people over 65 years have an increased risk of complications during an influenza outbreak and are therefore advised to get the influenza vaccination (FOPH 2017B).

Vaccination behaviour. The associated risks and behaviours concerning the influenza vaccine vary from year to year, between groups of different socio-economic status, targeted risk groups, persons from different cultural backgrounds and from community to community. This makes it difficult for public health authorities and clinical providers to develop effective emergency preparedness, communication strategies to educate the public and to tailor their services. Community variation in attitudes, beliefs and behaviours about influenza vaccination have been identified as an important issue, as is the lack of comprehensive assessment of community opinions and behaviours related to vaccination, and this also holds true for Switzerland and Basel (CIDRAP 2016). However, the varying effectiveness of the influenza vaccination as well as the requirement to annually renew the vaccine leads to vaccine hesitancy (WHO 2019A).

Improving vaccination campaigns. To better plan vaccination campaigns, it is essential to understand why individuals might hesitate in getting an influenza vaccination. Dubé et al. (2014) conducted a study of 13 countries and showed that vaccine hesitancy was prevalent in all and that the reasons for vaccine hesitancy varied depending on the country. This study could show that the local context is very important when trying to strengthen national vaccination programs. The WHO Strategic Advisory Group of Experts (SAGE) also recognize that vaccine hesitancy is a complex phenomenon and depends on the vaccine, place and the time in question (WHO 2014). There is a lack of studies which analyse the spatial variation in people not getting the influenza vaccine. Delamater et al. (2018) explore the spatiotemporal evolution of vaccine refusal and focus on nonmedical exemptions from vaccination. They concluded that there was spatial clustering of vaccine refusers, but these were mostly isolated regions. Therefore, it might be possible to also detect spatial variation of people not getting influenza vaccinations in Basel. Understanding peoples' reluctance in Switzerland to the influenza vaccination is important, as the vaccination can reduce the heightened demands made on primary care facilities, hospitals and clinical laboratories during an epidemic or pandemic (CRAWFORD ET AL. 2010; WHO 2018A).

1.2.4 Relevance of understanding vaccination uptake

In years where the vaccinated influenza strain does not closely match the circulating strain, the vaccination effectiveness is strongly reduced leading to a decrease in public confidence for the flu vaccine. In the United States of America this was the case for the season 2003/04 (CDC 2004). However, this is not limited to single seasons but seems to be generally true. Chan et al. (2018) have found that over a 17-year period, there has been frequent antigenic mismatch between the influenza vaccines and the circulating influenza viruses. Often it takes more than one year for a circulating strain to be identified and included in the influenza vaccine. There are many studies that discuss vaccination uptake (e.g. BISH ET AL. 2011; BÖHMER ET AL. 2011A; GUTHMANN ET AL. 2012; LIN ET AL. 2010; MAK ET AL. 2009; MERECKIENE ET AL. 2008; SCHMID ET AL. 2017) or virus evolution and transmission pathways (e.g. BRUGGER,

ALTHAUS 2018; GHEDIN ET AL. 2005; PYBUS et al. 2015), yet few seem to address geographic area variables of the people. Often spatial analysis of influenza or influenza-like illnesses are confined to a large-scale, as there is no fine resolution data (LINARD, TATEM 2012). The present study design ties in with this point, as it assigns the survey data on influenza-like illness and vaccination to small-scale geographic areas. This enables a statistical as well as a spatial analysis of the data. So far, no systematic analysis of the influenza vaccination target group could be identified. Most studies on vaccination target groups consist mainly in highlighting a change in definition of who should be vaccinated (OHFUJI ET AL. 2007) or describing how many people belong to the target group, what age/gender they are comprised of and their vaccination rates (e.g. BLANK ET AL. 2009; WIESE-POSSELT ET AL. 2006; WHO 2016A). In addition, the results of this study will deliver useful information on vaccination behaviour with regard to socio-economic and socio-spatial structures and may inform future vaccination campaigns.

1.3 Working definitions

One of the aims of the *National Strategy for the Prevention of Seasonal Influenza* (GRIPS) is the vaccine promotion amongst people with an increased risk of complications and their close contacts (FOPH 2014A). To this end this study also focused on these two groups and gives the definitions of further key terminology.

Risk group includes respondents who are 65 years and older and have a particular chronic illness. They are defined as the risk group because they more often have increased rates of complications when they contract influenza. People over 65 years also show higher rates for influenza related deaths (BARKER 1986; BARKER, MULLOOLY 1980; THOMPSON ET AL. 2009). With the help of the WHO Anatomical Therapeutic Chemical (ATC) classification system, the group from the University Hospital Basel could infer what kind of chronic illness the respondents had, based on their self-declared drug intake. The first level of the ATC classification system divides the drugs into 14 different anatomical or pharmacological groups, depending on the organ or system in the body on which they act (WHO 2021). Based on the ATC-classification the respondents were then identified as either being at increased risk if infected with influenza or not. Due to their increased risk of complications, individuals of the risk group are strongly advised to get an influenza vaccination every year (FOPH 2017B). Respondents of the **non-risk group** refers to all respondents minus those who are classified as the risk group.

Target group. The definition of the target group in this study is taken from the FOPH. They define the target group as individuals who are in the risk group (points 1., 2. below) and individuals who have frequent contact with this group (points 3.-5. below) (FOPH 2017B). With the available data from the household survey, the target group is thus defined as:

1. Respondents over 65 years of age
2. Respondents with a particular chronic illness (based on ATC-classification)
3. Respondents working in the health sector with patient contact
4. Respondents working with children (kindergarten, playgroup, day care, school, etc.)
5. Respondents who frequently visit persons in hospitals or retirement homes

This definition does not include pregnant women, or women who have delivered in the past 4 weeks and premature babies from the age of 6 months, who also belong to the target group by the FOPH definition. This categorisation of target group is very similar to Böhmer et al. (2011b) and Blank et al. (2009). Respondents of the **non-target group** refers to all respondents minus those who are classified as the target group.

General population. When this study mentions the general population, it refers to the entirety of respondents who participated in the household survey, the reason being, that a statistically significant number of questionnaires were returned to be representative of the general population. Naturally, some biases are unavoidable and are discussed in detail in chapter 6.1.

Influenza-like illness. As people who are infected with influenza often have similar symptoms it has led to the development of the influenza-like illness concept. This is a way of indirectly estimating the influenza burden of a population without having to take live samples (e.g. nasal swabs) from the population and have them tested in a laboratory (WIDDOWSON, MONTO 2013: 251). It should also be considered, that an individual presenting an ILI may have one of many other respiratory viruses that are not influenza, “e.g. respiratory syncytial virus, human metapneumovirus, and adenovirus” (HAYDEN, DE JONG 2013:384). Also, collecting data on ILI does not allow for any estimation on vaccine effectiveness, as this requires identification of actual influenza infection (WIDDOWSON, MONTO 2013:251). Nonetheless, working with ILI data is still useful as the data can easily be collected from individuals, as no laboratory testing is required and it still provides a good enough estimation of the influenza burden of a community or country. For this study, the ILI definition from the World Health Organization (WHO) is used and is defined as having 1) measured fever of ≥ 38 ° C; 2) a cough; and 3) onset within the last ten days (WHO 2014). As we cannot determine the onset, we included “incapacitated for 1-10 days” as the third criteria.

Influenza. The most specific and sensitive approach to diagnose an influenza virus infection is by the polymerase chain reaction (PCR) assay, which is a “rapid and sensitive method for detecting the genetic material of influenza viruses, and is now the first-choice laboratory test for influenza infection in both humans and animals” (WHO 2011A:2). Without this laboratory testing the clinical diagnosis of influenza is very difficult, as there are strong similarities to several other respiratory viruses that may be circulating simultaneously (ZAMBON 2013:233).

The best predictive signs for influenza are patients with a cough and fever (MONTO ET AL. 2000:3244; ZAMBON 2001:2120). Clinical diagnosis of influenza is also important to manage care of patients. Whenever, this study mentions influenza, it will always refer to PCR-confirmed influenza cases.

1.4 Data and methodological approach

To identify the complex interrelationships between health-related behaviours, socio-economic determinants, influenza-like illnesses and urban quarters, the analysis is divided into two parts. The data for these analyses comes from different sources. First, there is block level data on selected socio-economic and urban environment variables from the statistics office of Basel-City and the Swiss National Cohort. These datasets allow an understanding of the physical structure of the urban quarters and their social environment at the small scale of the building block as it varies among and between urban quarters. Secondly, a household survey was conducted, which was the largest survey on influenza in Switzerland. This allows identification of behavioural patterns related to influenza-like illness and vaccination. As such, this study brings together urban environmental statistical and behavioural survey data.

Analysis part 1 – Identifying urban quarter effects of influenza-like illnesses and health-related behaviours. GIS assisted analyses of spreading patterns of influenza blended with statistical data are designed to determine close contact environments (e.g. infrastructure in the quarter, population density, living density, housing density) and determinants in the urban social structure that may account for higher occurrences of influenza cases (such as age distribution, social life situations, education status, migration background, housing and living arrangements). To determine the place effect of different variables georeferenced data from the household survey was used. The analysis will start with spatial visualisations and analyses using ESRI's ArcGIS 10.6, a geographic information system, and combine the statistical data with the household survey data to get an overview of the dimensions and characteristics of the study area. Exploratory spatial analysis lets us discover underlying patterns in the data. Thanks to GIS it is possible to visualise these patterns by using quintile maps, percentile maps or kernel densities for example. However, the maps do not indicate whether the clusters of similar or dissimilar values are distributed non-uniformly across space. Waldo R. Tobler (1970) proposed his first law of geography, which stated that "[e]verything is related to everything else, but near things are more related than distant things" (236). This idea shows that there is a spatial dependence, i.e. it helps us to understand pattern distribution with relation to distance. We can use spatial-statistical methods, such as Moran's Index (further referred to as Moran's I) to operationalize this idea. Moran's I tests for spatial autocorrelation and is used to determine if the underlying pattern is random or not. The spatial analysis is important, as we assume that the data is spatially dependent, i.e. changing location will result in a change of variable value. In essence, the fundamental questions of geography are explored, as described by Meade and Emch (2010). Identifying the location of certain things in space, establishing if there is non-uniform distribution and, if so, trying to find reasons for their distribution by an integral analysis of the region.

Analysis part 2 – Identifying determinants of health-related behaviour, influenza-like illness and influenza vaccination. The main data source comes from an empirical study conducted across ten urban quarters of Basel (Am Ring, Bachletten, Bruderholz, Gotthelf, Gundeldingen, Iselin, Matthäus, Klybeck, Kleinhüningen, St. Johann), which is described in detail in Egli et al. (2019) and 5.1.1. (p.56). These quarters differ in their socio-economic, demographic and built environment (STATISTICAL OFFICE BASEL-CITY 2017A). The survey was distributed using the probability-proportional-to-size (PPS) sampling and the equal probability of selection method (EPSEM) so that each household had an equal probability of being selected. The central topics of the survey were influenza and common cold, health-related behaviours, aspects of the city environment, procurement of health information and personal data. The survey data will help to analyse what determines health related behaviour, especially vaccination behaviour, and influenza-like illnesses (ILI). It will also aim to identify quarter effects that may influence respondents' health related behaviour and the likelihood of getting an ILI. The results will be compared to the general population, the vaccination target group, and the risk group, which contains respondents who face an increased risk of complications if infected with influenza. The survey was distributed to a third of all households in the city (30,000) with a return rate of 27.2% (n=8149). The data is analysed using descriptive methods such as frequency tables and cross tabulations as well as analytical methods such as binary logistic regressions and odds ratios. The statistical analyses were performed using IBM SPSS Statistics 26 and visualised with Microsoft Excel 2016.

1.5 Thesis structure

Part I of the thesis outlines the conceptual and theoretical framework of the thesis. **Chapter 1** gives a brief overview of the topic, highlights the aims and research questions, discusses the relevance of the topic, shows what kind of data is used and how it is analysed and points to current knowledge gaps. **Chapter 2** explores central themes of health ranging from an individual level to the institutional level. Firstly, on an individual level, discussing various concepts of health, individual factors that determine health outcomes and the capability approach. Secondly, with a focus on the geographical aspect of health and how health data has found its way into geographic analyses. It is followed by a discussion on the development of social determinants of health and with a focus on how the city environment can affect health outcomes. **Chapter 3** deals with the medical aspect of influenza transmission and vaccination. It discusses previous pandemics as well as current seasonal epidemics. It also focuses on how influenza virus is transmitted and reproduces inside a host body. Following is an overview of current research on vaccination behaviour and the ethical consequences of a mandatory influenza vaccination. **Part II** gives an overview over the study area and the methodological approach. **Chapter 4** outlines the spatial context in which this study was conducted. It also presents and characterizes the quarters included in this study**. Chapter 5** outlines the various methodological approaches used in this study, ranging from exploratory analysis with GIS, to descriptive and analytical methods. **Part III** discusses the empirical results of this study. **Chapter 6** gives an overview of the characteristics of the sample. **Chapter 7** discusses the small-scale analysis of influenza-like illness and vaccination and its determinants. **Chapter 8** looks at the varying health behaviours between different population groups. **Part IV** holds the discussion and conclusion of this thesis, whereby **chapter 9** answers all the research questions and puts them in context with current literature in addition to identifying limitations and weaknesses of this study. **Chapter 10** will discuss how the findings can be integrated into urban immunisation programmes to increase vaccination rates and ILI prevention. It also includes some considerations and recommendations for those who also seek to conduct a high-volume paper and pen survey in a city context and finishes with some concluding remarks.

2 Combining multiple aspects to study influenza

This thesis is located at the intersection of medicine and geography and can be located within the subdisciplines of medical and health geography.

2.1 Health on an individual level

This chapter focuses on health from an individual's perspective and discusses various definitions of health, analyses different health related behaviours and their underlying theories, and concludes with the health capability approach.

2.1.1 Concepts of health

Definitions of health. Health can be defined in many ways. In its constitution, the World Health Organisation (WHO) defined health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (1948:1). At first this definition was highly influential, as it changed the perception of health to include a more integrated view and thereby changed many governmental approaches to health care (MEADE, EMCH 2010:18). So far, the WHO has not adapted this definition, which has led to increasing criticism (HUBER ET AL. 2011; JADAD, O'GRADY 2008; LARSON 1999; SMITH ET AL. 2009) especially as it classifies almost everyone as unhealthy and "unintentionally contributes to the medicalisation of society" (HUBER ET AL. 2011:2). Therefore, scientists are often left to redefine what constitutes health for their specific study, as the WHO definition is too broad. Others have also developed a definition of health to highlight people's resilience to disease, such as J. Ralph Audy (1971) who wrote "[h]ealth is a continuing property that can be measured by the individual's ability to rally from a wide range and considerable amplitude of insults, the insults being chemical, physical, infectious, psychological, and social" (142). This focuses on the dynamic quality of an individual's health, which adapts upon a change of environment (social and physical). Audy was convinced that health could be measured, yet to date there is no universal agreement on which variables to include into health models, as there seems to be an endless list of factors that all influence health in a direct or indirect way. This makes it difficult to compare various studies as everyone needs to define what health means in their specific context. Despite these difficulties when defining health, it is widely acknowledged that good health depends on a variety of different factors, e.g. environment, social and economic, and that they determine whether an individual is able to improve their health. This is where health promotion is crucial, as it not only addresses health on an individual level but takes a more holistic approach to address the various factors that influence health (see chapter 2.2.2 for health determinants).

Health promotion. The Ottawa Charter of 1986, a result of the first international conference on health promotion, aimed at achieving health for all by 2000. It set an important milestone in public health developments and the principles set out in the charter are still widely used in health promotion activities to date (WHO 2020A). There are five action areas that consist of the following: (1) Building healthy public policy by legislation, taxation or organisational changes, (2) creating supportive environments to encourage individuals to care for each other, their social and natural environment, (3) strengthening community action is essential as it empowers communities to take control, (4) developing personal skills so that individuals are better equipped to gain control over their own health and be better prepared to deal with chronic illnesses and injuries, (5) reorient health services to not only provide for clinical and curative needs but to support and enable individuals and communities to lead a healthier life (WHO 1986). This Charter furthered the development of a new WHO definition of health as it adds the perspective of health promotion, healthy lifestyle and urban health.

Responsibilities. These action areas focus on increasing the capability and capacity of individuals to improve their health outcomes, i.e. their physical, mental and social well-being, but also to improve the social and physical environments that ensure that healthy choices can be made in the first place. Thereby, health is seen as something that can be continuously exercised, rather than a purpose of life. Promotion of health is the joint responsibility of all levels and sectors of government, industry and the media, as well as the individuals themselves. To be effective it is essential that these stakeholders work together and adapt health programs to local needs. Since then, eight conferences on health promotion have followed, each with a different focal point (WHO 2020A).

2.1.2 Health behaviour

Many factors influence the health behaviour of individuals, be it their own personal beliefs, their social or physical context. Epidemiologists usually focus on the individual and their health-related behaviour or exposures when discussing health and disease. Rarely is the context, in which the individuals live and work, studied. This is probably due to the American tradition, in which most modern epidemiological methods were developed, which places a strong focus on individuals and leaves out society as a possible factor of influence. This also leads to the “expectation that important causes of disease will both act at and have direct biomedical manifestations at the individual level” (MCMICHAEL 2001:266-267).

Definition. In the field of health-related behaviour there is still no consensus as to which factors and to what degree predict a beneficial or adverse health outcome (NORMAN 2008). Health behaviour is generally defined and accepted as “those personal attributes such as beliefs, expectations, motives, values, perceptions, and other cognitive elements; personality characteristics, including affective and emotional states and traits; and overt behavior patterns, actions and habits that relate to health maintenance, to health restoration and to health improvement” (GOCHMAN 1997:3). This study focuses on the last part of the definition, i.e. health behaviour is what individuals do or refrain from doing. This does not necessarily have to be a conscious or voluntary act (GOCHMAN 1997). The four prevalent health behaviours often studied are smoking, drinking, healthy diet, and physical activity (CONNER, NORMAN 2017), which are also covered in the present study.

Socio-economic status (SES) and health behaviour. Many studies could show that health promoting and health adverse behaviour is associated with factors such as education, income and occupational status (ABEL 2007; BLAXTER 1990; CURRIE ET AL. 2008; DROOMERS ET AL. 2001; THRANE 2006; KOUVONEN ET AL. 2007). In other words, individuals with a high socio-economic status usually show healthier behaviour, e.g. less smoking, healthy diet or exercise, and vice versa. However, the lack of economic resources does not fully explain the observed differences in health behaviours. Smoking, for example, is quite expensive, yet it is most prominent among individuals with lower socio-economic status (SES). On the other hand, exercise such as walking or running are inexpensive or free but most prominent among individuals with higher socio-economic status. The relationship between socio-economic status and health behaviour is generally more continuous across all socio-economic levels rather than a discrepancy between two groups (e.g. the poor and others, or those educated at university and others) (DENNEY ET AL. 2014). In the USA, unhealthy behaviour (drinking, smoking, unhealthy diet, low levels of physical activity) is the cause of up to 40% of premature deaths (MOKDAD ET AL. 2004).

Influencing the behaviour. Cockerham (2014) emphasises that an individual’s health behaviours are influenced by social conditions. These create the circumstances that enable groups of individuals (in this case individuals of the same socio-economic status) to behave collectively. This shifts the focus away from thinking about health behaviours as a matter of individual choices. The notion that an individual’s behaviour reflects the social position of that person in society was originally proposed by Max Weber (COCKERHAM 2014). Figure 1 illustrates the association of how the socio-economic status of an individual influences the mediating factors of health, i.e. health behaviours, psychological and environmental factors, and how these factors influence the health outcome. It is important to consider the mediating factors when studying health outcomes of populations, as they reduce the direct association between the SES and the health outcome. The model provides a conceptual basis of how health behaviours mediate the effect of socio-economic status on health outcomes. This is particularly important for policy makers who aim to reduce differences in socio-economic status, as they should also take the mediating factors into account when trying to improve population health (PETROVIC ET AL. 2018). The model is useful as it can explain why individuals who have a low SES still might have good health outcomes. Therefore, including health behaviour and other mediating factors leads to better predictions than if one just studies the association between SES and health outcomes.

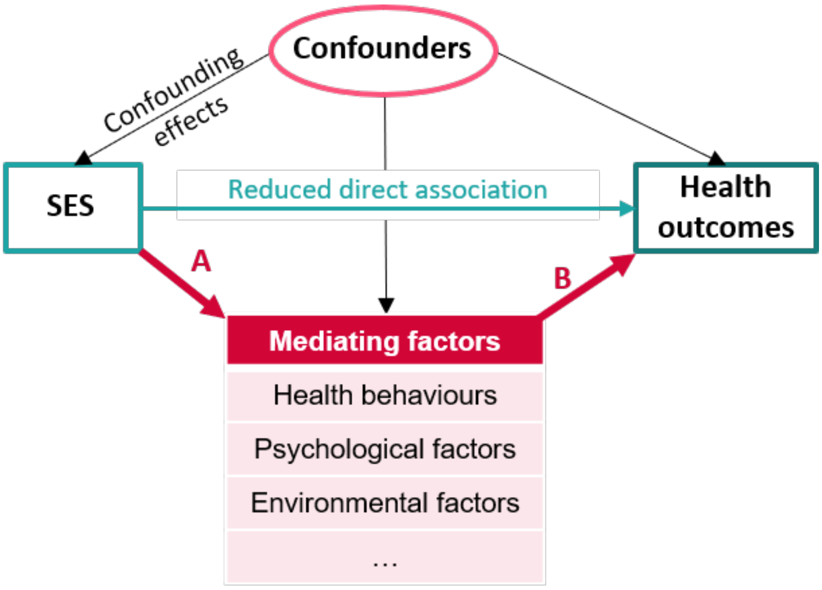


Figure 1 Model of the association between socio-economic status (SES), mediating factors, health and confounding factors
Confounders: confounding variables such as age, sex, genetics. These independent variables have a confounding effect on SES, health outcomes and the mediating factors. A: mediating factors are influenced by SES, B: Mediating factors influence health outcomes. (source: PETROVIC ET AL. 2018: Supplementary figure 1, slightly modified, own visualisation)

2.2 Geographical aspect of health

The following chapter moves from health on an individual level to the geographic distribution of good or bad health and gives a brief overview of health geographic research. The geographic approach to health can be based on several scales, from the micro-level of the block level and the neighbourhood, to the meso-level of the city and the macro-level of a country or even the whole world. When looking at these scales it is also important to discuss underlying inequalities that lead to the different health outcomes, which can be observed on every geographic scale. All geographic scales have an institutional component, e.g. policy of neglect.

2.2.1 Combining place and health

An old idea. The idea to link health and place dates back more than 2000 years, and is since known as medical geography. The academic origins of the field however, lie in a collection of chapters titled *Airs, Waters, Places*, which many authors falsely attribute to Hippocrates. The true author remains anonymous (EARICKSON 2009:9). In the 18th century, the field of disease ecology gained popularity, with works by Friedrich Hoffmann on regions and their specific diseases, and Leonhardt Ludwig Finke, who collected current medical knowledge. Finke, a professor of medicine, had a unique approach, which was based on geographic explanations for diseases. His most famous work, the three volume *Versuch einer allgemeinen medizinisch-praktischen Geographie* (engl. *World Map of Disease,* 1792-1795), is a systematic collection of current medical knowledge with global scope. It included data from seafarers, who had been to new places and encountered new diseases and remedies. Through this publication he is credited with founding the field of medical geography (DORN ET AL. 2010; FINKE 1792; KISTEMANN, SCHWEIKART 2010; KISTEMANN ET AL. 2019:33). The popularity of the field is also attributed to the colonialisation of many parts of the world and increasing global connectedness, which led James Lind to write an essay (1779) on the diseases of Europeans in hot climates (KISTEMANN ET AL. 2019:32-33).

Foundations of disease ecology. Yet it was not until the mid-19th century that John Snow mapped the course of disease (cholera) in London, and is thereby perceived to be the founder of modern disease ecology (KISTEMANN ET AL. 2019:12). His map of a London district is most famous and many scholars use it to illustrate the start of spatial analysis of diseases. It was published in his 1856 paper on *offensive trades,* in which he makes a case that factory fumes do not transmit cholera, which was widely believed, but instead the disease spread due to contaminated water from certain wells (VANDENBROUCKE 2013). However, it took another 35 years to correctly identify the bacterium that caused cholera, which was achieved by the German physician and hygienist Robert Koch. In retrospect, Snow's theory that makes a connection between water consumption and cholera by exactly mapping the disease incidents, seems obvious. But it is still remarkable that without being able to verify his theory, he had come to the right conclusion. For other diseases, such as tuberculosis and pertussis, the burden could also be reduced by exactly mapping their occurrences and analysing the patterns (KISTEMANN ET AL. 2019:35). The mapping of diseases to visualise the extent of the spread and to find possible reasons for the underlying patterns, is still practised today (KISTEMANN ET AL. 2019:13). A few years after Snow's publication of *offensive trades*, August Hirsch further developed this field by publishing a handbook on historical-geography pathology (1859-1864). However, the emergence of the pathogen theory soon led to a neglect of medical geography, as it was believed that diseases originated from pathogens (KISTEMANN, SCHWEIKART 2010). Until the beginning of the 20th century, the study of communicable diseases was of major concern, as they were the most important causes of disease and death (KISTEMANN ET AL. 2019:11).

Origins of medical geography. A decrease in infectious diseases, thanks to the slowly increasing availability of antibiotics after World War II, and a subsequent strong increase in degenerative diseases, which could not be explained by pathogens, helped to spark interest in the field again. Therefore, "[n]ew theories about society and cultural behaviour were needed to explain their causes and to guide research and interventions" (MEADE, EMCH 2010: 10). The origins of medical geography undoubtedly come from medicine, which has also been the cause of some misunderstandings (KISTEMANN, SCHWEIKART 2010). Many "geographers tend to have a rather outdated vision of medicine. […] We [geographers] ignore medicine and medical power/knowledge at our peril, but we need to avoid setting up medicine as some sort of folk devil from which we are 'progressively' distancing ourselves" (KEARNS, MOON 2002: 617). Thus, it is best not to completely set aside biological medicine as geographers, and to acknowledge that social concepts of health have also entered the field of medicine. **Jacques May** is considered by many to be the father of medical geography (BLATT 2015; MEADE, EMCH 2010). He had worked as a head surgeon in Hanoi for over ten years and noticed that the patients in Vietnam were experiencing different diseases than he had learned from his textbooks. This led him to conclude that the cultural and environmental context influences the health outcome of individuals (MEADE, EMCH 2010:10-11). It was not until 1949, when May initiated the commission on Medical Geography within the International Geographical Union, did the field of medical geography receive increasing attention again (KISTEMANN, SCHWEIKART 2010). **Melinda Meade** took the ideas of May and developed the triangle of disease ecology (1977). She realised that certain disease hotspots can be explained by combining information on population (e.g. demographic variables), culture (e.g. behaviour), and environment (e.g. habitat) (KEELER, EMCH 2018:46). This framework has also been adopted by others (e.g. CARELL ET AL. 2012) to study avian influenza.

The emergence of Health Geography. During the early 1990s, Robin Kearns (1993) advocated that the field of medical geography should be reformed and break away from a strong medical approach, which eventually led to the emergence of a new field called health geography. This new field emphasises that "a person's socio-economic status helps to shape his/her experience of places just as places of residence influence a person's opportunities for activity and experience" (KEARNS 1993:140). In other words, health geography understands place as an active entity which is socially constructed and influenced by cultural, political and economic factors. It also focuses more on pathological issues as well as health care systems and their locality (KEARNS, COLLINS 2010; KISTEMANN ET AL. 2019:18). Kearns, Moon (2002) identified three main themes in this new field: "[1] the emergence of 'place' as a framework for understanding health, [2] the adoption of […] sociocultural theoretical positions, and [3] the quest to develop critical geographies of health" (606). This acknowledges that there are social and cultural dimensions of health. To assess these new dimensions a broadening of methodological approaches was necessary. Therefore, qualitative research methods, previously only of subordinate significance, gained traction in health geography. They are particularly useful to help evaluate subjective opinions about a place, the determinants of health-related behaviour or community traditions (KISTEMANN ET AL. 2019:18).

2.2.2 Determinants of health

Initial ideas. Health is a dynamic phenomenon and people can be classified as being more or less healthy. Conceptions of what determines health changes over time and place as well as the definition of health itself. This affects the focus of public health policies. As an example, a prominent idea in Britain in the late 1940s was that social class defined a person's health, i.e. higher classes had better health than lower classes measured by mortality rates. Therefore, the introduction of the National Health Service (NHS), with its free health care provision, should decrease the health gap between the higher and lower classes. To everyone's astonishment, the better access to health care did not reduce the health gradient across these classes (FRANK, MUSTARD 1994). The traditional approach to dealing with issues of health was to make changes in the health sector and hope that this would solve the issue. However, the failed attempt to increase health equity led to the Black Report, which focused on health influencing factors beyond the scope of the NHS. It stated that "[s]ocial and economic factors like income, work (or lack of it), environment, education, housing, transport and […] 'life-styles' all affect health and all favour the better-off" (TOWNSEND, DAVIDSON 1982:15-16).

Determinants of health. What followed was the development of a model that encompassed multiple determinants that were perceived to influence an individual's health (Figure 2) originally proposed by Dahlgren and Whitehead in 1991. Every layer of the model shows which factors influence the health outcomes of individuals and which resources can lead to a healthy life. Resources, in a public health setting, are potentials that can be used by individuals to successfully cope with health burdens and challenges, and/or achieve a healthy lifestyle. In other words, resources are the capability of an individual to influence their own health outcomes. A health resource can be available in the living space or social environment of individuals, which cannot be directly influenced by themselves. The great achievement of the model is to illustrate that risk factors and resources that influence health are present at all levels of human life. The complex intertwining of health determinants poses a challenge to public health interventions. The interventions need to account for the fact that structural conditions such as the physical and social environment affect people's actions and conversely, people's actions affect the structural conditions surrounding them (ABEL, KOLIP 2018).

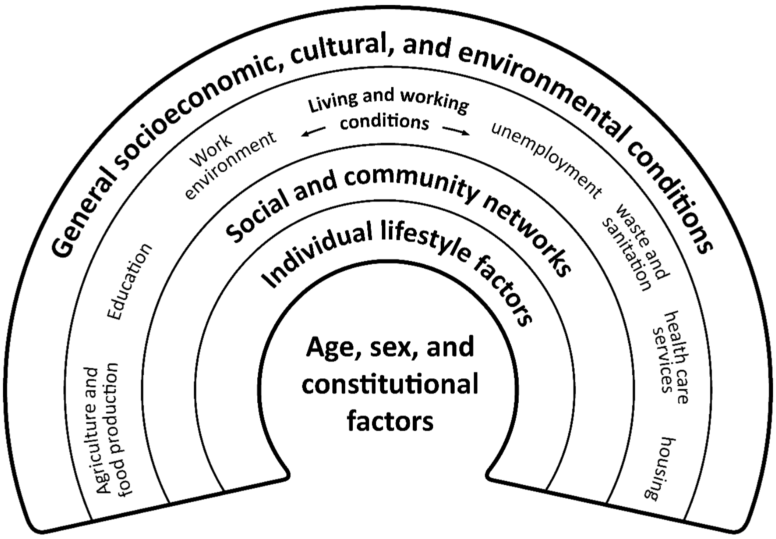


Figure 2 Main determinants of health to study disease prevention and health promotion
(source: DAHLGREN, WHITEHEAD 1991: 11, redesign: L. Goldman 2021)

Social determinants of health. There was a growing demand for scientific evidence regarding the effects of various determinants of health to make better policies and update Dahlgren and Whitehead's model. Therefore, the WHO facilitated research and policies that studied social determinants of health to gain a better understanding of global health disparities. The result was a booklet aimed at policy makers and the public health sector and covers 10 different areas (determinants of health) where policies could affect the health of individuals and communities. These areas were: (1) the social gradient, (2) stress, (3) early life, (4) social exclusion, (5) work, (6) unemployment, (7) social support, (8) addiction, (9) food and (10) transport (Wilkinson, Marmot 1998; 2003). The Commission on Social Determinants of Health observed that (CSDH 2008:1):

> *The unequal distribution of health-damaging experiences is not in any sense a 'natural' phenomenon but is the result of a toxic combination of poor social policies and programmes, unfair economic arrangements, and bad politics. Together, the structural determinants and conditions of daily life constitute the social determinants of health and are responsible for a major part of health inequities between and within countries.*

Studying determinants of health is complex especially as many models do not clearly define the determinants, i.e. how to measure them, and it might also vary due to the study area and context. Very often there are also limited definitions of what exactly is meant by health equity and how to measure it (CSDH 2008).

2.2.3 Environmental health

Health sciences frequently use socio-ecological models to describe health as a function of individual and socio-spatial determinants. The focus lies mostly on the regional or neighbourhood level (VOIGTLÄNDER 2017). An important aspect of many analyses of health and place, is that unequal resource distribution may affect health and lead to health inequalities. This leads many scholars to link “bad place” to “bad health” (DIEZ-ROUX, MAIR 2010). A more detailed discussion on health equality and equity can be found in the following chapter 2.2.4. There are two main directions when considering the influence of the environment on health. One approach focuses on the environment as the source of disease and another focuses on environment as a source of health.

Environment as source of disease. The built environment, and its indirect effect on air quality and noise emissions, is often associated with adverse health outcomes or pathogenic environmental factors (CLASSEN 2017:192). Certain features of the built environment may affect health, such as land use patterns, building density, access to destinations, street connectivity, transport systems, features of urban design, access to healthy food and recreational resources or physical decay (DIEZ-ROUX, MAIR 2010).

A notable example for this can be found in a study, commissioned by the World Health Organization (WHO), to analyse the effect of the environment on disease outcomes. The study defines environment as “all the physical, chemical and biological factors external to the human host, and all related behaviours, but excluding those natural environments that cannot reasonably be modified” (PRÜSS-ÜSTÜN, CORBALÁN 2006:22). Factors such as air, water or soil pollution, land use patterns, anthropogenic climate change or health related behaviours such as contaminating food by unclean hands or unsafe water, are included. Whereas factors that cannot be modified by environmental interventions are excluded, such as tobacco and alcohol consumption, natural environmental vectors, pollen or certain person-to-person transmissions. The study concluded that environmental factors cause 23% of premature deaths and result in a global disease burden (healthy life years lost) of 24%. However, not every region in the world suffers to an equal extent from premature deaths. In high-income countries, only 17% of deaths were attributed to environmental factors, whereas in low or middle-income countries (LMIC) it was 25%. Overall, children up to the age of 14 suffer the highest premature death rates with 36%. These estimates are conservative approximations, as there still are many unknowns concerning the causal linkage between environmental factors and health outcomes (PRÜSS-ÜSTÜN, CORBALÁN 2006). Thereby we can deduce that human health may also be an indicator for the state of the natural and social environment (MCMICHAEL 2003).

Environment as source of health. A city environment often also contains natural elements such as rivers, green spaces or forests, which strengthen the resistance against diseases and act as a health-promoting resource. Access to health care facilities, a distinct quarter identity and a high degree of walkability are all promoters of health too (CLASSEN 2017:192). There are multiple concepts that include different qualities of an environment that are best suited to promote health and well-being. For example, Wilbert M. Gesler studies healing places, which have a multidimensional character, i.e. they should be concerned with physical and mental health, spiritual and emotional needs as well as healthy social relationships. Therefore, the healing process is not limited to the purely physical cure (GESLER 2003:1-3). Many would attribute the natural environment to be a good place for healing. This might be true to a large extent, but the built, symbolic or social environments may also have a positive effect on well-being and healing processes (GESLER 2003:8-16). To understand the effect of the built environment on our health, we need to consider the determinants of health, especially those that influence health-related behaviour (CLASSEN 2017:192).

City planning and health. Due to the steady increase in the rate of urbanisation, especially in emerging and developing countries, public health authorities are facing major challenges to keep everyone healthy (UN-HABITAT 2016). But how can health be guaranteed in densely populated cities? Ten years ago, the WHO recognised that access to health and health equity should be given more attention in urban planning (WHO 2010B). Since the 1990s, small-scale segregation has led to a selective up- and downgrading of residential areas in many German cities. In the long term, this has led to disadvantaged urban areas with an above-average rate of socio-economically disadvantaged people, i.e. poor households, high unemployment rates, high rates of foreigners, single parents and families with many children (BÖHME, REIMANN 2012). In Basel, similar processes can be observed concerning small-scale segregation. Chapter 4.2 gives an overview of the different quarter types included in the study, which all differ in their socio-economic make up. In the disadvantaged quarters, socially-related health problems such as unhealthy diet, less physical activity or heavy alcohol consumption often correlate with increased environmental health risks and threats (BÖHME, REIMANN 2012). On the one hand, these risks and threats include increased traffic and associated noise and pollutant emissions, on the other they are also visible in the lack of green and open spaces as they provide recreational, play and exercise areas, meeting facilities and a favourable microclimate. Given the link between poverty and health, urban developers should especially consider disadvantaged quarters to decrease health inequities between quarters (BÖHME, REIMANN 2012). As the concepts of health equity and health equality are both essential for city planning, they are discussed in the following chapter.

Health and place bias. However, when studying place effects on the health of individuals, it should be kept in mind that "individuals may select […] their place of residence […] based on their health or based on their predisposition to certain behaviours" (DIEZ-ROUX, MAIR 2010:133). This is called the place and health bias. For example, people who prefer regular physical activity may prefer quarters which have more green spaces and infrastructure to accommodate their needs. While this is most likely true for individuals above a certain income, it may not be true for individuals or families with low income. They are more likely limited to quarters further from the city centre where rents tend to be cheaper.

2.2.4 Health inequality and health inequity in an urban context

Disparities in urban health. On average, city dwellers have better health than rural dwellers. These patterns are the result of aggregated health data which is not broken down by income, neighbourhood, or various population groups. As a result, inner-city differences are not visible and make it difficult to identify health inequalities within the city. Therefore, it is important to gather detailed data on city dwellers to identify the prevalent health issues, where they are and how to tackle them (WHO 2010B). Inequalities in the living and working environments of individuals are often direct consequences of inequalities in power, economic and environmental resources (CSDH 2008). The consequences of these inequalities become very apparent when, for example, comparing life expectancies in Japan (83.7 years) and Sierra Leone (50.1 years) from 2015 (WHO 2016B).

However, achieving health and health equity for all may not be the first priority for many social policies, yet it is often a direct consequence of these. Take the example of promoting only economic growth in developing countries. If this is done without any social policies to ensure that the benefits are distributed fairly, then economic growth will have only a small impact on the country's health equity (CSDH 2008). Therefore, creating health inequity might not be the intention when promoting economic growth but it can be a direct consequence of it. Thus, it is important to acknowledge that a wide array of factors ranging from individual, environmental and circumstantial to structural, all influence health outcomes in certain ways and can explain differences in health on various geographic scales. Yet what exactly is meant by equity and equality? Equality is a measurable concept that allows for quantitative statements and equity is a political concept that allows for moral statements (KAWACHI ET AL. 2002:647).

Health inequality. The term health inequality is used to describe differences in the health status of individuals or groups (WHO 2010B). Inequality is present in a population, if, for example, a disease X is more prevalent in group A, rather than group B. An inequality might also arise, if an individual practising a hobby dies prematurely, but her twin, who does not practice the same hobby, does not die prematurely. This difference in lifespan usually does not call for moral statements. The same goes for genetic predispositions that result in worse health outcomes. However, some forms of health inequalities can also be unjust and therefore classified as a health inequity (KAWACHI ET AL. 2002). It is difficult to measure health inequalities as we need to decide on "the level and type of analysis of disease causation" and "envisage the evolution of health risks over time; over the course of a life" (MCMICHAEL 2001:266).

Health inequity is a type of inequality that is systematic, socially produced, and unjust. They often show similar patterns across various populations and cluster spatially or by similar socio-economic status. However, not all inequalities are inequities. When comparing mortality rates between 80-year olds and 20-year olds one can clearly see that the mortality rate for the older generation is higher. While this is a measurable inequality it does not qualify as an inequity, as the higher mortality rate is the product of the natural ageing process and not socially constructed (WHO 2010B). Equity on the other hand is defined as the "fair opportunity for everyone to attain their full health potential regardless of demographic, social, economic or geographic strata" (WHO 2020B). The concept of (in)equity includes a moral judgement, i.e. that if there are known and preventable unfair opportunities it is unjust to allow them to continue. As the definition of equity is, most likely purposefully, kept very broad, it is difficult to define what can be classified as a fair opportunity and what is meant by full health potential. Does a fair opportunity for everyone mean that resources are distributed in a way to provide the best opportunities to the largest number of people, which might result in an unequal distribution of resources? Or does it mean distributing resources equally, which might not help the largest number of people, which might result in an unequal distribution of resources? These are philosophical questions that need to be addressed when talking about (in)equity, but go beyond the scope of this work. This thesis will not open this discussion but acknowledges the complexity of the questions at hand.

Factors influencing inequality. Differences in health depend on the place of residence and vary between continents, counties, regions and even within cities. Yet, it is paradoxical that the populations of most West European countries have never been healthier but at the same time, inequalities in health are increasing. This might be a direct result of growing income inequalities, which lead to health inequalities (DAHLEGREN, WHITEHEAD 1991:5). The Black Report from 1980, even though not published by the Thatcher government, had a lasting impact on the way we think about inequalities in health today. It showed that the poorest in Britain suffered the most from bad health. The report attributed this mismatch to a lack of health care service provision because of failing policies. The recommendations included: "health goals, tax changes, benefit increases, and restrictions on the sale and advertising of tobacco" (RICHMOND 2002:661). This report led health services in the UK to shift their focus from treating diseases to promoting and protecting health (BAMBRA ET AL. 2011). In Switzerland, the Federal Statistical Office (FSO) and the Caritas charity are the two main sources that monitor and report on poverty and poverty reduction efforts. The FSO has been conducting detailed studies and analysis on this issue since the 2000s and Caritas released its first report on the social situation of people living in Switzerland in 1999 (NEUKOMM, FONTANA 2015).

Since the 1980s, research on poverty has established that poverty is a driving force for health outcomes and is seen as the "cause of disease and premature death", which can only be mitigated by a "society [that] takes actions that transcend policy sectors and scientific disciplines" (MCMICHAEL 2001:335; MEADE, EMCH 2010:16). It also requires measures on the international level, which remediate the historical inequalities. This especially applies to developing nations that still suffer strong economic and health disparities, compared to developed countries (McMichael 2001:335-336). Overall, “globalization of economic and political power is increasing gaps in income, knowledge, and health everywhere, at every scale” (Meade, Emch 2010:16). Therefore, it can be concluded that if institutions do not create equal conditions, then it is difficult for individuals, communities or even nations to remain or become healthy. The geographic aspect of health often focuses on institutional policies.

The Ottawa Charter (1886), which aimed to achieve Health for All, inspired the launch of the WHO European Healthy Cities Network in 1988. The main idea was to adapt Health for All to the local city level to promote healthy cities and to put health on the political agenda of city leaders (European Commission 2021; Tsouros 2015). Cities within this network have been developing and testing many ideas to deal with key public health questions such as mitigating inequalities, addressing social determinants of health, creating health equity in all local policies, promoting healthy urban planning and many more. The network has also become vital for applying the Health 2020 WHO policy framework to the local city level. Health 2020 provides decision-makers and politicians with a tool to make informed, evidence-based decisions about interventions that promote health and well-being in cities (Tsouros 2015).

Access to health in Switzerland. One of the determinants of health is access to health care services, as described in chapter 2.2.2. Therefore, the following establishes the general state and accessibility of health care services in Switzerland. Compared to other countries in Europe, Switzerland has very high levels of health and wellbeing, only Icelanders have a higher life expectancy. Within Europe, Switzerland shows the second highest ratio of physicians and nurses per 1,000 inhabitants, which shows adequate access to health care treatment. In general, the population is very satisfied with the quality of the health care system (De Pietro et al. 2015). However, the cost of such a health care system is very high and a survey showed that “almost 3% of the poorest income quintile have an unmet need for medical examination or treatment because of costs – a share that is considerably higher than in Austria, Germany or the Netherlands” (De Pietro et al. 2015:xxvii). This leads to an unequal access to health from an economic perspective, especially as low-income households have to spend more of their income on health care than high-income households. This highlights the importance of exploring differences in health determinants across social groups.

The Swiss health sector has an annual turnover CHF 82 billion and is continuously growing making it an important economic sector. However, since the 1960s the cost of health care services has risen drastically as shown in Figure 3 (BFS 2019a). An ageing population and increasing numbers of chronically ill people will further increase the demand for medical services. The availability of ever better and newer treatments simultaneously leads to a rise in health care costs (PharmaSuisse 2016b).

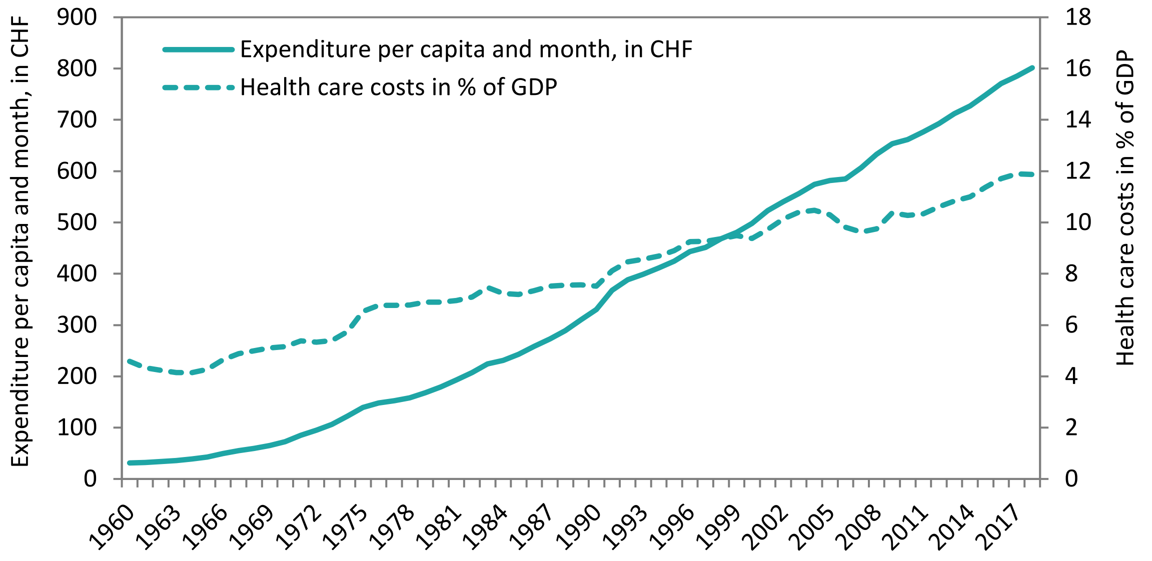


Figure 3 Cost of health care between 1960-2018
(data source: FSO 2020A, own visualisation)

3 Medical aspect of Influenza and vaccination

Despite living in times of modern medicine, (infectious) diseases still occur all over the world. The usual frequency of a disease within a community is referred to as an **endemic** level of the disease. This might not be the desired frequency, which might be zero, but shows the baseline level of disease occurrence within an observed population (CDC 2021). If the is a sudden increase in disease occurrence above the base line level for a particular period of time, it is called an **epidemic** (CDC 2021). Influenza in Switzerland is a good example of a seasonal epidemic, which mainly occurs during the winter months (FOPH 2020C). The influenza season analysed in this study reached an epidemic-level for 12 weeks (FOPH 2016B). Lyme borreliosis and tick-borne meningitis are also two notable diseases that reach epidemic level on a seasonal basis, but mainly during the warmer months (FOPH 2020C). An **outbreak** is defined the same as an epidemic but is usually used when referring to a specific community, region or a particular time (CDC 2021). To investigate the source of an outbreak, the affected people are questioned, or the pathogen is analysed by molecular typing. If possible, the source of infection should be eliminated and transmission reduced, which ends the outbreak, unless it is an infectious disease which might not be eradicated by only identifying the source (FOPH 2020C). If a disease spreads across many countries or even continents, causing a risk to a vast proportion of the world's population it is called a **pandemic** (CDC 2021; FOPH 2020C). A pandemic is more likely for human diseases that can be transmitted between humans and if there is no prior immunisation for most or all of the global population (WANG, PALESE 2013:218). The most notable pandemics of the past century, caused by influenza viruses, are described in the following chapter.

3.1 Influenza pandemics in the past

Seasonal Influenza consists of four virus types. Type A and B cause seasonal influenza epidemics or pandemics, whereas type C and D do not represent a public health priority (WHO 2018A). Type D does not infect humans. Despite efforts in pharmaceutical and non-pharmaceutical interventions, the last century has seen four influenza pandemics. The **1918 influenza (H1N1) pandemic** was one of the most severe in medical history, rapidly spreading throughout the world causing between 50-100 million deaths within one year. Deaths from most other infectious diseases were decreasing but this pandemic turned out to be one of the deadliest diseases in recent history (FANNING 2010). For **Switzerland**, it too was the worst catastrophe in recent history**.** No other disease has had such a strong hold on the Swiss population since. Although not directly involved in WW1, the Swiss were still faced with dire consequences such as supply shortages for coal and food. Coupled with harvest failures this led to widespread malnourishment and hunger of the population, leaving many vulnerable (SCHWEIZERISCHES ROTES KREUZ 2020; HUNT 2018). Some studies have shown that malnutrition is a risk factor for the clinical course of infections (KATONA, KATONA-APTE 2008; SCHAIBLE, KAUFMANN 2007). The Swiss Red Cross estimated that around 2 million people were infected with influenza, which was about half the Swiss population at the time (N.Z.Z. 1919:60; HUNT 2018). The pandemic led to a spike in the number of deaths as shown in Figure 4. **Basel** too, was affected quite severely with a morbidity rate of 26%, significantly higher than the national average (19%) (BULLETIN SGA 1919 IN TSCHERRIG 2016:171).

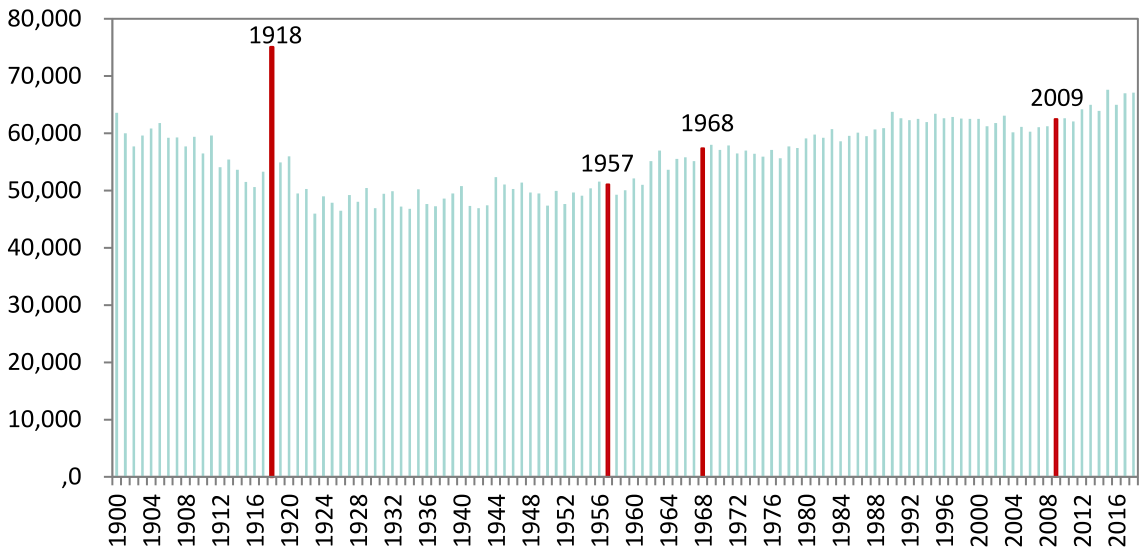


Figure 4 Overall deaths in Switzerland between 1900 and 2018, past influenza pandemics highlighted in red
(Data source: FSO 2020B, own visualisation)

Spanish flu 1918/19 in Basel. Figure 5 shows a couple of press releases from 1918, which highlight that the city was in a state of emergency and could not fully operate all public services such as the post office or public transport. Throughout the pandemic the local authorities appealed to the common sense of its citizens and therefore preferred the distribution of posters with warnings and behavioural guidelines rather than legal measures (TSCHERRIG 2016:95-96). It is striking to see how wide ranging the effects of the pandemic were. Considering the reduction of public services, it was very similar to the measures set in place due to the COVID-19 pandemic, where hospital visits were also prohibited, and public transport operated at a reduced frequency (COVID-19 REGULATION 2 2020). The similarities between the COVID-19 pandemic and the 1918 influenza pandemic in Switzerland are striking. At the beginning of the first influenza wave the federal government reacted fast. In the aftermath of the first wave the federal government delegated the responsibilities to the cantonal authorities, who reacted hesitantly when signs of a second waves were apparent out of fear of renewed restrictions and their economic consequences. This led to a second wave that was associated with higher rates of hospitalisations and mortality. After some weeks, the cantonal governments issued stricter and more centralised measures again which reduced the number of infections somewhat (STAUB ET AL. 2021). Staub et al. concluded that a "hesitant approach to public health interventions, despite early evidence of uncontrolled exponential growth, was associated with a lack of containment of the second waves of both the 1918 influenza and COVID-19 pandemics" (2021:5).

A

Bürgerspital Basel.

In der Influenza-Filiale **im Hilfsspital an der Burgfelderstrasse** gilt die gleiche Besuchsordnung wie im Bürgerspital. Personen, die daselbst Angehörige besuchen wollen, haben **schriftlich** (nicht telephonisch) beim Arzt des Hilfsspitals eine Bewilligung nachzusuchen, und erst mit der erhaltenen Bewilligung sollen sie sich zu den gewöhnlichen Besuchszeiten am Portal des Hilfsspitals melden.

11113 **Die Spitaldirektion.**

B

Nicht auf den Boden spucken!

Beim Husten u. Niessen die Hand oder das Taschentuch vor den Mund halten.

Sanitätsdepartement.

C

Postamtliche Mitteilung.

Zahlreiche Erkrankungen beim Postpersonal zwingen zu nachstehend verzeichneten Diensteinschränkungen:

Die Postbureaux

Basel 3 Schützenmattstraße,
„ 4 St. Johannvorstadt,
„ 8 Güterstraße,
„ 10 Elisabethenstraße,
„ 21 Riehenstraße,

sind vom 22. ds. an von **12 bis 2 Uhr mittags geschlossen**; der Schalterdienst ist beschränkt auf

Verkauf von Wertzeichen,
Annahme von Post- und Zahlungsanweisungen,
Auszahlung von Nachnahmen,
Bedienung der Schloßfächer,
Telegrammaufgabe und Telephondienst.

Die Einschreibebrief- und Paketpostaufgabe wird den andern städtischen Postbureaux zugewiesen.

Im Briefbestelldienst fällt teilweise die zweite Vormittagsvertragung aus.

Die Leerung der Nebenbriefkasten mußte eingeschränkt werden, eilige Briefschaften sind bei den Poststellen aufzugeben.

14603 **Die Kreispostdirektion.**

D

Straßenbahnen des Kantons Basel-Stadt.

Betriebseinschränkungen.

Wegen Personalmangel infolge Krankheit finden bis auf weiteres folgende Betriebseinschränkungen statt:

1. Die Linie 1 wird eingestellt.
2. Die Wagen der Linie 8 verkehren nur noch in einem Intervall von 12 Minuten.
3. Der Betrieb der Linie 15 wird auf dem Teilstück Barfüsserplatz-Thiersteinerallee eingestellt. Betreffend der Abfahrten ab Thiersteinerallee wird auf den Spezialfahrplan verwiesen. Abfahrten ab Bruderholz nach bisherigem Fahrplan alle 24 Minuten.

BASEL, den 21. Oktober 1918.

Verwaltung der kantonalen Straßenbahnen.

Figure 5 Local information on the 1918 pandemic

(A) press release from the public hospital of Basel, drawing attention to the visiting restrictions of influenza patients (NATIONAL-ZEITUNG 368 IN TSCHERRIG 2016:68), (B) warning poster, which exhorts the citizens not to spit on the floor and to hold their hand or a handkerchief in front of their mouth when coughing and sneezing (STABS SANITÄT Q3.3 IN TSCHERRIG 2016:95), (C&D) press releases informing of limited public services of the post offices and reduced frequency of local transport services both due to high volume of sick workers (NATIONAL-ZEITUNG 494 IN TSCHERRIG 2016:128-129).

The introduction of the influenza vaccine in the 1930s strongly reduced infection rates, which drastically decreased the number of influenza related deaths (BRESEE ET AL. 2018). Since the influenza pandemic of 1918, three other influenza pandemics followed. At the start of 1957 there was a major outbreak of H2N2 Influenza in Hong Kong. By the end of the year, the vaccine for the pandemic strain was already available. In 1968, history repeated itself when another major outbreak of influenza (H3N2) was identified in China. Here too, the vaccine was made available right after the pandemic peak. Fortunately, only half as many people died in this pandemic by comparison with the 1957 outbreak, even though the population had increased over the intervening decade. The scare of SARS coronavirus in Eastern Asia and other parts of the world in 2003 led the WHO to develop an overall framework for a pandemic response. This became particularly relevant during the most recent influenza pandemic of 2009, caused by the H1N1 Influenza A virus (MONTO, WEBSTER 2013:22-24). The last three influenza pandemics (1957, 1968 and 2009) did not lead to an increase in overall death rates in Switzerland, as shown in Figure 4. Pandemics like these are a stark reminder of what threats we face, should a renewed outbreak sweep across the globe. It is impossible to predict new pandemics but given that many people are very mobile and live in urban areas the reach of the next pandemic might be further and faster than the H1N1 pandemic of 2009 (WHO 2019A). This has been proven true by the 2020 COVID-19 pandemic. Therefore, it is vital to understand the transmission patterns of infectious diseases, such as seasonal influenza as well as the vaccination behaviour of the target population, to be better prepared for unexpected disease outbreaks.

3.2 Seasonal influenza

Typical course of infection. Figure 6 schematically shows the typical course of infection of influenza A (ANDERSON 2016:8). Everyone is potentially susceptible to an infection. The point of infection is where the virus enters the body and replicates in host cells. The incubation period, i.e. the time between infection and onset of illness, is when a person is infectious. This period can last between 1 to 4 days, most commonly 2 days. The incubation period and the infectious period overlap, making this the prime time where an infected person can infect other people without knowing that they are infectious (HAYDEN, DE JONG 2013:373-375). This time window impacts the basic reproduction number (R_0) which expresses the average number of people subsequently infected by one infected individual. For influenza this number is between 0.9 and 2.1 persons, meaning that an infectious person infects on average one to two persons (CHOWELL ET AL. 2008). A sick person remains infectious for a few days even after most symptoms have diminished, making it important to stay at home a little longer so as not to infect other people. A bacterial infection is the most common secondary infection following influenza, a so-called superinfection. People of the risk group, who usually have weaker immune systems, face an increased risk of death from these secondary bacterial infections (HAYDEN, DE JONG 2013:373-375).

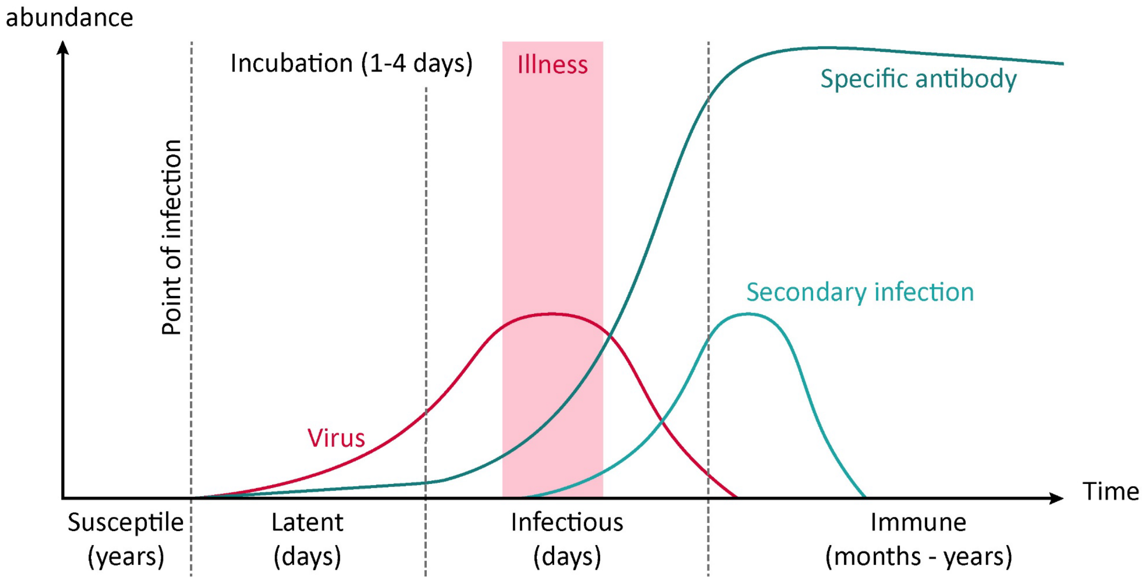


Figure 6 Schematic of a typical course of infectious disease (e.g. Influenza A) within a host
(own visualisation, based on ANDERSON 2016:8; WIDDOWSON, MONTO 2013; HAYDEN, DE JONG 2013:373-375)

Morbidity and mortality. The impact of influenza morbidity, the rate of people who fall ill due to influenza, can affect a community in different ways. The consequences are usually measured by the number of doctor consultations, hospital admissions and hospital critical care, but also through the number of days missed at the workplace or school and the sale of pharmaceuticals. These sources can be used for influenza surveillance, but as influenza epidemics are highly dynamic, it is very difficult to predict trends (ZAMBON 2013:232).

Influenza-related mortality, the rate of people who die from an influenza-related cause, is difficult to estimate, as many influenza cases are not confirmed with laboratory testing and it is often not noted on hospital discharge forms or on death certificates. Sometimes influenza deaths are also falsely attributed to other diseases or secondary infections (IULIANO ET AL. 2018; THOMPSON ET AL. 2003).

Vulnerability of certain groups. Certain groups of people show higher rates of complications after an influenza infection than others and this is why these groups of people are especially advised to have an influenza vaccination (FOPH 2020D). “Among **children**, the most common underlying risk factor is asthma, whereas among the elderly, chronic obstructive pulmonary disease and other chronic lung conditions are the most common risk factors associated with hospitalization” (WIDDOWSON, MONTO 2013:258). Adults who have one or more chronic illnesses are ten times more likely to get hospitalised than a healthy adult (WIDDOWSON, MONTO 2013). Therefore, one can conclude that if chronic illnesses go untreated, e.g. due to lack of or restricted access to medical resources, it leads to higher influenza-associated hospitalisation rates. This is especially true for low income populations in the USA (GLENZEN ET AL. 2000). **Pregnant women** also show a greater probability for severe complications from influenza during pandemics (JAMIESON ET AL. 2019) but also for seasonal influenza (DODDS ET AL. 2007).

Usually, with increasing **age** the immune system's memory also grows as a result of multiple infections. However, the elderly (persons ≥65 years) are also faced with an ageing immune system which is not as agile anymore (also known as immunosenescence), resulting in higher rates of complications from influenza, a problem many nursing homes have to tackle (WIDDOWSON, MONTO 2013:255).

Path of the influenza virus. But how does an influenza virus enter the body and replicate? And how is the immune system called into action? Figure 7 gives an overview of how an influenza virus infection works. The numbers in the text correspond to the numbers in the figure. Influenza viruses are transmitted in little virus filled droplets (1), which are released when people cough, sneeze, or just talk with each other. Hand contamination or other surfaces touched by an infectious person may also transmit the virus (HAYDEN, DE JONG 2013:373). However, as the virus is not well adapted to live outside of the human body, it does not survive for long. Therefore, infection with influenza is most likely from close (physical) contact with an infectious person. In its core the influenza virus contains RNA, which carries information on the virus composition. On its outer layer it shows two different proteins. One is called Hemagglutinin (HA), of which there are 17 varieties, and the other is called Neuraminidase (NA), of which there are 10 varieties. This makes a total of 170 different flu varieties (DESAI 2019). Every virus strain has one kind of HA and one kind of NA. (2) Hemagglutinin enables the virus to attach itself to the sialic acid and can thereby enter the epithelial cell, found in the respiratory system. (3) Once influenza virus gets inside the cell, it dissolves and the RNA segments make their way towards the nucleus, where the cell DNA is stored. (4) In the nucleus, the RNA takes over and starts producing many copies of itself, as well as HA and NA proteins. The cell is no longer able to fulfil its designated function (DESAI 2019; HAYDEN, JONG 2013:375). (5) As the human cell is producing all the viral RNA and proteins, it is damaged over time and the cell content leaks out. This leakage causes inflammation and depending on where this damage occurs it can cause different symptoms. If the damage occurs in the nose area one might experience a stuffy or runny nose, if it occurs in the throat, it leads to a sore throat and if it occurs in the lungs it might lead to a cough. If a person has a strong immune response it might cause fever, a strong feeling of fatigue or body aches, as the immune system battles the intrusive virus. (6) The newly formed viral particle will try to infect new human cells, but it is still attached to the sialic acid. This is why the virus needs the neuraminidase. It helps the daughter cell to break loose and infect a new cell (DESAI 2019; HAYDEN, DE JONG 2013:375). (7) Inside the human cell, transport molecules bring the virus proteins HA and NA to the surface. (8) The white blood cells (B-cells) recognise the presented virus parts as intruders and produce antibodies. When a B-cell encounters the virus, it stimulates maturation into mature B-cells, which then release millions of antibodies. These antibodies then attach themselves to the viruses, thereby preventing them from infecting further cells. The production of antibodies continues for a couple of days until all viruses are eliminated. The specific antibodies remain in circulation and provide immunity against that virus (ENCYCLOPAEDIA BRITANNICA 2019). (9) The immune system also activates the T-cells to eliminate infected cells.

To guarantee a host's immunity for several years or even decades, memory B-cells are formed. However, the presence of efficient antibodies puts pressure on the virus to mutate fast and away from the circulating strains. This ensures that the host will not already have antibodies in the next influenza season (BAUMGARTH ET AL. 2013:283-4). This long-term protection could be shown in people who were born before the 1918 pandemic (Influenza A, H1N1) and were exposed to that pandemic strain (JONES, ADA 1987). They developed specific antibodies to that strain, which most likely also protected them during the 2009 pandemic, caused by some H1N1 parts of the same pandemic strains from 1918. Granted, this study was of people between 90 and 100 years of age, but it still highlights the effectiveness of the immune system memory. This might explain why the 2009 pandemic mainly affected younger people (DAWOOD ET AL. 2009).

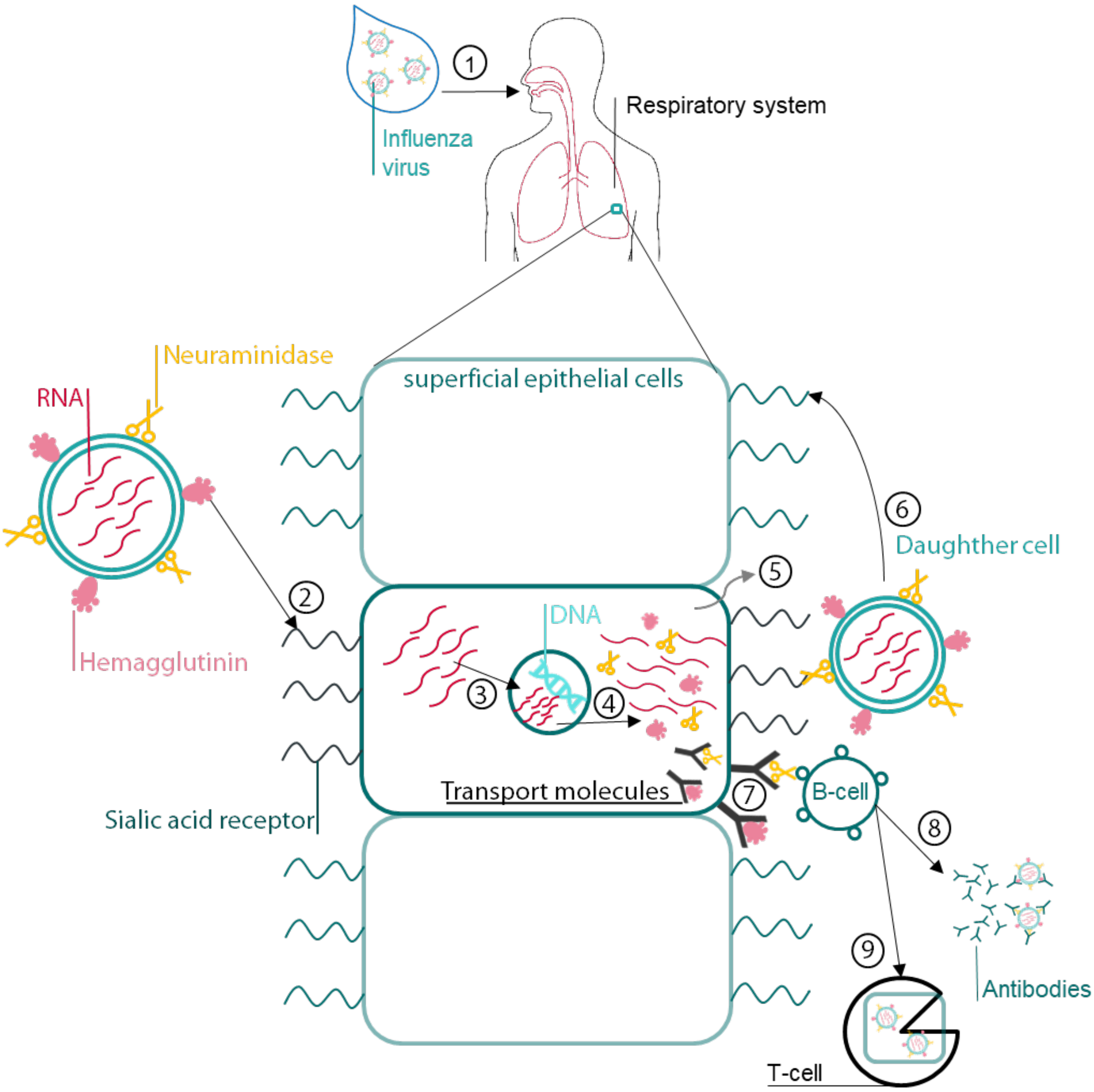


Figure 7 Influenza infection in humans and the immune system response
(1) Influenza viruses enter the body. (2) The virus attaches itself to a human cell. (3) The virus dissolves and its RNA find their way to the cell nucleus. (4) Inside the nucleus, the RNA starts producing virus particles. (5) This process damages the cell over time. (6) When enough virus particles are produced they form into a new virus, ready to infect the next cell. (7) Transport molecules inside the human cell bring NA, HA proteins to the cell surface where (8) B-cells recognise these proteins as intruders and start producing antibodies. (9) T-cells are activated which start eliminating the infected cells (own visualisation, based on DESAI 2019; HAYDEN, DE JONG 2013)

Even if the numbers of vaccinated people were higher, this would most likely not be able to disrupt the annual epidemics. As the virus mutates rapidly, it renders any pre-existing antibodies of the last season useless. There are two main mechanisms of how an influenza virus mutates, i.e. antigenic drift and antigenic shift (BAUMGARTH ET AL. 2013:292).

An **antigenic drift** is a result of minor changes of the antigens, components on the surface of the virus that are recognised by the antibodies, due to an inherent copying error. The copy error is a result of point mutations of viral RNA that cause small changes in viral proteins or antigens. These minor changes allow the virus to escape the antibody binding and are the main reason why an influenza vaccination needs to be administered every year (ENCYCLOPAEDIA BRITANNICA 2020A). The antigenic drift is also a main reason why the circulating influenza viruses may sometimes not match the vaccine strain, even though the WHO biannually recommends an influenza vaccine composition, based on previous surveillance. Therefore, having worldwide surveillance of influenza is important to improve vaccine strain recommendations (CHAN ET AL. 2018).

An **antigenic shift** on the other hand, is caused by a substantial change in the viral antigens, most commonly studied for influenza type A. This usually happens via genetic reassortment rather than a specific mutation. Reassortment happens if a host (e.g. a pig) is simultaneously infected with two different viruses (e.g. human and avian influenza). It is far less likely for humans to get infected with both human and avian influenza, but could happen in a poultry farm for example. As the virus RNA contains eight segments they are able to reassort within the host leading to the emergence of new influenza A subtype. An antigenic shift can also occur when an influenza A virus jumps from an animal to a human. Given that the animal reservoir for influenza A viruses is quite large, it might not be surprising that this form of antigenic shift can happen and may cause a new pandemic (ENCYCLOPAEDIA BRITANNICA 2020B).

3.3 Influenza surveillance systems

Surveillance in Switzerland. To understand the representativeness of national data on influenza and influenza-like illness it is worth looking at the surveillance systems which play a key role in acquiring data on these issues. Switzerland has a mandatory and a voluntary reporting system for infectious diseases.

The **mandatory** Federal Office of Public Health's surveillance system is an ongoing systematic collection of incidences of 54 infectious diseases, which include seasonal influenza and new influenza subtypes. The analysis of this data and the interpretation of health-related data essential for the planning, implementation and evaluation of public health action is also part of the surveillance. This system does not have a research focus (ALTPETER 2019). The aim of these notifications is to catch circulating diseases early on to try and prevent further infections and health risks. Physicians, hospitals and laboratories therefore have an obligation to notify the cantonal office of public health on infectious diseases by following the principle *who diagnoses, reports* (FOPH 2019D). Despite the reporting requirement, underreporting does occur. But experience so far has shown that it is sustainable and robust during a crisis (ALTPETER 2019). The **legal basis** for surveillance is laid down in the Epidemics Act of 2012, Epidemics Regulation and the Federal Department of Home Affairs (FDHA) regulation of notifiable observations in communicable diseases of humans.

The **voluntary** Sentinella reporting system is run by general practitioners in cooperation with the FOPH. The programme commission, which determines the diseases that should be reported, is made up of representatives of physicians, the department of communicable diseases of the FOPH, university family doctor institutes, general practitioners, internists and paediatricians. The system monitors infectious diseases, including influenza, to provide insight into the course of disease but also enables research in family medicine. It was initiated in 1986 and every year approximately 200 doctors participate. The administration of the system lies at the FOPH, where the data is collected and processed (SENTINELLA ADMINISTRATION 2019). Data on influenza is obtained from weekly reports of the practitioners from the Sentinella network, from nasal swabs which are tested at the National Reference Centre for Influenza (CNRI) in Geneva and from laboratory confirmed influenza cases, which are reported to the FOPH as part of the mandatory notification system (FOPH 2019B). Surveillance of vaccine preventable diseases can also help to evaluate measures that were taken to increase vaccination rates.

Global surveillance. Many countries monitor influenza using a variety of different systems. What most have in common is documenting the number of people seeking medical attention due to an influenza infection. Yet, the presence of influenza can only be determined with laboratory diagnostics. When the laboratory confirmation is missing, the patients are documented as having an influenza-like illness. This surveillance system is quite sensitive and can capture seasonal variations well for temperate climates. Often people with suspected influenza are additionally sampled and tested to gain information on the circulating influenza viruses. This is needed to predict future epidemics and for vaccine production. Since 2003 the PCR method, for rapid detection of influenza, increased the opportunities for global surveillance (WIDDOWSON, MONTO 2013:252). The WHO Global Influenza Program (GIP) initiated a Global Surveillance and Response System (GISRS), which currently operates in 144 countries (WHO 2018B). As influenza spreads easily and rapidly across space with globalisation adding to the speed of the spread, it is very important that local authorities work together on a global level. The GISRS also works as a global alert if a new influenza virus is found. But it also monitors influenza throughout the year, estimates the risk of the circulating virus strains, gives advice on vaccine composition and conducts research for new laboratory diagnostics as well as new vaccines and novel treatments for influenza (WHO 2018B). After the influenza pandemic of 2009, the WHO decided to issue a manual on how to collect and standardise data as well as how to use reporting systems, as there were many areas where surveillance could be improved (WHO 2011B). The WHO subsequently established a framework to share information on circulating influenza viruses to improve predictions for the influenza vaccines (WHO 2011C). Collaboration across country borders is especially important as “no single institution or country has all of the capacities to respond to international public health emergencies caused by epidemics and by new and emerging infectious diseases” (WHO 2020c).

3.4 Influenza vaccination

In Switzerland vaccination trials for influenza vaccination were already carried out in 1919. However, at that time it was too early to make any statements about its effectiveness, but it was already concluded that the vaccine did not seem to have any harmful side effects (SCHWEIZERISCHES GESUNDHEITSAMT 1919). However, it was not until the 1930s that widespread experiments and production started to take off (BRESEE ET AL. 2018).

National Prevention. The Swiss government and in particular the FOPH, the cantons and numerous other players have been involved in influenza prevention for many decades. The most recent nationwide strategy was published in 2014 by the FOPH called *The National Strategy for the Prevention of Seasonal Influenza* (GRIPS) with a runtime between 2015-2018 (extension till 2020). Its aim is to reduce the number of serious illnesses caused by seasonal influenza (FOPH 2014A; FOPH 2018A). The strategy comprises three areas of action with specific prevention measures. The first area is public health research, which aims to better understand the burden of influenza disease and the costs-effectiveness of various preventive measures. The second is patient protection, which targets health and health education institutions to promote vaccinations amongst their staff to protect the people they care for. The third area is vaccine promotion amongst people with an increased risk of complications and their close contacts. It is important that the people in question know the advantages and risks concerning the influenza vaccination so they can make a well-informed decision (FOPH 2014A:7-9). In short, Switzerland focuses on both pharmaceutical interventions, such as vaccination, and non-pharmaceutical interventions, such as frequent washing of hands, sneezing into the elbow or tissue, wearing a facemask, or staying home if symptoms of influenza appear (FOPH 2014A:19-20). These preventative measures can really help when thoroughly applied as could be shown during the Coronavirus pandemic as the same safety measures aimed at reducing transmission of Coronavirus are also effective for reducing transmission of influenza. This was observed by the Robert Koch Institute (2020), who concluded that the abrupt decline in respiratory diseases, including influenza, were a direct consequence of nationwide measures to contain and slow down the COVID-19 pandemic in Germany.

Vaccination rates over time. Despite these prevention efforts, the vaccination rates are still fairly low and have been so over the past decade (Figure 8). The FOPH annually publishes a report on the influenza season. The mean vaccination rate over the past 10 years of people above 64 years old was 34.6% (SD 4.8%), yet the vaccination rates among this age group declined from 42% to 28% during the last decade (FOPH 2011; 2012; 2013; 2014B; 2015A; 2016B; 2017D; 2018A; 2019C; 2021). This is far below the WHO-vaccination goal of 75% (Figure 9). The vaccination rates of chronically ill people have also declined a little over the past decade (from 31% to 27%) with an average of 28.8% (SD 2.5%) per season. Fortunately, health care workers have shown a slight increase in vaccination rates (from 19% to 26%) over the past seven years (no data available for the whole decade). Manufacturers of the influenza vaccine publish the number of vaccine doses available to the Swiss market. Based on the assumption that all doses are administered and that each person only gets vaccinated once, the overall vaccination rate of the population is estimated. Based on this, the average influenza vaccination rate over the past 10 years was 13.7% (SD 2.5%) with no strong variations over time. Figure 8 also shows an increase in the estimated vaccination rate of the general population during the season 2016/17, one year after the revision of the Medical Profession Act, which allowed pharmacists to administer vaccines. However, in the following season the vaccination rates dropped to previous levels. Therefore, it remains unclear whether vaccination pharmacies actually increase the vaccination uptake of the general population or whether people who would have got a vaccination elsewhere, used the pharmacy instead.

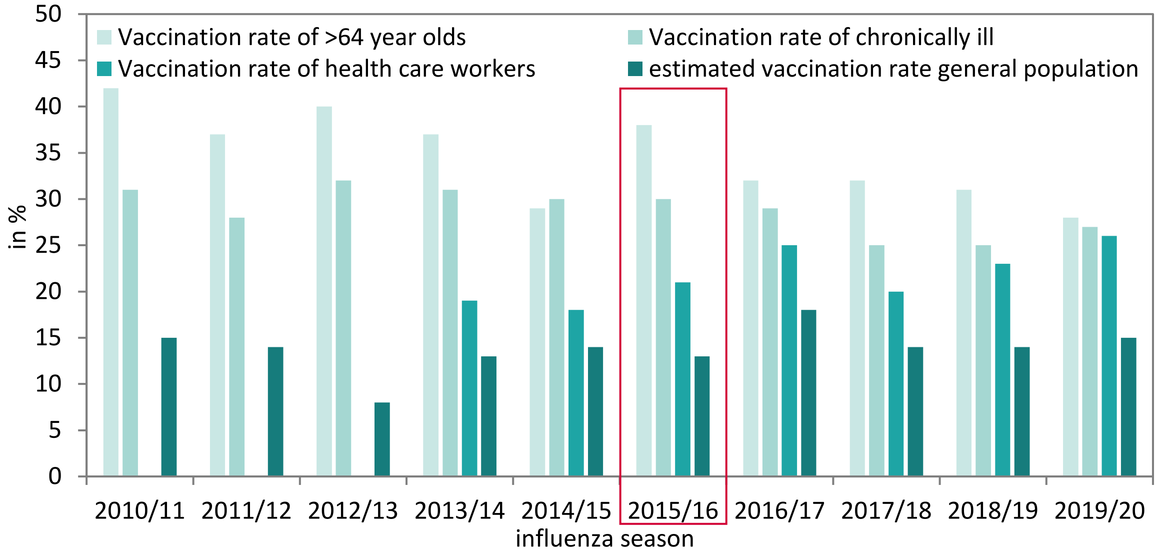


Figure 8 Vaccination rates of seasonal influenza over the past 10 years (2010/11 - 2019/20)
season of household survey highlighted in red (own visualisation, data from FOPH 2011; 2012; 2013; 2014B; 2015A; 2016B; 2017D; 2018A; 2019C;2021)

International prevention. Increasing immunisation rates of people at risk of complications or severe illness due to an influenza infection has become the main paradigm for vaccination programs around the world (BRESEE ET AL. 2018) and is on the agenda of many international institutions, such as the WHO or EU but also on a smaller national scale. The **WHO** passed a resolution to reduce the influenza burden in 2003. It urges member states "to establish and implement strategies to increase vaccination coverage of all people at high risk, including the elderly and persons with underlying diseases, with the goal of attaining vaccination coverage of the elderly population of at least 50% by 2006 and 75% by 2010" (WORLD HEALTH ASSEMBLY 2003:2). Despite this, many European countries are still very far from the WHO vaccination coverage goal of 75% as shown in Figure 9. The **EU** council issued a recommendation in 2009 with the aim to reach "75 % vaccination coverage of the older age groups" as well as "the risk group of people with chronic conditions" (COUNCIL OF THE EUROPEAN UNION 2009:71) as soon as possible. This shows clear united efforts to reduce the global influenza burden by promoting vaccines as the most effective strategy to fight influenza. Some European countries (e.g. Austria, Czech Republic, Malta, Poland and Slovenia) as well as the USA even suggest that all adults get an influenza vaccination (CDC 2020; WEINBERGER 2018). Even though it is well known that influenza vaccination is the best prevention strategy, the overall vaccination rates for the European Region are almost all below the WHO goal of 75% (Figure 9).

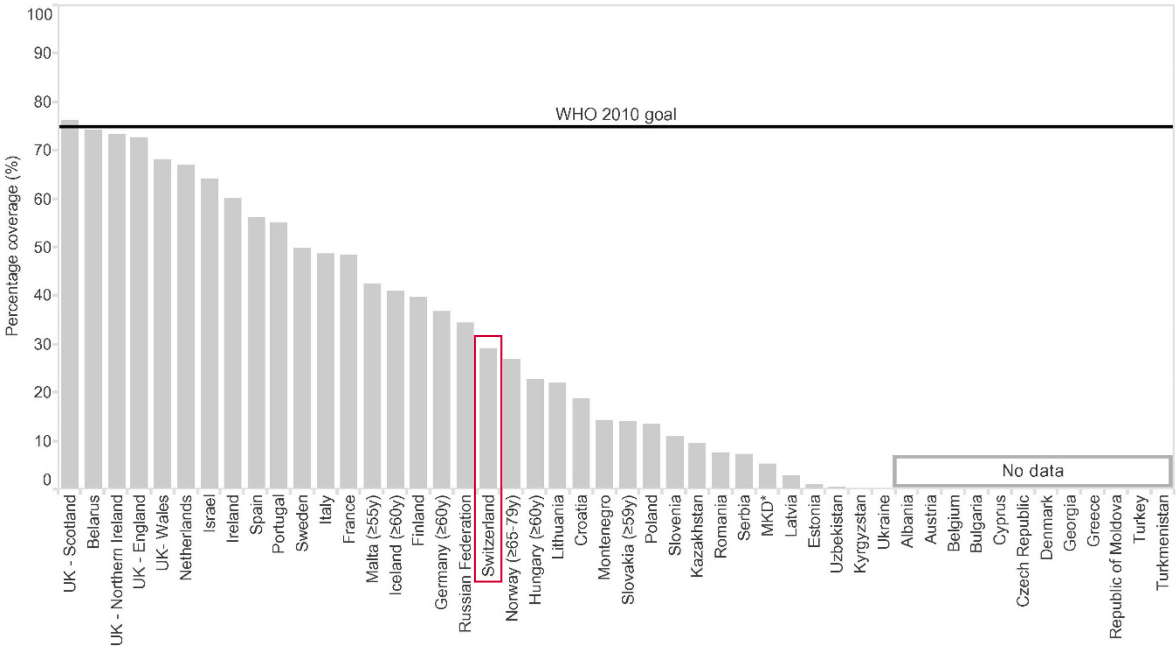


Figure 9 Vaccination coverage of people ≥ 65 in WHO European Region, season 2014/15
Switzerland highlighted in red (JORGENSEN ET AL. 2018:445)

The national and international prevention efforts mainly focus on people at high risk of influenza related complications. Yet, a study by Tsang et al. (2019) suggests that vaccinating children might indirectly protect other household members from influenza. Their results show a 5% lower probability for unvaccinated people to get influenza in vaccinated households. However, only about 10% of infections with influenza are caused within the household, so it is still important to focus on individual vaccination benefits as well as protecting those with an increased risk of vaccine related complications. Chowell et al. (2008:852) even suggested vaccinating 60% or more of the healthy population, as they respond well to vaccines. For the risk group on the other hand, the influenza vaccines often do not provoke a strong post-vaccine immunity, resulting in less effective protection against the vaccinated strains. These studies do raise the question, why national and international prevention efforts mainly focus on the risk group and those in close contact with the risk group, as generally speaking, the more people get vaccinated for influenza on a regular basis, the better the overall public health outcome.

Vaccine effectiveness. Yet there are two overall factors that determine the probability of the vaccine being effective. The first depends on the person's age and health. The second depends on whether the vaccinated strains match the circulating strains. To assess the effectiveness of the influenza vaccine, the CDC calculates the rate at which the influenza vaccine has reduced the risk of disease. Thereby the proportion of the population which did not get a vaccine but contracted influenza is compared to the proportion of the population which did get the vaccine and contracted influenza. The vaccine effectiveness is usually between 40-60% (CDC 2019).

Attempts to increase vaccination rates. With the national and international goal of increasing vaccination rates for influenza, a pilot project was launched in Basel in 2003, which enabled people to get an influenza vaccination in the pharmacy. These vaccines were administered by a doctor. The aim of the campaign was to provide simple and uncomplicated access to vaccinations, especially for people of a risk group (e.g. elderly, people who work with risk groups), who are not currently going through medical treatment. Due to the success of the pilot project the influenza vaccination campaigns were continued, i.e. people could get vaccinated in the pharmacy by a doctor (SPINATSCH ET AL.2013; EICHENBERGER ET AL. 2012). The Pharmaceutical Care Research Group at the University of Basel monitored the vaccination activities of these pharmacies in Basel since the introduction of the pilot project. They have concluded that the pharmacy provides a suitable contact point for individuals who have never been vaccinated against influenza and that the cooperation between the pharmacies and the doctors can raise awareness and increase vaccination rates of individuals at risk. However, the rate of people who get a vaccination for the first time stabilised at around 6% after 10 years (SPINATSCH ET AL. 2013). In 2015, Switzerland revised the Medical Profession Act (MedBG), which allows pharmacists with additional training in vaccination to vaccinate their customers directly without the need for a doctor (FOPH 2015B). The aim of this was to make certain vaccines, e.g. influenza vaccine, more accessible. However, the health system in Switzerland is subject to cantonal law where local authorities can decide whether and which vaccinations may be administered directly in the pharmacy. Basel-City was one of the last cantons to allow the pharmacists to administer influenza vaccinations from May 2018 onward (PHARMASUISSE 2016A). As of 2020 almost all cantons allow certain vaccines to be administered in pharmacies with the exception of Aargau, Appenzell Innerrhoden and Appenzell Ausserrhoden, who only provide vaccination counselling (PHARMASUISSE 2020).

Vaccinating in pharmacies. The vaccination service provided by a community pharmacy can easily be introduced given appropriate additional training and that they raise the vaccination rates of the at-risk population (FRANCIS, HINCHLIFFE 2010). The International Pharmaceutical Federation (FIP) assessed the impact pharmacists have on community immunisation around the world. In their sample of 45 countries, those nations with a high degree of freedom for pharmacists showed higher population immunisation rates. Many countries first enabled pharmacies to administer influenza vaccines but were quick to extend the range of vaccinations to those from the national recommendations (FIB 2016). This speaks in favour of pharmacists worldwide to play a more active role in administering (influenza) vaccines, managing vaccine documentation and reminders as well as organising vaccination campaigns. Pharmacies are also an ideal place to store the vaccines, as they are designed to store drugs anyway. This also helps ensure the quality of the vaccine products. Vaccination pharmacies seem to be a relatively easy way for public health officials to increase vaccination rates among the general population as they provide a low-threshold vaccination service.

3.5 Influenza vaccine hesitancy

Any public health measure is largely dependent on the acceptance and adherence of the public to the suggested measure. However, as the last influenza pandemic in 2009 showed, the adherence to the vaccination strategy was very poor in Switzerland with only 8-30% of people (depending on the canton) getting the influenza vaccine (FOPH 2010). When studying any kind of health interventions, it is very important to include pre-existing knowledge and priorities of communities (TANNER 1990). Eicher et al. (2014) analysed lay persons' beliefs and perceived effectiveness of vaccination to try to understand why some people adhere to public health measures and others do not. They concluded that fundamental beliefs are very important when trying to make sense of disease outbreaks, as they function as a sorting system to link information in a chain of reasoning. This highlights the importance of knowing what lay persons think is the origin of the disease. Most would agree that it has a natural origin, which can be explained by modern medicine. Therefore, most public health interventions are designed to refer to the natural origin of influenza.

Vaccine uptake – global challenge. It is a global challenge to increase the influenza vaccination rates for specific risk groups as well as the general population (WHO 2015). Numerous studies examine influenza vaccine uptake in various population groups around the world (BISCH ET AL. 2011; MERECKIENE ET AL. 2008; LIN ET AL. 2011; MAK ET AL. 2010) and have tried to understand why people are reluctant to accept an influenza vaccination (JARRETT ET AL. 2015; LARSON ET AL. 2014; SCHMID ET AL. 2017). There are a multitude of reasons why people choose to get vaccinated. Bish et al. (2011) for example, draw on the psychological concept of the 'omission bias', first described in Spranca et al. (1991), to explain vaccination reluctance. Thereby people believe that potential side effects or even getting influenza from an influenza vaccination is worse than getting influenza without the vaccination, even if the eventual outcome is the same.

Vaccine hesitancy. The WHO established a Strategic Advisory Group of Experts (SAGE working group) which serves as principal advisor on issues regarding vaccines, immunisation and all vaccine-preventable diseases (WHO 2018C). The group was formed in 2012 and aimed to design a model to understand the interrelations of the vaccine hesitancy determinants. Thereby vaccine hesitancy was defined as "a delay in acceptance or refusal of vaccination despite availability of vaccination services. Vaccine hesitancy is complex and context specific, varying across time, place, and vaccines. It is influenced by factors such as complacency, convenience and confidence" (WHO SAGE 2014:7). The last three factors were part of an earlier model on vaccine hesitancy, whereby *complacency* is understood as having low risk perception for vaccine-preventable diseases. Effective immunisation efforts may even lead to complacency and vaccine hesitancy. *Convenience* refers to the physical access to vaccines as well as the way they are made accessible (adapted to cultural context to make it convenient), affordability of the vaccine and health literacy of individuals. *Confidence* with a vaccine depends on whether an individual believes in the effect and safety of the vaccine itself, experiences a competent administering of the vaccine and believes that policy-makers have no alternate motives when promoting certain vaccines (LARSON ET AL. 2014:2151; MACDONALD 2015:4161-4162). Building on this the working group derived a broader model of vaccine hesitancy determinants in the form of a matrix. This features three main spheres of influence, namely contextual, individual and group influence and vaccine/vaccination specific issues (Table 2). The matrix includes an array of different determinants all based on the collective knowledge and experience from the working group members, all experts in their own field (LARSON ET AL. 2014).

Table 2 Matrix of vaccine hesitancy determinants from the SAGE Working Group (WHO SAGE 2014:245-247; MacDonald 2015:7, own visualisation)

Determinants of vaccine hesitancy	
Contextual influences	• Communication and media environment • Influential leaders, immunization programme gatekeepers and anti- or pro-vaccination lobbies • Historical influences • Religion/culture/gender/socio-economic • Politics/policies • Geographic barriers • Perception of the pharmaceutical industry
Individual and group influences	• Personal, family and/or community members' experience with vaccination, including pain • Beliefs, attitudes about health and prevention • Knowledge/awareness • Health system and providers – trust and personal experience • Risk/benefit (perceived, heuristic) • Immunization as a social norm vs. not needed/harmful
Vaccine / vaccination specific issues	• Risk/benefit • Introduction of a new vaccine or new formulation or a new recommendation for an existing vaccine • Mode of administration • Design of vaccination programme/Mode of delivery • Reliability and/or source of supply of vaccine and/or vaccination equipment

	• Vaccination schedule • Costs • The strength of the recommendation and/or knowledge base and/or attitude of health care professionals

Addressing vaccine hesitancy. To analyse the successes and failures in addressing vaccine hesitancy, the SAGE working group systematically reviewed interventions that addressed this problem. A significant increase in influenza uptake could be seen when the vaccine was made mandatory for health care workers, improving access to vaccinations or making it more convenient and implementing an active follow-up system. For educational interventions there is no clear indication that it helped overall. Combining multiple interventions was most effective. However, some interventions were not successful regarding general vaccination uptake such as outreach campaigns (via posters, websites, media releases etc.), monetary incentives, improving any form of quality control at clinics and in some instances reminder systems failed (WHO SAGE 2014:12, 47). This highlights the importance of understanding the concerns of the vaccination target audience specifically concerning the vaccine in question. Particularly as the influenza vaccine, compared to standard vaccines, shows annual variations in effectiveness (OSTERHOLM ET AL. 2012).

3.6 Bioethics of influenza vaccination

An act of solidarity. In northern Italy, an entire high school, students and teachers alike, chose to get the influenza vaccine during the season 2017-2018. This was widely covered in the media as the reason for it was to protect one student who was undergoing cancer therapy and whose immune system would not be strong enough to withstand an influenza infection (GIUBILINI 2019:1-2). This is a nice example of an entire school opting to vaccinate to protect the most vulnerable pupil by creating a herd immunity against influenza. Now if we scale up from the school to a nation, it is most likely that many lives could be saved if we achieve high enough vaccination rates of the general population. This is particularly important, as there are always individuals who face medical exemptions from influenza vaccines.

Mandatory vaccination. Is the individual vaccination decision more important than the public health strategy of protecting those most vulnerable to an infection? There are many benefits concerning compulsory vaccination. The vaccination is currently the best way to protect against influenza. The more people get vaccinated the higher the probability of creating herd immunity. This protects those who cannot get a vaccination due to medical reasons. So, a vaccination not only benefits the health of an individual but also that of the general population. For the state, it would also be cheaper to conduct a mass vaccination campaign, rather than undergo the cost of hospitalising patients due to an influenza infection. There would also be a reduction in the productivity losses due to people calling in sick (INFOVAC 2020). The revision of the Medical Profession Act (MedBG) in 2015 meant that pharmacies were now allowed to administer the vaccine. This eased access to the vaccine, as the number of places increased where individuals could get a vaccination and pharmacies often do not require people to make an appointment for the vaccination (FOPH 2015B).

The current COVID-19 pandemic has relaunched the discussion of mass vaccinating the population and whether it should be mandatory when it becomes available. We might ask the same question regarding the influenza vaccination. Should there be mandatory vaccinations for people in close contact with risk groups, e.g. medical personnel? Brennan (2018) makes a strong case for mandatory vaccination, not because it benefits the general population, especially the at-risk population, but because they "wrongfully impos[e] undue harm upon others" (37). However, Brennan assumes "the vaccines in question (A) are highly effective, (B) have a low incidence of side effects, (C) protect against serious illnesses, and (D) that the evidence for A-C is strong and widely available, such that the overwhelming majority of people who might dispute A–C would be unjustified and epistemically irrational for doing so." (37) The effectiveness of the influenza vaccine, however, ranges between 40-60% (CDC 2019), which might not qualify as being highly effective. Therefore, this alone does not justify a mandatory vaccination, based on Brennan's assumptions.

Drawbacks. There are also some drawbacks concerning a mandatory vaccination. In Switzerland, the action of a needle entering a person's skin is classified as physical assault. Therefore, no one can be vaccinated by force. In countries that have mandatory vaccinations, the vaccination rate of the general population is not much higher than in Switzerland (INFOVAC 2020). This begs the question of effectiveness of a mandatory vaccination.

Conclusions. These considerations have led the Swiss government to appeal to the solidarity of the general population whilst leaving them with the freedom of choice. An exception has been defined if there is a particular threat to the public health on a national or international level. The vaccination can then be made mandatory for workers in specific settings, such as health care facilities, if there is an increased probability of transmission or if there are particularly vulnerable persons in these facilities. The vaccination may only be compulsory for a defined time period (EPV 2015: ART 38, ABS. 2-3).

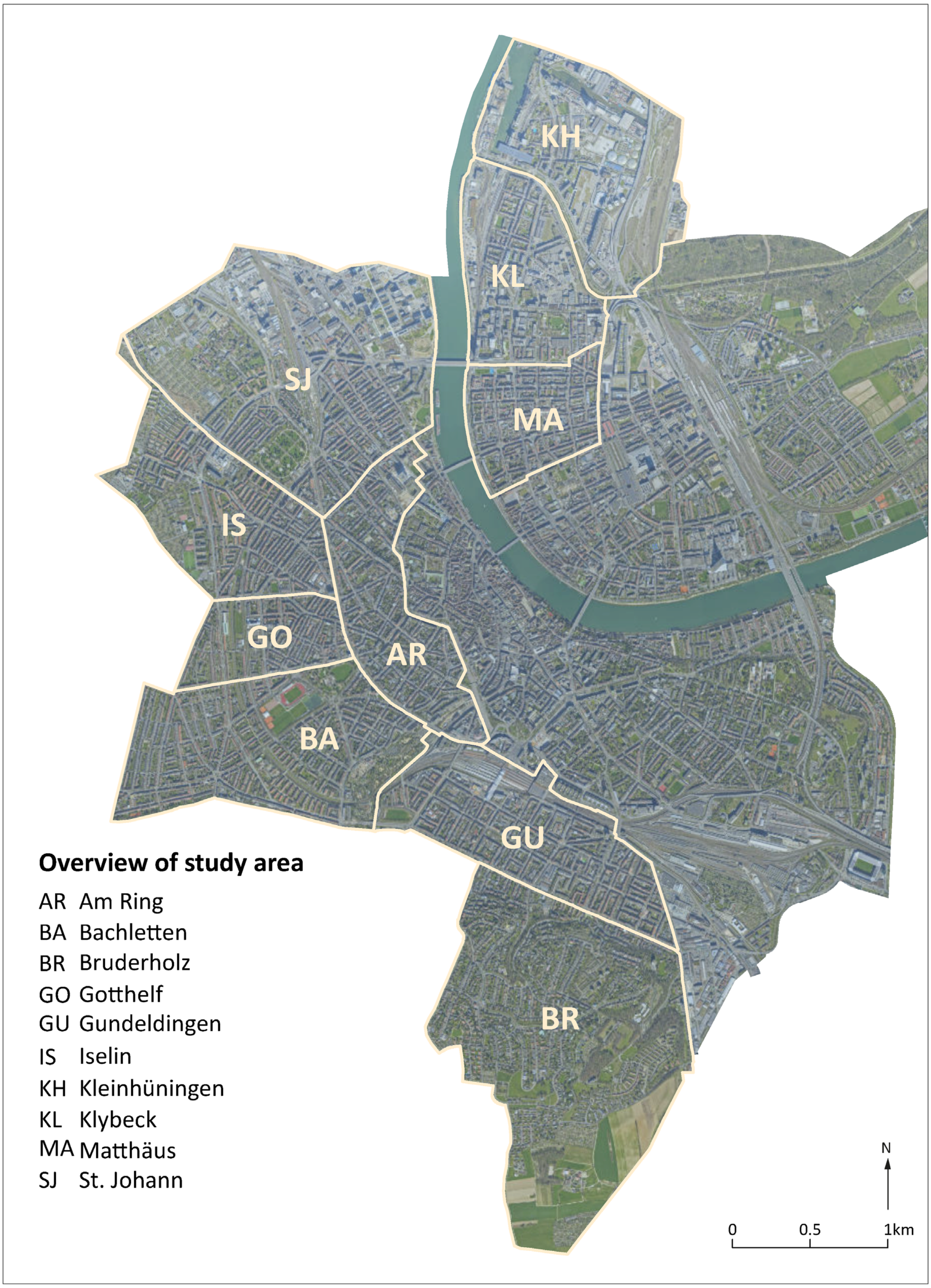
Part II – Study Area and Methodological Approach

4 Study area

The Swiss Context and current trends. 84.6% of the resident population in Switzerland lives in areas with an urban character and half of those live in one of the major agglomerations in Switzerland (Zurich, Geneva, Basel, Berne, Lausanne) (FSO 2018A). In 1970 Basel experienced a population peak of around 236,000 inhabitants, but the population quickly declined over the following 30 years to around 187,000. Around the year 2000 the population started to increase again and surpassed the 200,000 mark in 2018. Basel is the third largest city within Switzerland and had a resident population of 198,206 persons (as of 2016) the year the study was conducted (STATISTICAL OFFICE BASEL-CITY 2019A). It is also within the top 10 of highest population density per hectare (FSO 2018B). Switzerland, as many other Western nations, is faced with an ageing society where the proportion of young people (<20years) has strongly decreased to 20.1% over the past decade and the proportion of over 64-year-olds has strongly increased to 18.1%. It is estimated that by 2045 the proportion of over 64-year-olds will have increased to 26% (FSO 2018A). In general, large cities such as Basel have a slightly younger population than smaller cities under 100,000 and the proportion of people over 65 is lower (FSO 2018B). Concerning the foreign-born population, Switzerland has one of the highest rates in Europe with 25%. However, 44% of those with foreign nationality have been living in Switzerland for at least 10 years (FSO 2018A). In Basel the foreign-born population is significantly higher than the Swiss average at 35.7%, but it varies greatly by quarter (STATISTICAL OFFICE BASEL-CITY 2019A). The average size of a household in Switzerland is 2.24 people, but almost half of all households in the urban core are 1-Person households (FSO 2018A).

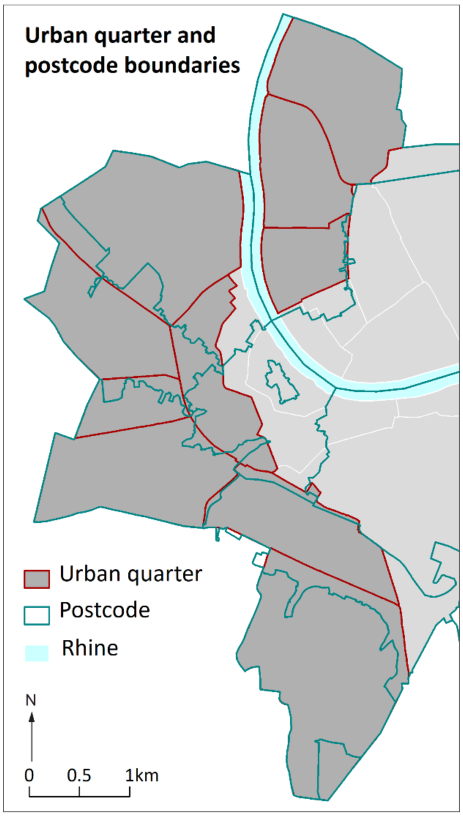
Place specifics of Basel. As a place of residence is not merely a locality but is also influenced by cultural, political, and economic surroundings the following offers a brief overview of the study area and its local context. Basel is a typical central European city of medium size. In recent decades, the amount of built-up land has increased significantly, mainly at the expense of agricultural land. But Basel is also a special case. Because of its location on the border, the contiguous built-up area extends not only beyond the city limits, but also beyond cantonal and national borders. A cross-border, urban agglomeration of Basel with shares of Swiss, German and French territory has long been a reality. This is why close economic and social links across the borders have existed for almost two decades (SANDTNER 2004).

Study area. Map 1 below gives an overview of the study area. Out of 19 urban quarters that make up the city of Basel, 10 were selected due to their differences in demographic composition and physical features. The quarters are all next to each other and form a band through half the city. Section 4.3 offers a detailed characterisation of all quarters included in the study. The research protocol is described in detail in Egli et al. (2019).



Map 1 Overview of the study area
(Source: Base map data for quarter boundaries: Bau und Verkehrsdepartement des Kantons Basel-Stadt, Grundbuch und Vermessungsamt, Fachstelle für Geoinformatik. Image: ©2019 Google, ©2019 Flotron/Jerrmann, Maxar Technologies. Concept and cartography: M. Brunner, N. Goldman 2020)

4.1 Geographic scales of the study area



Map 2 Comparison between urban quarter and postcode boundaries
(Source: Postcode boundaries: Amtliche Vermessung Schweiz, Swisstopo. Base map: Bau- und Verkehrsdepartement des Kantons Basel-Stadt. Grundbuch- und Vermessungsamt. Concept and cartography: M. Brunner, N. Goldman 2020)

Urban quarters. This study works with the administrative quarter boundaries to facilitate an analysis on the quarter level. However, it is acknowledged that there are many different definitions of an urban quarter and many see it as a socially constructed space with fuzzy boundaries (e.g. FABIAN ET AL. 2017). 100 years ago, the statistics office Basel-Stadt divided the city into 19 statistical urban quarters. These boundaries have remained unchanged, which allows small-scale analysis of the developments in the city (STATISTICAL OFFICE BASEL-CITY 2020A). The idea of using the postcode level was abandoned, as the spatial division is less regular than that of the quarters as illustrated in Map 2. This is most notable for the quarters Kleinhüningen, Klybeck and Matthäus which have the same postal code, but the quarter Bruderholz has three different post codes. Also, the boundaries between the postcode districts follow a different logic than the district boundaries. For these reasons the quarter level, rather than post code level, was chosen for this study.

Statistical Block. In Basel, a statistical block is defined as all sides of a block being bordered by streets. Sometimes the boundary is not necessarily a street, but could be several different features listed in the zone plan, such as an agricultural zone, railway, green zone or forest. Each block consists of a continuous and closed area. Adjacent blocks cannot overlap each other (STATISTICAL OFFICE BASEL-CITY 2020A). The overview map of Basel shows that the closed block edge development is very prominent in most of Basel's quarters except for Bruderholz. The block edge structure is a key element of urban design and has shaped many cities all over the world. The geographical analysis of urban areas is often based on statistical building blocks, as the available data is often aggregated to this level by municipal statistics offices. It also has the advantage that it is based on the architectural structure of the city and that clear boundaries are established by the streets. However, the use of statistical block was not popular in all cities. Based on the definition above, it is possible that the blocks are very different in size and thereby it limits comparability between blocks. Therefore, some cities have started to use block sides, a further break down from the full block. The block side data can then be aggregated for larger road sections or streets (HEINEBERG 2014). Berlin, for example, also uses the same definition of statistical blocks (STATISTIK BERLIN BRANDENBURG 2020) as well as the United States Census Bureau, where it is called a “census block” (ROSSITER 2011). The one difference between the US and Basel definition lies in the area coverage. The US census block is a nationwide unit, i.e. a wall-to-wall coverage, where adjacent blocks do not overlap each other, whereas the statistical blocks of Basel and Berlin essentially leave out streets and squares.

Other studies. As mentioned in the introduction, the geographic scale of other studies on influenza are often only concerned with larger scales and look at the spatial variation on a global level (BLOOM-FESHBACH ET AL. 2013; TAMERIUS ET AL. 2013), on a country level (YU ET AL. 2013) or on a regional level (MAO, BIAN 2010). Although it is widely recognised that cities play an important role in disease transmission, they are not often studied. This is most likely due to the large amount of data needed to make any valid statements on city-wide influenza transmission (MAO, BIAN 2010). Therefore, many studies try to model how influenza spreads in a city context.

4.2 Socio-spatial and economic structures within the study area

It is long recognised that socio-economic determinants such as education, income, age, etc. influence health outcomes. However, persons of particular educational status and income brackets tend to cluster in similar areas. Clustering of similar income groups is very common and can be quite pronounced. In Basel, the qualitative differences between urban spaces are less pronounced compared to US cities, where segregation between rich and poor communities and districts has increased since suburbanisation. The economic segregation of individuals affects choice of residence, access to jobs, health care, education and retail services (SWANSTORM ET AL. 2005:284).

From industrialisation to globalisation. An explanation for the heterogeneity of the population structure across Basel can be found in its history. The rapid industrialisation of silk ribbon production in the 19th century increased the demand for manual labour (WECKER 2000). Over the next century Basel grew as an industrial hub, attracting more workers from the surrounding region and resulting in the construction of many worker settlements like Iselin, Sankt Johann, Matthäus, Klybeck or Kleinhüningen (STATISTICAL OFFICE BASEL-CITY 1938). The typical worker settlement structures in these quarters with their block edge development and low shares of green space can be seen in the map series below. These historical developments lead to quarters with different characteristics based on the built environment, socio-spatial composition of inhabitants and functional mixture of different uses (HABICHT 2008; WECKER 2000). During the second half of the 20th century Basel experienced a phase of deindustrialisation due to various developments in the chemical industry, e.g. relocation of production plants and company mergers (WÄHREN ET AL. 2009).

The traditionally industrial city went through a phase of deindustrialisation in the 20th century. Today, many large pharmaceutical companies have their headquarters in Basel making it a well-recognised life-science cluster within Europe (VOGEL 2021). A staggering 80% of the working population was employed in the service sector, which might be the reason why Basel had the highest Gross Domestic Product per capita in 2011, as the wages in the service sector are typically higher than in primary or secondary sectors. However, despite this, Basel also has the second highest social assistance rate (6%) of all Swiss cantons (OBSAN 2014). This illustrates that Basel is a city of strong contrasts, which is also noticeable on a spatial level.

Commuters. The strong industrial heritage explains why Basel has experienced a long tradition of cross-border and cross regional commuter flows, which are still quite high today with 101,670 people commuting to the canton Basel-City, whereby commuters are defined as people working in the canton for at least 1h per week. Note that Basel only has a resident population of approx. 198,000 for 2016 (STATISTICAL OFFICE BASEL-CITY 2019A). This study does not include incoming commuters to Basel, yet it is important to keep in mind that the higher the commuter volume the higher the influenza-like illness prevalence (CHARAUDEAU ET AL. 2014). Including commuters in the study was not deemed feasible but should be a focus within studies modelling the spread of influenza-like illnesses.

4.3 Characteristics and selection of the urban quarters

Those individuals with a low and high socio-economic status are both limited in the freedom of choice in the housing market, but for very different reasons. While the disadvantaged have only very limited choices in finding housing due to financial constraints, the latter may only satisfy their specific housing needs in certain urban quarters. As Basel has larger spatial units with uniform housing quality, the groups at both ends of the socio-economic spectrum are mostly segregated into different quarters (EDER SANDTNER 2005). Ethnic segregation does not prevail independently of socio-economic status in many Swiss cities. This leads to urban quarters which are rarely dominated by just one migrant group, but always have a high proportion of native population of the same socio-economic status (WIMMER 2004). In Basel, the clusters of individuals with low socio-economic status are not necessarily isolated socially, as the quarters they live in are usually not the quarters they work in. This leads the individuals to have cross-quarter spheres of action (EDER 2001). Individuals of higher socio-economic status, but non-traditional, are more socially and spatially mobile as their financial conditions allow them to react flexibly to the housing supply. This population group is spread more evenly across Basel according to their own personal preferences and availability of high-quality living space. The modern middle class, which can be characterised as heterogeneous in their financial and biographical background is equally spread out across the city (EDER SANDTNER 2005).

Table 3 Five types of urban quarters in Basel
(source: translated and adapted from Eder Sandtner 2005)

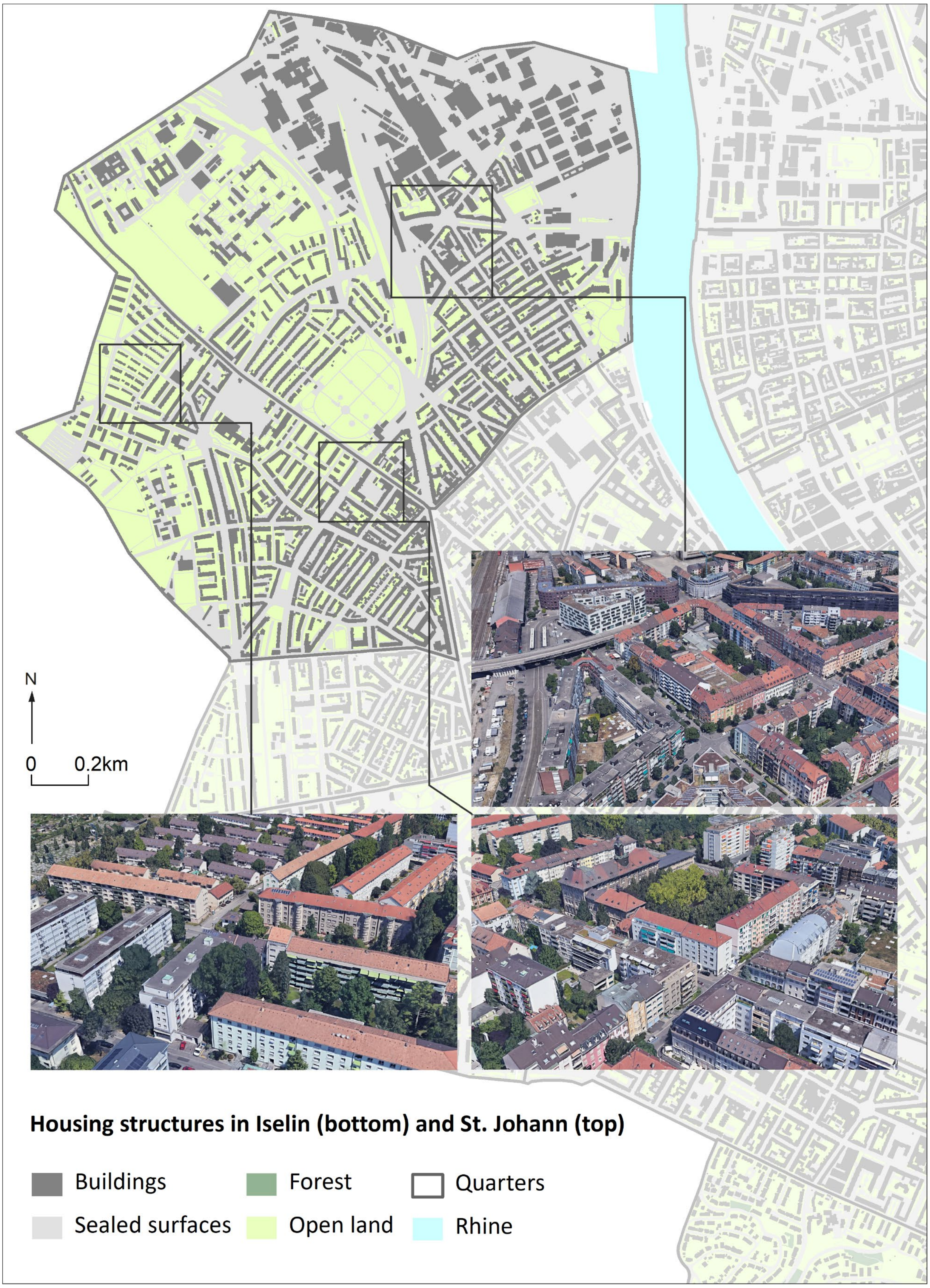
Degree of homogeneity	Type	Characterisation	Quarter in study area
Socially homogeneous quarters with traditional patterns of Fordist division	Type 1	Industrial or commercial quarters, residents of lower socio-economic status, quarters with little green space, mostly on the periphery of the city	Kleinhüningen (Map 7) Klybeck (Map 7)
	Type 2	Loosely built up and unencumbered quarters with residents of higher socio-economic status	Am Ring (Map 3) Bachletten (Map 4) Bruderholz (Map 5)
Heterogeneously composed quarters with socio-spatially flexible residents and different living quality	Type 3	Quarters with a large proportion of cooperative housing and various types of development structure, residents with average socio-economic status (e.g. quiet rows of terraced houses and block edge development on busy streets)	Iselin (Map 6) Gotthelf (Map 4)
	Type 4	Quarters with good supply and maintenance infrastructure with residents of average and lower socio-economic status. Quarters with little green space and qualitatively very different small and micro-apartments, transit quarters	Gundeldingen (Map 5) Matthäus (Map 3) St. Johann (Map 6)
	Type 5	Luxuriously renovated and gentrified old towns with post-modern upper-class households	No quarter of this type selected, as number of people living in these types are quite small

Housing structures. The following housing structure maps each consist of an overview of two quarters and show the different types of land cover, namely buildings, sealed surfaces, forest, and open land. This enables an overview of the physical structures of each quarter. The land cover data is taken from the official cadastral survey (BAU- UND VERKEHRSDEPARTEMENT DES KANTONS BASEL-STADT 2016). To keep it simple the individual land cover types were classified into four main categories. To add a three-dimensional aspect to the maps, detailed images of selected areas within the quarters were sourced via Google Earth, since this tool provides maximal flexibility regarding zoom levels, viewing angles and viewing direction. The images usually focus on areas typical for that respective quarter. The images were then integrated into ArcGIS map. Looking at the map series below, it becomes apparent that the physical built up area of each quarter varies, especially concerning housing structures and rate of (publicly accessible) green space.

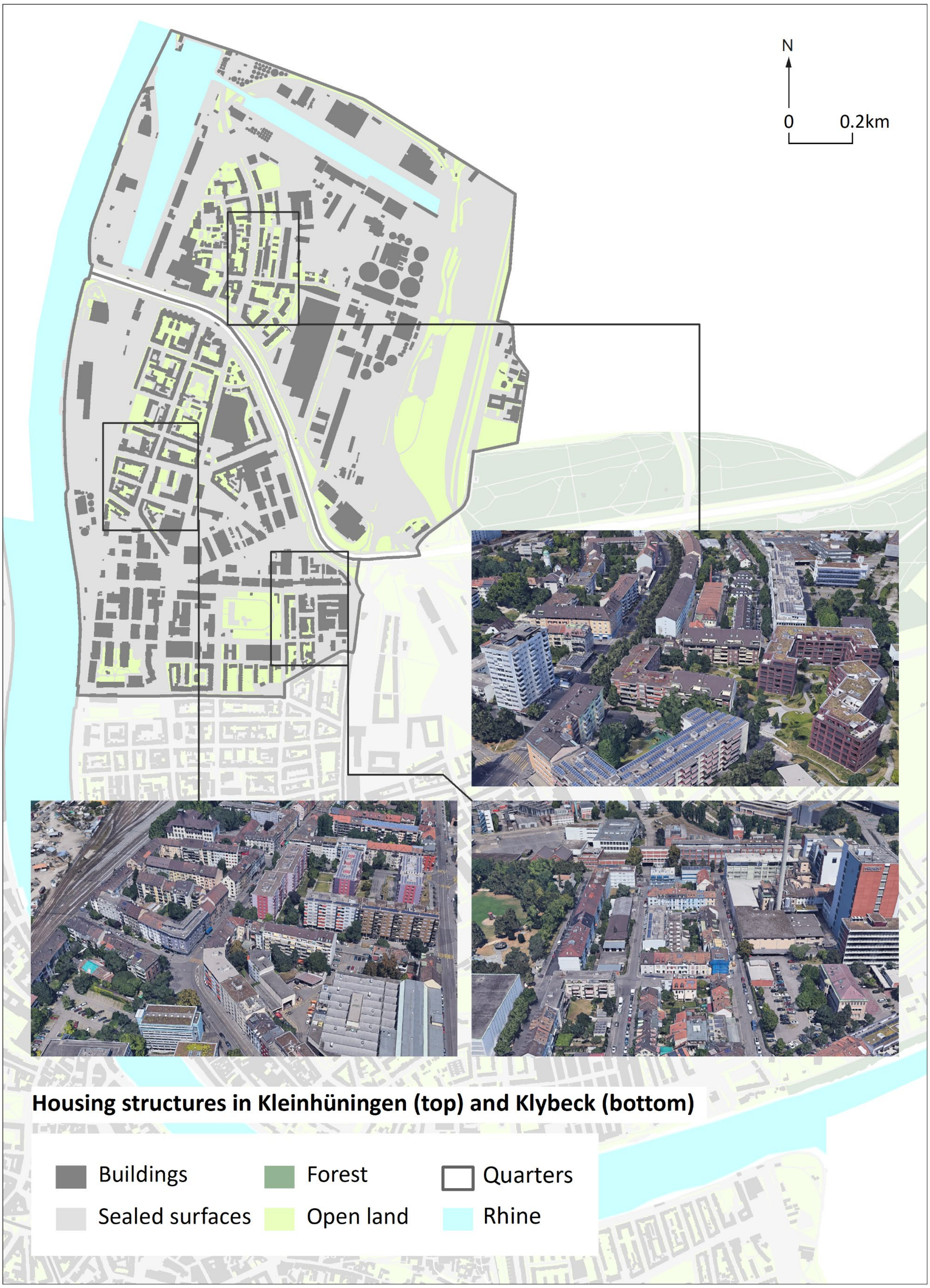
Map 3 Housing structures in Am Ring and Matthäus
(Sources: Base map: Bau- und Verkehrsdepartement des Kantons Basel-Stadt. Grundbuch- und Vermessungsamt. Imagery: ©2019 Google, ©2019 Flotron/Jerrmann, Maxar Technologies. Concept and cartography: M. Brunner, N. Goldman 2020)

Map 4 Housing structures in Bachletten and Gotthelf
(Sources: Base map: Bau- und Verkehrsdepartement des Kantons Basel-Stadt. Grundbuch- und Vermessungsamt. Imagery: ©2019 Google, ©2019 Flotron/Jerrmann, Maxar Technologies. Concept and cartography: M. Brunner, N. Goldman 2020)

Map 5 Housing structures in Bruderholz and Gundeldingen
(Sources: Base map: Bau- und Verkehrsdepartement des Kantons Basel-Stadt. Grundbuch- und Vermessungsamt. Imagery: ©2019 Google, ©2019 Flotron/Jerrmann, Maxar Technologies. Concept and cartography: M. Brunner, N. Goldman 2020)



Map 6 Housing structures in Iselin and St. Johann
(Sources: Base map: Bau- und Verkehrsdepartement des Kantons Basel-Stadt. Grundbuch- und Vermessungsamt. Imagery: ©2019 Google, ©2019 Flotron/Jerrmann, Maxar Technologies. Concept and cartography: M. Brunner, N. Goldman 2020)



Map 7 Housing structures in Kleinhüningen and Klybeck
(Sources: Base map: Bau- und Verkehrsdepartement des Kantons Basel-Stadt. Grundbuch- und Vermessungsamt. Imagery: ©2019 Google, ©2019 Flotron/Jerrmann, Maxar Technologies. Concept and cartography: M. Brunner, N. Goldman 2020)

5 Methodological approaches

The underlying study aims to understand the distribution patterns of influenza, influenza-like illness, and vaccinated individuals within an urban context, using Basel as an example city, and determine which factors influence the likelihood of individuals to get an ILI. Further, it also aims to understand which factors may determine an individual's propensity to get vaccinated and in what ways does the vaccination behaviour of different population groups vary. This chapter provides an overview of the various data sources that were pooled for this study. It then follows up with a detailed description of the various methodological approaches that were used to analyse the data and can be broadly categorised into an explorative spatial analysis with GIS and statistical analysis with SPSS.

5.1 Data sources

Different data sources are used for this thesis. The specifics of each source are described below as well as how the different datasets are combined to enable a more integrated approach in the urban quarter analysis.

5.1.1 The household survey

The primary data for this study consists of a large-scale household survey (see appendix) which was carried out by the research group Human Geography/Urban and Regional Studies, in cooperation with the participating institutions, in ten selected urban quarters of Basel between April and May 2016, right after the peak of the influenza period. The survey was designed in cooperation with the Department of Biomedicine at the University of Basel and the Division of Clinical Bacteriology and Mycology at the University Hospital Basel. The Human Geography research group coordinated the distribution and data entry of the survey with the help of many undergraduate students and staff from the participating institutions. A total of 30,000 questionnaires (= one third of all households in Basel-City) were distributed in ten quarters around Basel, making this the largest survey on influenza in an urban context undertaken so far in Switzerland. Lessons learned from organising a high-volume survey as well as recommendations for other researchers are given in chapter 10.2 (p. 132). The survey was adapted to each quarter, with respect to the neighbourhood map at the end of the questionnaire. This map was superimposed on a grid carrying a mesh size of 200m x 200m. This allows for a more accurate spatial location of the respondents. The respondents could voluntarily self-disclose their location while preserving their anonymity. These locations were entered into the Geographic Information System (GIS), which allows an analysis of the survey data with respect to place of residence. The survey booklet was placed in a large envelope which also contained an addressed and pre-stamped return envelope to ensure that the respondents faced no additional cost, apart from their time, for taking part in the survey. The survey covered a multitude of topics on the household level. An overview of the covered topics is given in Table 4.

Table 4 Overview of the covered themes and variables in the household survey (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Themes	Variables
Incidence and severity of disease	· Illness incidence (season of 2015/2016) · Symptoms and number of days with restrictions on daily activities · Contact to health professional regarding symptoms · Anyone else in close contact environment with similar symptoms · Medication to treat symptoms
Vaccination uptake and behaviour	· Vaccination behaviour · Reasons for or against vaccinating · Experience with vaccination · Regularity of influenza vaccination · General vaccine behaviour
Perceptions of own health and preventive measures	· Perception of own health · Having a General Practitioner · Chronic illness · Smoking behaviour · Drinking behaviour · Perception of certain health behaviours · Implementation of certain health behaviours
Health information	· Source of information on health issues · Perceived use of health information
Close contact opportunities	· Personal mobility and frequency of use · Frequency of engaging in various activities · Number of contacts with people on a regular day · Working in the health sector · Working in an open-plan office · Regular visits to a hospital or retirement home · Looking after care-dependent family members at home · Living with chronically ill people
Socio-economic situation	· Gender · Age · Nationality · Educational level · Employment status · Monthly gross household income
Personal environment	· Residential status · Living space per capita · Number of people per household · Household structure · Living with children
Quarter characteristics	· Location of residence · Exposure to environmental influences · Share of green areas (data from Statistical office Basel) · Share of built-up area (data from Statistical office Basel)

Sampling procedure. To obtain a statistically significant population sample to analyse the target and risk group with respect to the general population the questionnaires were distributed across the ten urban quarters according to a specific distribution key. To account for varying population sizes between the urban quarters a probability-proportional-to-size (PPS) sampling was chosen to plan the city-wide distribution of questionnaires. To ensure that every household within each quarter had an equal probability of being selected the equal probability of selection method (EPSEM) was used. As pen and paper questionnaires are known for having low response rates, a conservative assumption of a 12% return rate was made. The number of necessary returns needed to be a statistically significant representation of each quarter was calculated as follows:

$$n \geq \frac{N}{1 + \frac{(N-1)e^2}{K^2 V(1-V)}}$$

n = min. required sample size
N = No. of households by quarter;
e = sampling error 5%;
K = 1.96 confidence level (95%);
V = distribution of responses (50%)

Detailed information on the numbers is listed in Table 5. Based on these calculations more questionnaires than number of households should have been distributed in the quarter Kleinhüningen, which is not possible. Thus, every household received one questionnaire (EGLI ET AL. 2019).

Table 5 Defining a representative sample
(source for no. of households: Population Statistics 2014, Canton Basel-City, own calculation and visualisation, previously published in EGLI ET AL. 2019)

Quarter	No. of private households (N)	Minimum required sampling size (n)	Necessary number of distributed questionnaires (if 12% response rate)	Distribution key: every x household
Am Ring	5456	359	2991	2
Bruderholz	4038	351	2924	1
Bachletten	6710	363	3028	2
Gotthelf	3764	349	2906	1
Gundeldingen	10085	370	3084	3
Iselin	8860	368	3069	3
Kleinhüningen*	1291	296	2469	1
Klybeck	3506	346	2886	1
Matthäus	8012	367	3055	2
St. Johann	9180	369	3073	3
Total	**60902**	**3538**	**29485**	

The questionnaire was composed in German and was additionally translated into English, Italian, Turkish, Serbo-Croatian and Albanian as these are the most commonly used languages in the study area (Table 6). The aim of this was to reduce the selection bias, based on German language fluency. Despite being a national language, French was not a dominant language in any of the quarters in the study area. However, some respondents were surprised or angry that the questionnaire was not translated into French. It was perceived as an affront, as French is a national language of Switzerland and many people are used to things being translated into at least one other national language. Therefore, it might be worth considering to also provide questionnaires in French for future studies in the German speaking parts of Switzerland, even if it is not a dominant language within the study area.

Table 6 Foreign population by citizenship as a percentage of all foreigners in the urban quarter (source: Population Statistics 2014, Canton Basel-City, own calculations, and visualisation, previously published in EGLI ET AL. 2019)

Quarter	Largest segment	2nd largest segment	3rd largest segment	4th largest segment
Am Ring	Germany (27%)	Italy (10.3%)	Spain (5.9%)	United Kingdom (4.7%)
Bruderholz	Germany (32.6%)	Italy (11.8%)	UK (7.5%)	France (5.2%)
Bachletten	Germany (32.3%)	Italy (13.2%)	Spain (5.2%)	United Kingdom (4.9%)
Gotthelf	Germany (32.2%)	Italy (12.5%)	Turkey (4.9%)	Spain (4.9%)
Gundeldingen	Germany (20.5%)	Turkey (14.9%)	Italy (12.7%)	Serbia*, Montenegro*, Kosovo* (9.8%)
Iselin	Germany (18.3%)	Italy (15%)	Turkey (12.6%)	Serbia*, Montenegro*, Kosovo* (7%)
Kleinhüningen	Italy (15.7%)	Germany (14.5%)	Turkey (14.3%)	Serbia*, Montenegro*, Kosovo* (10.5%)
Klybeck	Turkey (16.7%)	Italy (15.5%)	Germany 11.3%)	Serbia*, Montenegro*, Kosovo* (10.9%)
Matthäus	Germany (17%)	Italy (10.8%)	Turkey (10.6%)	Serbia*, Montenegro*, Kosovo* (10.5%)
St. Johann	Germany (17.2%)	Turkey (12.2%)	Italy (10.8%)	Portugal (8.7%)

*Official language of Montenegro: regional Serbo-Croatian and Albanian; Serbia: Serbo-Croatian; Kosovo: Albanian, Serbo-Croatian, Turkish

Data editing. The data was edited and analysed using the IBM statistics program SPSS version 26. The questionnaires are uniquely identified by an urban quarter and an identification number, which enables a comparison between the digital record and the original questionnaire. Questionnaires with incomplete data, such as missing all personal or health information, were rejected. Free answers were harmonised and grouped into new categories for further analysis. New variables were created from original data such as age groups from the year of birth or living space (in m^2) per person from number of persons per household and living space per household. The dataset was also enhanced by the project partners from the University Hospital Basel, under the leadership of Prof. Adrian Egli. They analysed the variable of the self-stated medication of the respondents and classified it according to the Anatomical Therapeutic Chemical (ATC) Classification system used by the WHO – allowing the identification of baseline diseases based on regular medication. They also assigned the respondents into two groups, the risk group and non-risk group, according to their ATC classification. Creating new variables, instead of editing the original data, ensures the availability of the original data and all data processing remains traceable. This procedure produces an accurate and consistent data set which fulfils the requirements set by Swiss data protection laws and the ethics commission (EGLI ET AL. 2019).

Ethics and data protection. The survey was audited and approved by the Ethics Commission of North-Western and Central Switzerland as an observational study (EKNZ project ID 2015–363 and 2016–01735; trial registration number NCT03010007). The collected information was anonymised in IBM's statistics software SPSS Version 26.0 in accordance with the Swiss legal guidelines and the standards of the Ethics Commission of North-Western and Central Switzerland. The information from the household survey will be used for preventative medical purposes (avoidance of infectious diseases) and for the following part of the project. In accordance with the data protection laws in Switzerland and the standards of the ethics commission the data will not be used commercially or in any other way that is not approved for the research project or passed on to people or institutions outside of the research project. The data is within a secured domain and only accessible to researchers working on the project. The large-scale survey is anonymised in all parts. The possibility for personal identification to take part in a competition was voluntary and is not part of the research project. The question in the questionnaire which deals with the residential location within the quarter will not be analysed as part of the survey, but will be used separately in the statistical geoinformatics part of the research project. Hence, it is used for the production of maps with the spreading patterns and spatial concentrations (hot spots) of influenza in relation to quarter characteristics.

5.1.2 External statistical data

Statistics office of Basel. Data from the statistics office of Basel was used to estimate any potential biases in the questionnaire regarding age or gender distribution, educational level, nationality, or income. The statistics office provides a wide range of data in the fields of population, taxation, social assistance, and spatial and environmental issues. The data mostly contains the block, district, or residential identifier, which enables spatial analysis. The use of the data is subject to a corresponding data usage contract. For this thesis, socio-economic variables such as net income, living space per person and persons per statistical block are used for a multilayer analysis. Combining this with the survey data provides the basis of the spatial analyses with GIS. The environmental variables such as share of green space and building density are attached to the survey data to find the underlying determinants for ILI and vaccination. This secondary data has the advantage of being very comprehensive, which enables a small-scale analysis on the block level. This might show heterogeneous structures within the boundaries of the official quarters of Basel.

However, using this data requires great attention, as the statistics office has different data sources and types. For example, on the one hand they have statistics of population and households, which is federal data, and on the other hand, they have population statistics, which come from the canton itself. The actual number of the resident population differs between the federal and cantonal data, as they work with different definitions. The federal government's definition includes only the permanent resident population and foreign nationals who have a residence permit for at least 12 months. This ties in with the UN recommendation, as the permanent resident population of all nations equals the world population (BFS 2019B).

The cantonal definition includes the permanent resident population and the non-permanent resident population. The latter consists of foreign-born persons who stay less than 12 months, who are official permanent residents in their original country. However, as these persons also use the local infrastructure and occupy flats this makes them an unneglectable economic factor, which must be considered when planning for the city. As this study focuses on Basel, and not comparing the cantons with each other, the cantonal data from the statistics office Basel-City is used (STATISTICAL OFFICE BASEL-CITY 2019B).

PCR-confirmed Influenza incidents. This study includes PCR-confirmed influenza incidents from the season 2013/14-2017/18. The collection of this data is described in Egli et al. (2019). This data was used, as the ILI data from this study only consisted of one single season limiting the explanatory power of any identified influenza hot spots.

Methods developed by the ISPM. The Institute of Social and Preventative Medicine (ISPM) in Berne was the first to develop a Swiss neighbourhood index of socio-economic position (Swiss-SEP) which is an area-based measure with a sliding neighbourhood definition. A neighbourhood is defined as 50 households using Census 2000 and road network data. The objective of this index is to provide a basis for studying socio-economic characteristics of a place when studying health (PANCZAK ET AL. 2012). In 2017 the index was updated to the Swiss-SEP 2.0 index and comprised the following four variables: (1) Occupation: proportion of households who are headed by an individual in manual or unskilled occupation (only in paid employment), (2) Education: proportion of households who are headed by an individual with no formal or only compulsory education, (3) Crowding: number of persons per room and (4) Rent: Median rent per square metre (SNC 2020). The data was provided as the index value between 0 and 100 (low values = low socio-economic status, high values = high socio-economic status), and coordinates of the centre for each neighbourhood. The statistical blocks in Basel are a little larger than these neighbourhoods, so the average index value per statistical block was calculated to be able to visualise the data with ArcGIS. This index is used to assess the association between socio-economic position and influenza.

Vaccination pharmacies. The Department of Pharmaceutical Sciences (University of Basel) joint with the association of Pharmacists in Switzerland (PharmaSuisse) provided data on vaccination pharmacies in Basel (n=45), which included data on the number of vaccinated individuals and some demographic factors. This was also included at a later stage in the analysis, as it became clear that alternative vaccination locations could be important for increasing vaccination uptake of the general population.

5.2 Explorative spatial data analysis with GIS

Identifying place effects. This chapter discusses the methods frequently used for spatial analysis of disease mapping. Exploratory spatial analyses are used to visualise data and discover interesting patterns. By including the spatial environment of the urban quarters, this study tries to understand if spatial spreading patterns of ILI coincide with aspects of the urban environment as well as the quarter structures and identifies if this may be significant or merely statistically incidental, i.e. without epidemiological significance. The results for the spatiotemporal spreading of newly infected persons in the city will be gained through statistical geo-informatic methods. ILI incidences and relevant aspects of the urban environment will be visualized in GIS and combined with different types of aerial photography. GIS analyses of ILI spreading patterns blended with statistical data are designed to determine the urban social structure that may account for higher occurrences of ILI cases (such as age distribution, social life situations, education status, migration background, housing and living arrangements). This helps determine, for example, if the number of ILI cases is higher in densely built, densely populated areas and in areas with certain age structures.

Maps in this study. All the maps for this study were made in accordance with the recommendations set out by the Leibniz Institute for Regional Geography in Leipzig (AUGUSTIN ET AL. 2017). ESRI's ArcGIS version 10.6 is used to visualise some survey data in a descriptive way. This helps to put the data into context and localise it. The base map containing individual statistical blocks/quarters/cantonal boundaries was obtained from the specialist unit for geoinformation in Basel. The statistical office of the Canton Basel-City provides socio-economic data containing variables such as living density or net income. This data enables a comparison between survey data and the official city census and determines any reporting biases that may be present. To reduce misinterpretations of maps, Augustin et al. (2017:16) suggest giving the confidence intervals as a table or in the text, as they are difficult to portray in a map.

Combining dataset with residential block ID. ArcGIS is used to combine the data set with the information about the residential block ID. The map of Basel, which comes with residential blocks, was also enriched with the locations of the respondents (as points on the map). To combine all locations of the respondents with the corresponding block ID, all points had to be assigned to the nearest residential block. With the tool "intersect" it was possible to assign the related residential block IDs to the points. The complete table was exported to Excel, the information corrected (especially typing mistakes) and then imported into the program SPSS. This enabled the joining of both tables so that the result was a complete data set with the residential block ID. If respondents only provided the quadrant, they were placed in the middle of the quadrant, which sometimes was outside of a statistical block. This made analysis on the block level harder, as many respondents had to be excluded from the analysis.

5.2.1 Analysis of disease clusters

To detect underlying patterns when looking at the geographic distribution of variables, a spatial-statistical test was used, Moran's Index. This can determine whether clusters of similar values are randomly distributed or not. Many spatial statistics are essentially operationalisations of Tobler's first law of geography, which says, "everything is related to everything else, but near things are more related than distant things" (TOBLER 1970:236), which emphasises spatial dependence. Essentially, spatial statistics incorporates geography into the statistical framework by using an exact location with a coordinate system or by analysing proximity and neighbours. This can be done by using hot spot and outlier analyses for example (BENNETT ET AL. 2017). It is also useful to consider the spatial distribution of a health variable (for this study it is vaccination and ILI) on its own. This may already show certain patterns and can inform decisions on the type of spatial dependence test that can be used (Richardson 1992). Many scholars use spatial autocorrelation methods to determine disease clustering. Some studies even use more than one analytical method as it might show different spatial patterns (E.G. LOTH ET AL 2010; JACQUES, GREILING 2003). Geo-visualisations then help to show these patterns with different kinds of maps. Knox (1989) defined a cluster as “a geographically bounded group of occurrences of sufficient size and concentration to be unlikely to have occurred by chance” (17). Studies on influenza, which also talk about clusters, often refer to clusters of viruses without any geographical components (e.g. SOLOVYOV ET AL. 2009). Whenever this study mentions clusters, it will always refer to the geographic cluster as defined by Knox.

Cluster detection. By including data of PCR-confirmed influenza cases from the University Hospital Basel (and a large private laboratory providing data) this study visualises the spread of influenza incidences from five seasons. This is done with the help of Kernel Density Estimates in a georeferenced system (Geographic Information System – GIS), without establishing hypotheses on spreading patterns. By including the spatial environment of the urban quarters this study tries to understand if spatial spreading patterns of influenza coincide with aspects of the urban environment as well as the quarter structures and identifies if this may be significant or mere statistically incidental, i.e. without epidemiological significance. Yet, it should be considered that local clusters can occur even if there is global spatial randomness.

Spatial autocorrelation. Statistical analysis of data often sets out some conditions for the data structure. Usually it requires the data to be random. Yet for spatial data, this is very often not the case. This problem is referred to as spatial autocorrelation and is an important pitfall in spatial analysis (O’SULLIVAN, UNWIN 2010). It basically refers to Tober’s (1970) idea of spatial dependency, insofar that data from close locations are more likely to be similar than data from far locations. The fact that there are varying spatial phenomena make geography worth studying and relevant (O’SULLIVAN, UNWIN 2010). The pitfalls of spatial analysis will be further discussed in the following chapter. This study tested the ILI and vaccination prevalence with the commonly used spatial autocorrelation test, Moran’s Index. The values range from -1 to +1 indicating the degree of clustering (-1=dispersion, 0=spatial randomness, +1=clustering) (KAUHL 2015:5). For this data, a positive spatial autocorrelation indicates that areas with high ILI incidence are close to other areas with high ILI incidence.

Kernel Density Estimation (KDE). As the data on influenza (PCR-confirmed) is discrete, i.e. countable, the KDE method is used to interpolate the point data. See Figure 10 for a visualisation of KDE. Kernel densities of influenza data can be used to illustrate where the influenza incidences occurred most frequently. The kernel density tool calculates the density of features in a certain area around those features. Contrary to a regular point density calculation, the kernel density tool (KURLAND, GORR 2012, GIBIN ET AL. 2007, KING ET AL. 2015) fits a smoothly curved surface over each point, whose surface value diminishes with increasing distance from the centre (i.e. from the point). The resulting raster dataset illustrates the density of the points by adding the values of all the kernel surfaces where they overlay the raster cell centre. Point density differs from the kernel density tool insofar as it merely returns the number of influenza cases within a given search distance, without accounting for distance relationships between points inside the search distance. This may help explain certain patterns of influenza occurrences and may provide a starting point for the statistical analyses with the survey data.

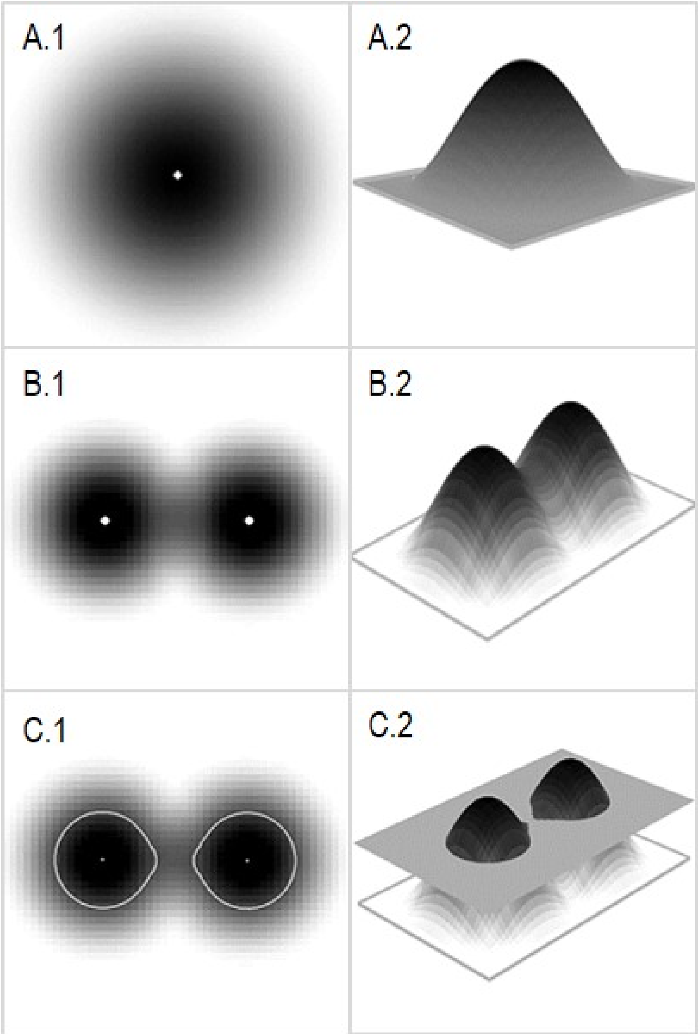


Figure 10 Kernel Density Estimation (KDE)
(A.1) KDE of a surface and (A.2) volume for a one point dataset. (B.1) KDE of a surface and (B.2) volume for a two points dataset. (C.1) 50 percent surface and (C.2) volume contour for a two points dataset (**s**ource: Gibin et al. 2007: 2-3)

Linking socio-economic status to influenza. There are different ways of linking socio-economic factors to ILI. This study discusses two different approaches. The first uses a multilayer analysis which has been published by Egli et al. (2020). This approach is based on other studies that also explore multi criteria analysis (e.g. CARVER 2007, NICHOLSON 1996, SANSON 1991). The multilayer analysis essentially creates its own index of socio-economic status and includes the following three variables: net household income (CHF), population density (persons per ha) and living density (m^2 per person). All the data is available for the block level and was provided by the statistical office of Basel-City. The datasets were imported into ArcGIS, reclassified using Jenks (1971) natural break method and reassigned with scores from 1 to 5, whereby 1 represents a low social status (i.e. high population density and low net income) and 5 a high social status (i.e. low population density and high net income). The individual datasets (one data set for every variable) were then added to each other in an equal way, resulting in scores between 3-15 (given 3 datasets), characterising the urban environment. This yields a map of the city, characterising the individual statistical blocks into more and less desirable living places (EGLI ET AL. 2019).

The second way to link socio-economic status is by using the Swiss neighbourhood index of socio-economic position (Swiss-SEP), developed by the Institute for Social and Preventative Medicine, Bern. Essentially, it is a similar approach to the multilevel analysis with the difference of the variables included in the Swiss-SEP. Their geographic scale was even smaller as one neighbourhood consists of 50 households. This dataset is especially useful if one were to extend the analysis to the national level and would allow for a fine scale analysis. Whereas the approach taken by Egli et al. (2020) could only be carried out in cities that provide data on the block level. Therefore, this study uses the Swiss-SEP to make it comparable to other studies who also use this index.

5.2.2 Some considerations for spatial data

Spatial autocorrelation. Positive spatial autocorrelation is associated with a geographic clustering of similar values, not necessarily high or low values, which leads to less spatial variability than in random systems. There are frequent positive spatial autocorrelations for demographic and socio-economic variables such as population density and house price, which is known as the ecological fallacy (described in detail below). "Neighborhoods often are clusters of households with similar preferences. Families tend to organize themselves in a way that concentrates similar household attributes on a map […] with government policies and activities, such as city planning and zoning, reinforcing such patterns" (GRIFFITH 2003:5).

Negative spatial autocorrelation is associated with geographic clustering of dissimilar values, which also leads to less spatial variability than in random systems. A prime example is a chessboard, where neighbours fundamentally differ from each other. Maps with negative spatial autocorrelation are highly fragmented and it is difficult to distinguish them from random distribution. Social science variables are rarely distributed this way. If it does occur, it can be a result of spatially competitive economic activities (GRIFFITH 2003).

Zero spatial autocorrelation is associated with no spatial clustering, i.e. there is no detectable spatial pattern, the data is distributed randomly across space (O'SULLIVAN, UNWIN 2010).

Modifiable Areal Unit Problem. A strong concern for any spatial analysis is the Modifiable Areal Unit Problem (MAUP). "The issue here is that the aggregation units used are arbitrarily with respect to the phenomena under investigation, yet the aggregation units used will affect statistics determined on the basis of data reported in this way" (O'SULLIVAN, UNWIN 2010:37). In other words, this means that the results of the spatial analysis can vary greatly depending on the selected geographic scale. For his study the MAUP was almost impossible to avoid, as the survey data on the household level needed to be aggregated to the block level for practical and privacy reasons. Therefore, great care should be taken when studying influenza-like illness and vaccination data which was aggregated to the block and quarter level. The aggregation of data into administrative boundaries also neglects that environmental features often do not follow these boundaries (MAANTAY, MCLAFFERTY 2011).

Ecological fallacy. The ecological fallacy is similar the MAUP, as it also states that true data on one geographic scale might not be true on another scale (O'SULLIVAN, UNWIN 2010). For example, influenza incidence correlates with socio-economic status on the quarter level, but it cannot be assumed that individuals with a low socio-economic status are more prone to get influenza. It is only possible to conclude that quarters with a high proportion of individuals with a low-socio-economic status tend to have more influenza incidence. It is not possible to infer the health status of an individual by knowing their socio-economic status, except for the geographic unit that was used for the analysis (example adapted from MAANTAY, MCLAFFERTY 2011).

Non-uniformity problem. The urban space is not uniform which can lead to specific patterns caused by predetermined physical built up space. As an example, influenza incidences are only recorded where residential buildings are located, and not on streets or in public spaces. This leads to spatial clusters and gaps on the map which arose because space is not uniform. A specific nonuniformity problem is the edge effect and arises when arbitrary boundaries are laid out on the study area. This is often necessary to keep the study design manageable. This can be a problem as the centre of the study area has data observations in all directions, whereas the edge of the study area does not. Yet, the phenomenon under scrutiny does not stop at the boundaries and therefore leads to a skewed dataset (MAANTAY, MCLAFFERTY 2011; O'SULLIVAN, UNWIN 2010). The non-uniformity is less of a problem for this study as it aggregates the survey data on the block and quarter level and the spatial analysis is only exploratory.

5.3 Statistical analysis of the Data

Descriptive analysis. The descriptive analysis gives an overview of the study data and by means of simple correlations (Chi-square, Craver-V) preliminary assumptions can be tested. To enable comparisons between different groups, gender, age and education, proportions will be used rather than absolute values and where possible the confidence interval of 95% for population proportions are given.

Analytic analysis. To identify the determinants of vaccine uptake and ILI incidences a logistic regression analysis is used. This approach helps to find the determinants of the observed spatial patterns of the survey data. Other studies also use logistic regression analysis to estimate the association between vaccination uptake and other variables (BÖHMER ET AL. 2011A; BÖHMER ET AL. 2011B; SETBON ET AL. 2010; TIAN ET AL. 2019; VAUX ET AL. 2011). As the dependent variables in this study are all dichotomous, logistic regressions are used as suggested by Long and Freese (2003) and Kleinbaum and Klein (2010). Logistic regressions also have the advantage of describing a probability, which is particularly useful when studying disease, as it describes the likelihood of an individual getting a disease. This is the reason why logistic regressions are commonly used in epidemiology to study risk factors for a particular disease (IMREY 2000; KLEINBAUM, KLEIN 2010).

Standard OLS regression equation (1) where y is the dependent variable, i.e. the variable we aim to predict or understand. All the X's are the explanatory variables, the ones that help predict the dependent variable or the ones we believe to cause a particular outcome of the dependent variable. The β's are the coefficients, which represent the strength and type of relationship of each explanatory variable X to y. These relationships can be positive, negative or non-existent, i.e. no relationship between X and y. The ε is the residual, or error term, and shows the model over and under predictions. This means it calculates the difference between the observed value and the predicted value. A small error term indicates a good model fit, while a large error term indicates a bad model fit (ESRI 2019).

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 +_{\dots} \beta_n X_n + \varepsilon$$

Study variables. In this study, the dependent variables are influenza-like illness (ILI) and vaccination. The independent variables (also referred to as determinants, predictors) are dichotomous or polytomous, i.e. have more than two characteristic values. If the latter applies, dummy variables need to be created. As the obtained data shows mostly ordinal or nominal scale, dummy variables (with only two characteristic values) are created to be able to include them into the logistic regression model. It might be clear that by categorizing the variables into only two classes (e.g. splitting the variable age into two classes of ≥65 years and <65years), it leads to a reduction of information and limits the final explanatory power. A conceptual model containing variables of interest was defined before starting the regression analyses. Statistically speaking, multilinear models assume that the independent variables are truly independent of one another, but for survey data this is often not given. Confounders in this study include age, income and education. These variables might distort the association between exposure and outcome (RAZUM ET AL. 2018). Confounding variables do not necessarily mean that multilinear models are unusable, but the results should be interpreted with care.

The conceptual model. The model consists of a set of variables which can be grouped into five categories such as:

(1) socio-economic status: educational level, income, gender, age, nationality (as seen in BÖHMER ET AL. 2011B; BRYANT ET AL. 2006; TAKAYAMA ET AL. 2012; VAUX ET AL. 2011; YUE, TARRANT 2014)
(2) working environment: health care worker, working with children, working in an open plan office, contact with more than 50 people per day, working as upper/middle management (as seen in BLANK ET AL. 2009; GODIN ET AL. 2010; VAUX ET AL. 2011)

(3) health and health related behavior: chronic illness, smoking, alcohol consumption, regular hand washing, regular health check-ups, healthy diet, regular physical activity (as seen in BLANK ET AL. 2009; BÖHMER ET AL. 2011B; TAKAYAMA ET AL. 2012; VAUX ET AL. 2011; YUE, TARRANT 2014)
(4) personal environment: daily public transport use, living space, no. of people per household, children >7 years in same household, living with chronically ill persons, looking after care dependent person at home, regular visits to hospital and care home (as partially seen in VAUX ET AL. 2011; WADA, SMITH 2013)
(5) quarter characteristics: exposure to negative environmental influences, share of green space, share of built up area (as partially seen IN FENG ET AL. 2016)

Whereas the individual factors are clearly identified in the scientific literature, only few medical/epidemiological studies were found that conceptualized "geographic area" variables (BLOOM-FESHBACH ET AL. 2013; FENG ET AL. 2016; SAMMON ET AL. 2012; TAMERIUS ET AL. 2013; WALTER ET AL. 2011). It is a unique feature of this model is that it focuses not only on individual characteristics obtained from the survey, but also includes quarter characteristics. It is essential to define the conceptual model before running the regression analysis and not succumb to the temptation of running multiple regressions and select the one with the best results.

Variable selection. After having defined the variables for the conceptual model, the appropriate method for variable selection within the regression model needs to be defined. There is not a single statistical procedure to do so, but there are several options and they might not necessarily deliver the same answers. The three options are forward, backward and forced entry selection. The **forward selection** is where variables are included one by one in a stepwise fashion until the model does not improve its predictive power. The **backward selection**, is where all variables are included in a first step and then eliminated in a stepwise fashion until the model does not improve its predictive power. The **forced entry** method is used to ensure that all factors that could potentially answer the questions are included in the model (RAZUM ET AL. 2018).

5.4 Limitations of the data

The survey has at least five limitations. First, the WHO-definition for influenza-like illness (ILI) might not capture all cases as it is quite a broad definition and an influenza infection can only be determined via a laboratory test. Respondents might therefore have been classified as having an ILI without being tested positive for influenza. The ILIs are not congruent with the influenza cases, but it captures a sufficient amount to be able to recognize general trends. Second, the number of ILI-cases for the study period (season 2015/16) is relatively small (n=358, 4.4% of study population). This makes small scale spatial analysis of

ILI cases difficult, as there are not enough data points for a block level analysis for example. However, the number of ILI cases is still within the usual influenza attack range of 2-5%. Third, for the quarter of Kleinhüningen not enough valid questionnaires were returned to make it statistically significant. This limits any results concerning this quarter. Fourth, there is an overrepresentation of women (62%), people above 50 years and Swiss nationals. To account for this overrepresentation the regression models always include gender, age and nationality. Fifth, for variables concerning self-reported health behaviours it is difficult to assess to which degree the answers can be compared as there is no standardised level for frequency. For example, a healthy diet or regular physical activity might mean very different things to different individuals.

Self-localisation of respondents on maps. The map provided in the questionnaire contained a grid of 200x200m, where respondents could either make a cross at their location of residence and/or only indicate the quadrant (e.g. E15). To georeference the residence of respondents an exact address is needed. By the self-localisation on the provided map the location is not address precise thereby limiting the resolution on the small scale. All self-localisations are kept at the block level-scale, which is also the smallest scale at which the survey data is allowed to be published. It is also questionable if the respondents who provided their location information were able to correctly identify their place of residence, as the map did not contain every street name. This presupposed that the respondents know their neighbourhood well enough to identify their residence block with incomplete information. Also, it would have been easier to georeference the locations if the map had contained all the street names and the reference number for every block. This would have likely improved the data accuracy during the georeferencing phase.

Part III – Empirical Results

6 Characteristics of the sample

Valid number of returns. Figure 11 shows the number of questionnaires that were distributed, returned and included in the study. Questionnaires were excluded if essential information was missing (personal information and health information) or if it was evident that the questionnaire was not filled out truthfully (e.g. joke answers). This procedure excluded 92 questionnaires from the study. The resulting return rate of 27.2%, was higher than initially expected from a paper and pen survey. This shows that the topic was met with great interest. Additionally, the participants could partake in a lottery including an Apple Laptop worth CHF 2500 and two “Pro Innerstadt”coupons each worth CHF 500 by providing their contact details at the end of the questionnaire. This may have also influenced the willingness to fill out the questionnaire.

Figure 11 Flow chart of distributed questionnaires
(own illustration)

In general, the high response rate indicates interest in the topic and a personal concern. This is also confirmed by the percentages in the different age groups who responded in demographically young quarters and demographically old quarters. Therefore, it can be concluded that influenza is a topic of interest to many, irrespective of vaccination behaviour, and that communication strategies related to influenza can be especially effective if they take urban quarter characteristics into consideration.

Biases. Despite efforts to reduce selection bias, it was difficult to avoid. For this study it is suspected that there might be a non-response-bias, i.e. those individuals that filled out the questionnaire differ from those who did not fill out the questionnaire. A reason might be that the characteristics of those who refused are related to health-behaviour, i.e. not getting vaccinated against influenza. This effect could be observed for non-responders to participation, who consumed more alcohol and tobacco in comparison to study participants (RAZUM ET AL. 2018). The questionnaire was provided in multiple languages to reduce the selection bias based on proficiency in German. It also included an addressed and pre-stamped return envelope to make it as easy as possible and free to participate in the questionnaire.

6.1 Sample overview

Gender. Despite the large number of distributed questionnaires and the careful distribution process, there are some biases in the data. The skewed gender ratio among the respondents (62% women, 38% men) is quite remarkable although not surprising. Previous studies have also found that women are more likely to respond to questionnaires and even more so if the topic is health related (e.g. AMUNDSEN 2013; DICKINSON ET AL. 2012). The overrepresentation of women within a household suggests that they are primarily responsible for the health of the household, and therefore, may be the first person responding or taking interest in this particular survey. The share of men and women working part or full time is almost the same, but with men having more fulltime employment and women working more part-time. This might result in women spending more time at home and having the mental capacity to fill out a lengthy questionnaire. The over and under representations of the genders is difficult to eliminate, as it is not possible to control who of the household fills out the questionnaire. Therefore, the results were analysed by proportion within a gender. The dataset has the added advantage that it is quite large, making it feasible to analyse proportions.

Age. In general, there is a slight underrepresentation of respondents younger than 29 years and a slight overrepresentation of respondents between 45 and 84 years. Figure 12 visualises age distribution by gender of the survey participants (darker colours) in comparison to the census data from Basel (lighter colours). There is an overrepresentation of men above the age of 55 and women between 50-79 and an under representation of men under 49 years, where the underrepresentation was particularly large for the under 30 age group. Women are underrepresented in the below 30 age group. There is no survey data for respondents younger than 15 years of age. However, overall there is a relatively even distribution of the age structure of the respondents.

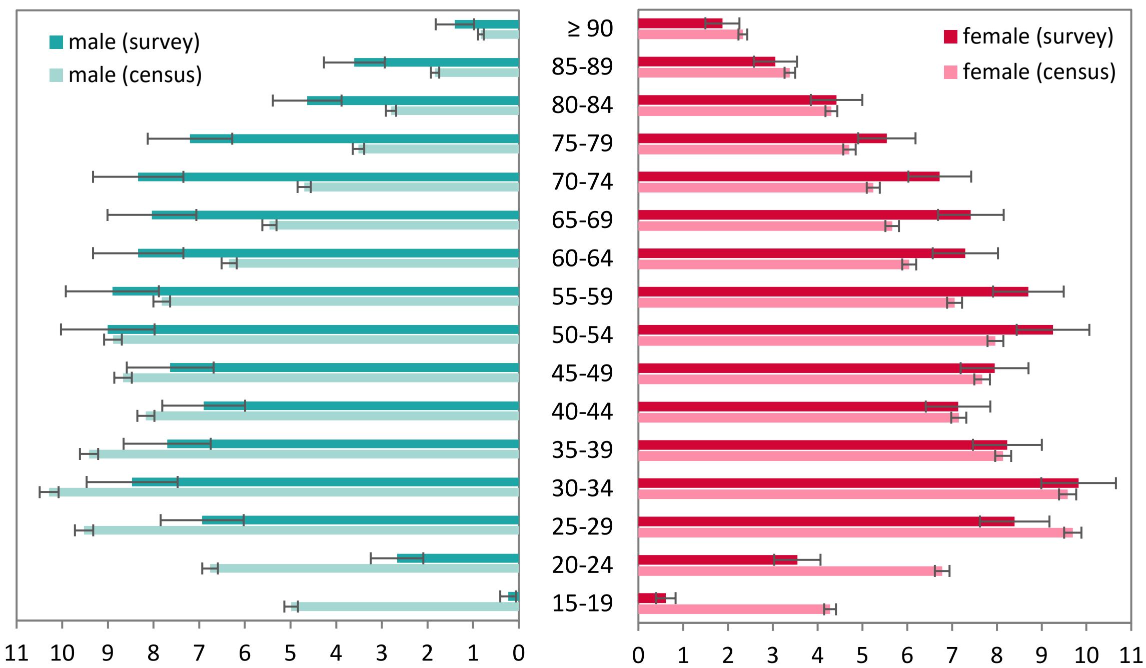


Figure 12 Gender distribution in survey vs city census
95% CI (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Nationality. There were higher than average response rates from Swiss respondents (79.3%) although the census data from 2016 shows only 64.3% Swiss nationals. This means that the Swiss are overrepresented in the data. The proportion of non-Swiss respondents or those who responded in the other major languages is rather low, although they were addressed in their own language. This underrepresentation raises the question of how to access these population groups better to access their knowledge and opinions on influenza and immunisation.

Household structures. Most respondents live in rented apartments or houses (72.5%, n=5908) as compared to condominiums or own house (23.9%, n=1944), which is very typical for Switzerland and especially urban cantons such as Basel-City (FSO 2020C). Most respondents live alone or with one other person (1-person-household 41.7%, n=3397, 2-person-household 34.3%, n=2798) and have a median living space of 50m^2 per person. Out of all respondents, 21.5% (n=1700) live with children, of which 3.7% (n=294) are single parents.

Education. On the one hand, there is a strong overrepresentation of respondents (67.4, n=5,283) who have a tertiary education level (higher vocational training or from a university, college) compared to census data, where 40.2% (n=65,360) have attained this education level. On the other hand, the survey has a strong underrepresentation of respondents who only have had compulsory school (5.4%, n=421), compared to census data (20.3%, n=32,970) (STATISTICAL OFFICE BASEL-CITY 2020b). As respondents in this study were more highly educated than the general population, it begs the question how the results concerning vaccination behaviour would differ given an averagely educated population group. Angela Bearth from the research group Consumer Behaviour at the ETH Zürich, studied the behaviour of the Swiss population concerning adherence to Corona Safety measures, such as social distancing, hygiene and the wearing of masks. They too had an overrepresentation of the highly educated in their study. However, she draws a conclusion that might also be directly applicable to this study concerning people's vaccination behaviour, which can also be considered a safety measure to not catch influenza. She concludes that the level of education probably has less influence on the perception of risk than one intuitively thinks, as there are other psychological mechanisms that counteract factual knowledge. These include trivializing assessments, i.e. people think they are less at risk because they live healthy lives or because they think their immune system is strong. Bearth thinks that in this way people try to dissolve the inner tension that can arise from dangerous behaviour, even though they know about the corona safety measures. This study has not yet been published in a peer reviewed journal, but despite this the study authors wanted to communicate the results to the public via newspaper articles (WÜRSTEN 2020).

Income. The question on income revealed the most missing values with 23.9% (n=1944) of respondents not wanting to share the level of household income, despite the personal anonymity being provided. Approximately half of those who did answer (51.1%, n=3173) stated that their monthly household income was ≤6000 CHF. The census data from 2014 shows that the annual median net income for the respondents in the study area was on average about 47,900 CHF, which is about 4000 CHF per month. The net income is taken from tax return data where health costs and charitable donations have already been deducted (STATISTICAL OFFICE BASEL-CITY 2017B).

6.2 Incidence and severity of disease

The survey data itself does not enable a distinction between influenza or an influenza-like illness, as influenza itself can only be identified through laboratory testing. Respondents were asked if they had suffered a bad cold during the past winter, to which two in five people (41%, n=3335) stated that they did. Of those, almost a third of these respondents (n=972, 29.1%) were incapacitated up to five days, another quarter (n=968, 29%) were between 5-10 days and 14.8% (n=494) were incapacitated for more than 10 days. Around a quarter of ill respondents (n=901, 27%), did not indicate how many days they felt incapacitated. As the survey was distributed at the end of the influenza season it may not be a surprise that many respondents who were ill might not have been able to remember how many days they had been incapacitated for. Figure 13 shows the distribution of the reported common colds (excluding ILI) and ILI (defined as having fever of $\geq 38\,°$ C, a cough, and being incapacitated for 1-10 days) across the influenza season. It follows the typical pattern of an influenza season, with a peak around February. The rate of respondents who reported an ILI (4.5%, n=358), almost corresponds with the average attack rate of influenza (2-5%). The ILI rate among those who did not vaccinate was higher (5.8%), than among those who did get a vaccination (1.8%). The odds ratio of 0.319 (95%CI 0.226-0.450, p<0.001) for the vaccinated respondents clearly shows that they are less likely to get an ILI compared to those who are not vaccinated.

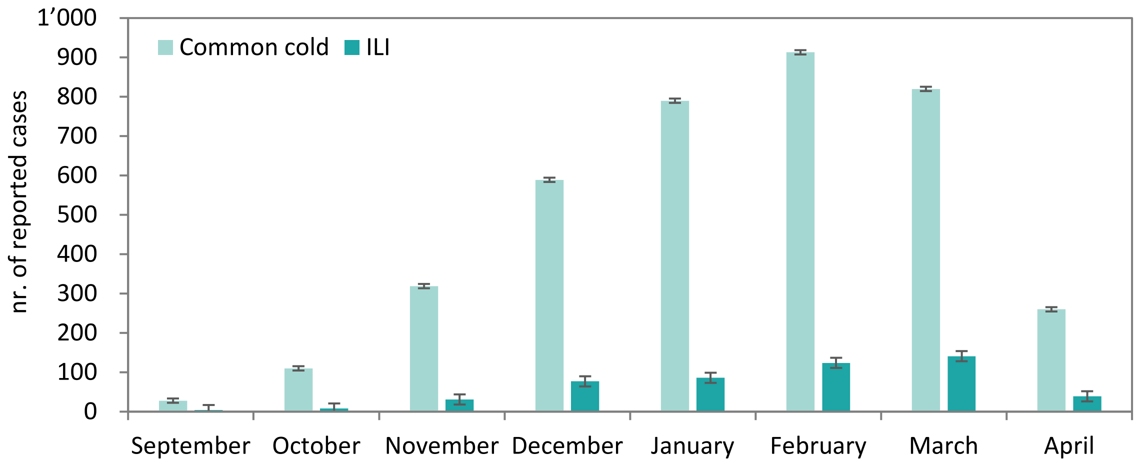


Figure 13 Self-reported common colds and ILI during the influenza season 2015/16
(source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Symptoms and professional help. Approximately three quarters of ill respondents reported a runny nose and a cough, followed by a sore throat and a strong sense of fatigue (Figure 14). Only one quarter indicated having had a fever. This shows that most people who fall ill during the influenza season most likely have the common cold rather than influenza, keeping in mind that fever is one of three typical symptoms for an ILI. Of the respondents who had a bad cold (self-reported) only 38.2% (n=1271) had consulted a health professional regarding their symptoms, at a medical practice (61.7%, n=752) or the pharmacy (24%, n=293). Of those who had an ILI, 45.9% (n=164) sought medical attention, but the majority did not, despite having influenza symptoms (54.1%, n=193). Even though most respondents (61.8%) reported various symptoms of illness and having been incapacitated for several days, the majority tend to get by without the help of professionals and self-medicate. Of those who reported a bad cold, the majority (74.9%) had taken medication to alleviate their symptoms.

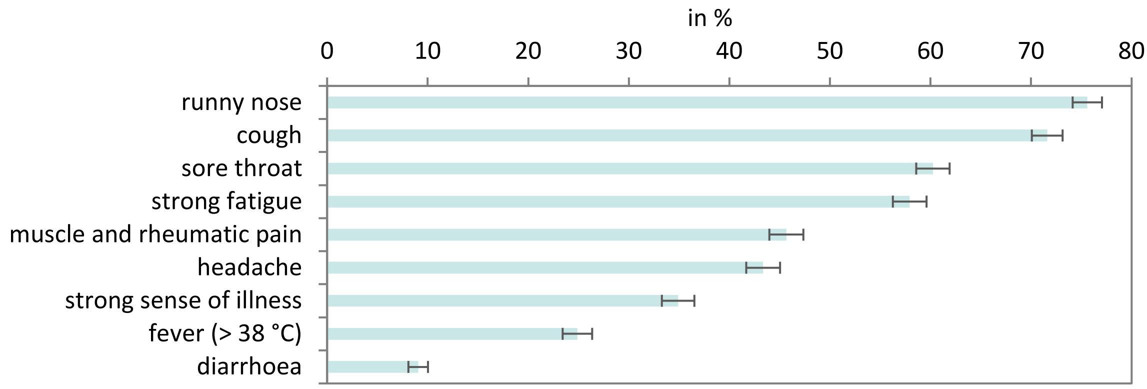


Figure 14 Prevalence of symptoms during the influenza season 2015/16 among respondents with self-reported illness
multiple answer, 95%CI, n=3335 (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Transmission. Of those with a common cold or ILI, the clear majority (70.4%, n=2348) reported that someone else in their close environment had been ill with similar symptoms, of which 2/3 were within the family (66.2%), half at work (50.2%) and 1/3 within their circle of friends (33.6%). This indicates that the family might be the primary source of transmission, which has been shown by studies on child-to-parent or child-to-child transmission paths (Endo et al. 2019; Teo et al. 2007).

7 Small-scale analysis of influenza-like illness and vaccination

Case definition for ILI. Out of all respondents, 4.5% (n=358) were infected with influenza or an influenza-type illness (ILI), which corresponds with the average attack rate of influenza (2-5%). The World Health Organization (WHO 2014) defines an ILI as follows: 1) measured fever of ≥ 38 C°; 2) cough; 3) with onset within the last 10 days (as onset is impossible to determine from the survey data, we selected for 1-10 days ill, no exclusion of certain symptoms). This definition does not capture all cases but enough to see overall trends. However, the number of PCR-confirmed cases for the same season from the University Hospital Basel, i.e. people who had their blood tested for the influenza virus, was also very low (n=115) for the entire city of Basel. The hospital data has a selection bias, as only the individuals who had influenza and were seeking medical attention could be selected. The survey data on the other hand, targeted all households in the study area.

General illness. The survey covered roughly one third of Basel's households. Approximately 40% of the households surveyed (n=8,149) had become ill at least once during the season. If projected onto the total population, there is a potentially large segment of the population that may become ill with influenza or ILI. With roughly 30% who reported having been incapacitated for up to 5 days and another 30% between 5 to 10 days, the resulting economic impact might be quite significant. The work environment appeared more than any other opportunity for contact as the place where one is close to other ill persons. This gives employers a large role in communication strategies related to vaccination.

Symptoms and medical advice. While the majority of respondents reported various symptoms of illness including fever, strong fatigue, muscle and bone ache and having been incapacitated for a number of days, the majority tended to not seek medical attention and self-medicated. Only about a third were in contact with a health professional regarding their cold symptoms. 71.1% reported that someone else in their close environment had been ill with similar symptoms, of which 65.7% within the family, 49.8% at work, 10.4% in the neighbourhood, 33.4% within their circle of friends, only 3.7% in their club.

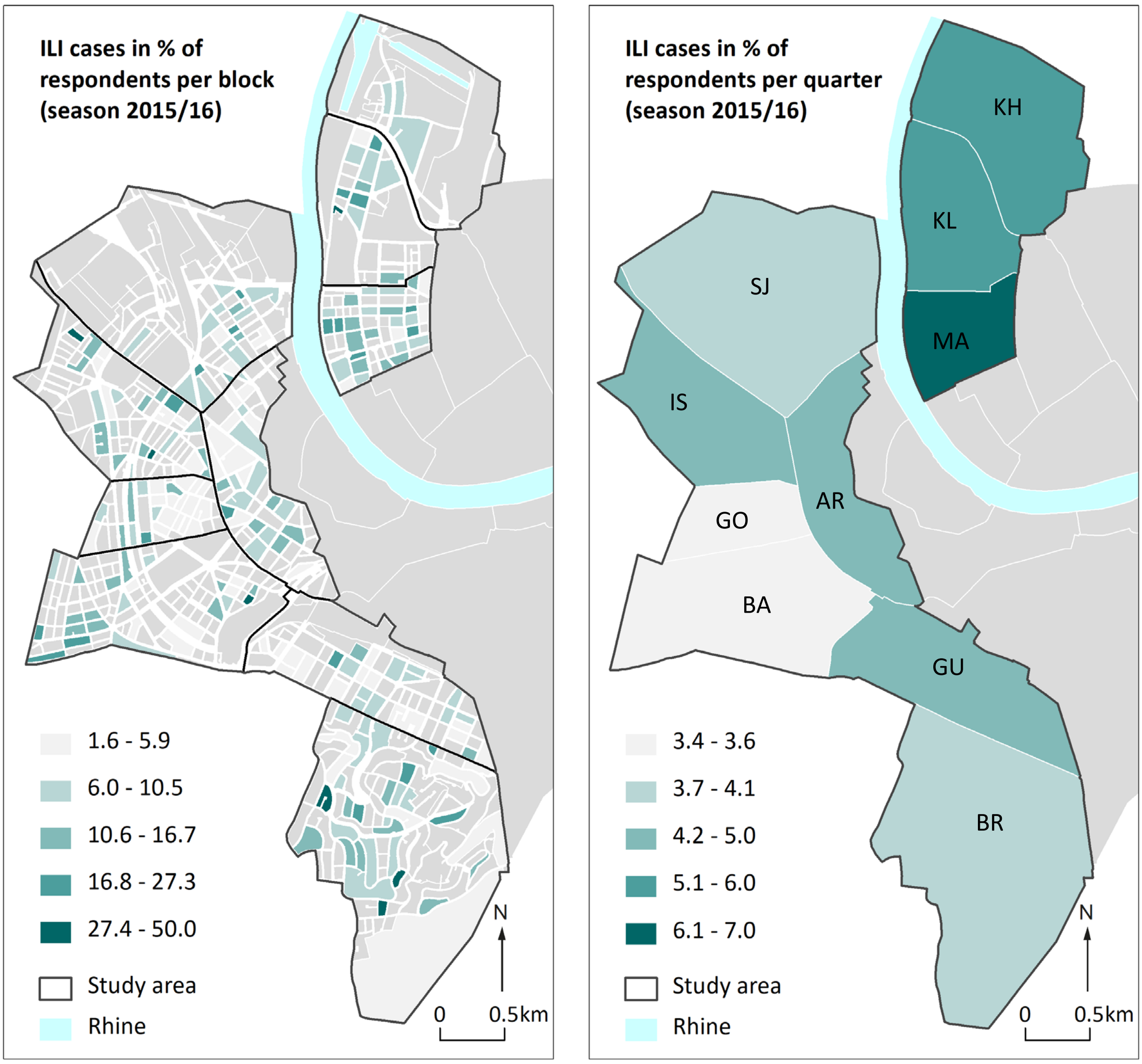
Temporal spread of ILI. The majority of those surveyed (58.9%, n=4770) had not been infected with influenza or an ILI, 29.9% (n=2426) had become ill several times and 11.2% (n=909) had been ill once during the influenza epidemic of 2015/16. The number of cases started to increase in October and peaked in February with a maximum of over 1000 respondents having been ill in those months, then a slightly lower number of infections in March (n=984), and a rapid decline in April.

7.1 Spatial distribution of influenza-like illness

To visualise the spatial distribution of self-reported ILI, different geographic scales were used. Two thirds of the data could be georeferenced on the block level, which was chosen as the starting point for the exploratory analysis with GIS. When only looking at the point pattern of ILI incidences the pattern does not appear to be significantly different from random, as the Moran's I is -0.002 (z-score: -0.436, p-value: 0.663). As the point pattern of ILI is not corrected for population density, the percentage of respondents per block and per quarter that had an ILI were calculated and are shown in Map 8 (left). It was done for two different geographic scales to highlight that the results can differ, depending on the chosen scale. This was previously discussed in chapter 5.2.2 (p.66) under the modifiable area unit problem. There is no solution for this, but one should be aware of its effect.

There are some blocks within the study area that did not have any respondents with an ILI, these blocks have the same colour as areas outside the study area. On the block level, it is difficult to make out any spatial trends, as the number of returned questionnaires per block varied greatly (between 0 to approx. 50 returns). This makes it difficult to identify clusters on the block level, except for the quarter Matthäus, which even at this level, shows many blocks with higher ILI rates. The categories were classified with Jenks natural breaks, to maximise the difference between the categories. Some blocks show ILI rates of up to 50%, when the average influenza attack rate is between 2-5%. This is because if for one block there were 2 questionnaire returns and 1 was classified as having an ILI, then the ILI rate of that block is 50%, for 4 returns per block and 1 ILI, the ILI rate is 25% and so on. So, this scale also overrepresents the actual ILI rate of that block, as there are not enough returns for every block to make it representative for all people living in that block. This led to the visualisation of the data on the quarter level (Map 8, right). The number of returned questionnaires on the quarter level were significant enough to serve as a representative sample of each quarter, except for Kleinhüningen. The map shows that the three Kleinbasel quarters (Kleinhüningen, Klybeck, Matthäus) and Am Ring have above average ILI rates (greater than 4.5%) and all other quarters have below average ILI rates, with the lowest rates recorded in Gotthelf, Bachletten and Bruderholz.

The response rate of the questionnaire was not evenly distributed across the study area, e.g. an above average number of individuals responded to the questionnaire in the Gotthelf quarter. Thus, a kernel density analysis of ILI cases might contain a spatial bias, as the density of ILI cases is higher for more densely populated quarters. Kernel density estimates were not considered useful for the analysis of ILI, as the study area only covers half of the city and an area edge bias would probably distort the results.



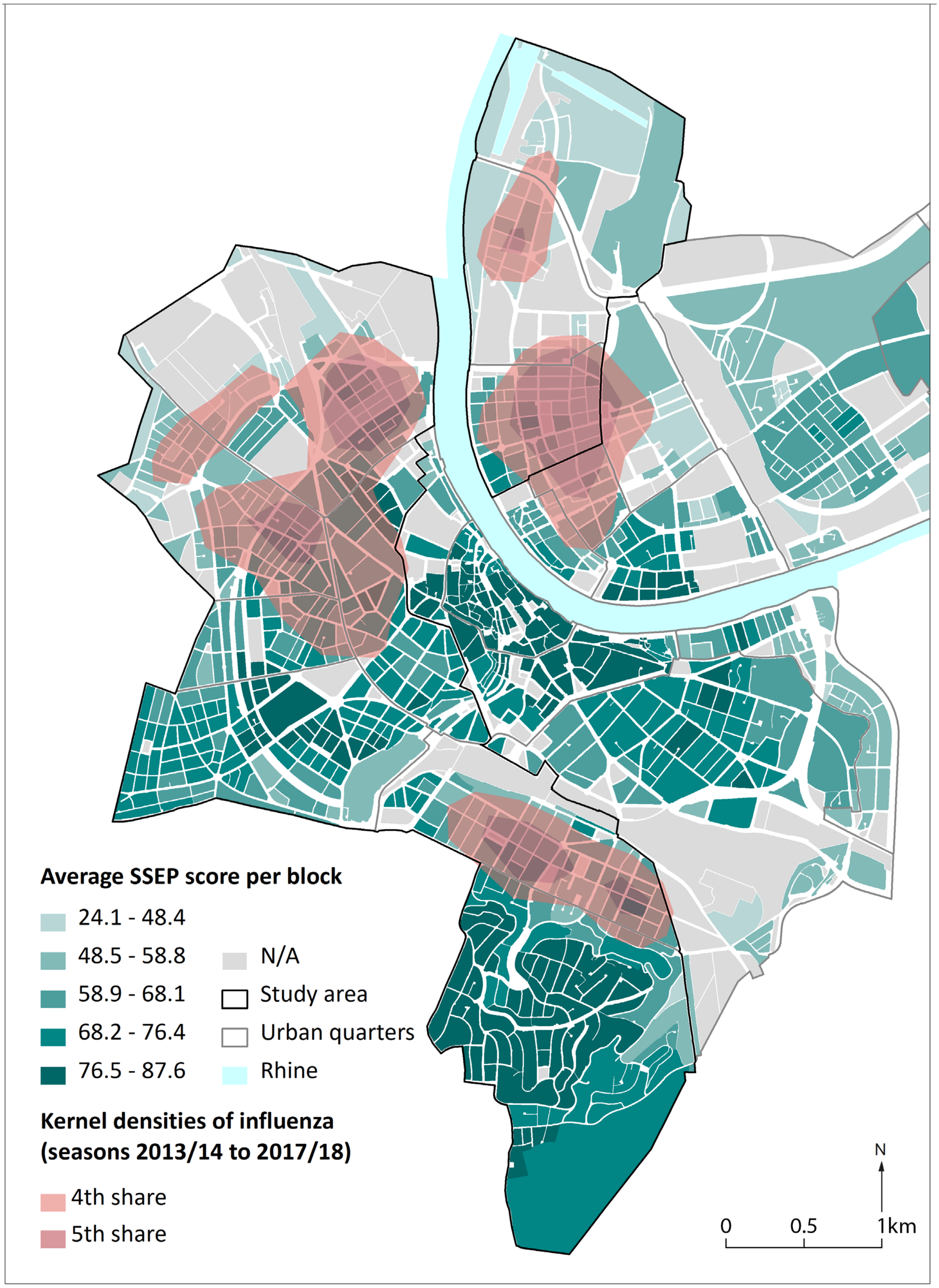
Map 8 ILI cases in % of respondents per statistical block (left), per quarter (right)
95% CI: AR ± 1.5%, BA ± 1.1%, BR ± 1.1%, GO ± 1.1%, GU ± 1.3%, IS ± 1.4%, KH ± 3.7%, KL ± 2.4%, MA ± 1.8%, SJ ± 1.4%
(Data source: Human Geography Research Group, Department of Environmental Sciences, University of Basel. Base map data: Bau und Verkehrsdepartement des Kantons Basel-Stadt, Grundbuch und Vermessungsamt, Fachstelle für Geoinformatik. Concept: N. Goldman, Cartography: M. Brunner, N. Goldman 2020

Analysing the clusters. To check if the ILI clusters are consistent over time they are set in context with PCR-confirmed influenza cases from multiple seasons (2013/14 - 2017/18). Thereby, if recurring spatial clusters of influenza incidence are identified it can be assumed that they follow a similar pattern every year. This eliminates potential biases that might exist by only observing one season. Egli et al. (2020) have found that in Basel the regional clusters of influenza incidence across this time are similar for every studied season, except for season 2016/17 which showed high influenza incidence across the whole city. Map 9 shows the kernel density estimates as clouds for the sum of all five seasons (2013/14 - 2017/18) across the study area.

Influenza data. In a second step influenza data (PCR-confirmed incidents) from the University Hospital Basel is placed upon the socio-economic data. The influenza data is used here, as this data is available for multiple seasons (2013/14 - 2017/18). Thereby, if there are recurring spatial clusters of influenza incidence it can be assumed that they follow a pattern. This eliminates potential biases that might exist by only observing one season. Egli et al. (2020) have found that in Basel the regional clusters of influenza incidence across this time period are similar for every studied season, with the exception of season 2016/17 which showed high influenza incidence across the whole city.

Socio-economic index. The Institute of Social and Preventative Medicine developed the Swiss neighbourhood index of socio-economic position (Swiss-SEP) which is an area-based measurement. This data was provided on the block level for the whole canton Basel-city and was used as the primary data layer in GIS. In 2017 the index was updated to the Swiss-SEP 2.0 index and comprised the following four variables: (1) Occupation: proportion of households who are headed by an individual in manual or unskilled occupation (only if in paid employment), (2) Education: proportion of households who are headed by an individual with no formal or only compulsory education, (3) Crowding: number of persons per room and (4) Rent: Median rent per square metre (SNC 2020). A low index value can be understood as a low socio-economic status and a high value corresponds to a high socio-economic status.

Linking influenza data and socio-economic position. Map 9 shows the kernel density estimates as clouds for the sum of all five seasons (2013/14 - 2017/18) across the study area on top of a layer containing an index for socio-economic position. It can be observed that blocks with a high average SSEP score had fewer influenza incidents in comparison to blocks with a low average SSEP score (Figure 15). Despite it being a significant correlation (Spearman $p<0.001$), the effect size is weak ($r=0.205$). Egli et al. (2020) conducted a very similar analysis and arrived at the same conclusion. The difference is that they used their own index for assessing socio-economic position, which was based on population density, housing density and net income. Their data was aggregated to the block level, whereas the SSEP data was based on the household level and operated with a sliding neighbourhood definition. Nevertheless, the SSEP data also needed to be visualised on the block level to ensure that individuals could not be identified based on the data. For a detailed analysis of influenza in the city context, refer to the study by Egli et al. (2020) who studied influenza virus transmission prospectively over five years for Basel.



Map 9 Socio-economic position (SSEP) and kernel densities estimates of influenza
A high SSEP score indicates high socio-economic status, a low SSEP score indicates a low socio-economic status. The KDE show the highest shares of influenza incidents summarised for five seasons. (Data sources: SSEP: Institute of Social and Preventative Medicine, Bern. Influenza data: University Hospital Basel. Base map data: Bau und Verkehrsdepartement des Kantons Basel-Stadt, Grundbuch und Vermessungsamt, Fachstelle für Geoinformatik. Concept: N. Goldman, cartography: M. Brunner, N. Goldman 2020)

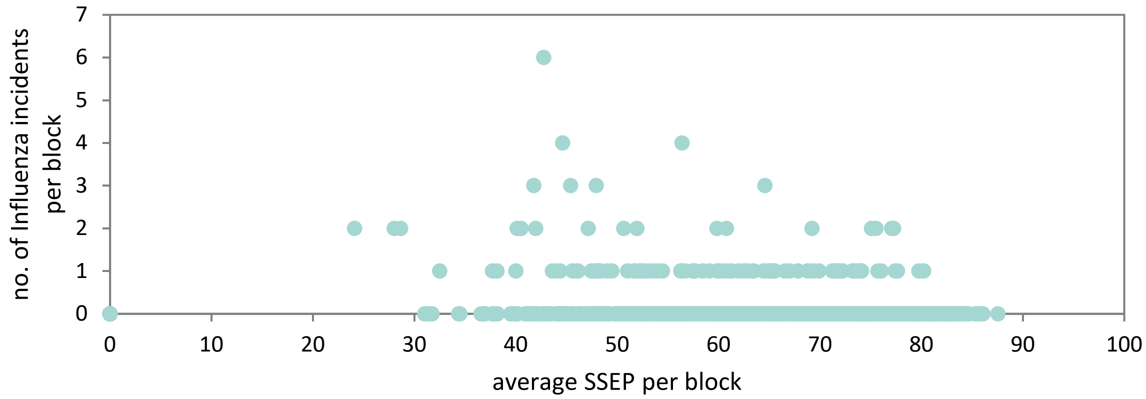


Figure 15 Average socio-economic position and number of influenza incidents per block
Every dot represents one statistical block from Map 9 (Source: SSEP: Institute of Social and Preventative Medicine, Bern; Influenza data: University Hospital Basel, own visualisation)

Spatial variation. When comparing the prevalence of ILI (Map 8) with the prevalence of confirmed influenza (Map 9) similar patterns are visible, the clusters of influenza incidents from kernel densities mostly reflect the ILI data from the survey, with the exception of St. Johann. This quarter was not one with the highest ILI rates, but when looking at the influenza data, it clearly shows that there are a high number of absolute incidences. This might be because the ILI data (from the survey) was corrected for population density, whereas the influenza data (from the hospital) shown as kernel densities does not account for varying population densities. This can lead to problems as spatial data (e.g. population density) is rarely uniform. This leads to the detection of influenza hotspots but they only reflect population density (MAANATAY, MCLAFFERTY 2011). This is most likely a first-order spatial variation, as the KDE mainly reflect population density. Should a high presence of influenza incidence lead to a higher number of influenza incidences, then we can observe a second-order spatial variation (O'SULLIVAN, UNWIN 2010). But it is very difficult to determine which kind of spatial variation is present in the maps presented here. Therefore, comparisons between the two data sets (influenza and ILI) should be treated with caution. Overall, the fact that ILI and influenza incidents cluster in very similar areas of the city goes to show that studying the spread of ILIs is a good proxy for studying influenza on a city scale.

7.2 Determinants of influenza-like illness

Binary logistic regression analyses were performed to estimate associations between different predictive variables and the dependent variable (ILI or vaccination). An exploratory approach was chosen to find the best regression model. These analyses were performed in two steps for each target variable. First, simple binary logistic regressions were used to assess the impact of each of the variables on the likelihood that an individual got an ILI or the influenza vaccination. The n-values are included to show the number of cases included in the univariable analysis. The independent variables that were considered significant (p-value ≤0.05) in their individual regressions were then entered in a multivariable regression model in the second step. A forward and backward stepwise selection (likelihood ratio - LR) of variables was used to progressively include or exclude variables from the final model. To estimate the goodness of fit for the binary logistic regression, the Hosmer-Lemeshow-Test was used, where an insignificant p-value (≥0.05) is considered to illustrate a good model fit. This test is the most reliable to assess the goodness-of-fit for the binary logistic regression (IBM 2020). This approach is like the one used by Setbon, Raude (2010). For both multivariable models the Hosmer-Lemeshow-Test yielded high p-values (forward: p-value=0.528 (5th step), backward: p-value=0.528 (11th step)) showing that the models fit the data well. The regression model takes many different variables into account. The relative low number of cases included in the regression analysis, compared to the number of total respondents, is because not all individuals provided all the information. This reduced the number of cases included in the regression, as the regression is run on complete data. Imputing the missing values could be done, but it may distort the results in a way that makes them very difficult to interpret. Therefore, this study has refrained from imputing missing values.

Predicting factors for ILI. Table 7 shows the summary of the univariable and multivariable logistic regression analysis. Individuals who have a vaccination, are ≥65 years old, or regularly visit someone in hospital or a care home are less likely to get an ILI. This holds up for both multivariable models. However, it must be noted that vaccination is also a function of age, i.e. the older the individual, the more likely they are to get a vaccination (Figure 18, p. 96). Also the survey data showed that only 1.5% (n=36) of respondents over 64 years had actually had an ILI. It is quite surprising that there are so few elderly respondents who reported an ILI. It is not clear if this reflects the ILI rate of the actual city population or if the survey did not capture all ILI cases due to self-reporting or other factors. Regarding those who regularly visit someone in hospital or a care home, a Chi^2-test yielded a significant correlation ($p<0.001$) with those respondents and their vaccination status. This indicates that people who visit the sick and elderly on a regular basis might be aware of the risk and more often take precautionary measures such as the vaccine.

Individuals who smoke daily or live with 3 or more people in the same household are more likely to get an ILI. This too holds up for both multivariable models. A Chi^2-test showed there is a significant correlation ($p<0.001$) between the number of people per household and their vaccination status, i.e. those living with 3 or more people were less often vaccinated than smaller households. This might be because larger households tend to be comprised of younger people, who are less often vaccinated, whereas single or 2-person households tend to be older on average. A Chi^2-test found a significant correlation ($p<0.001$) between age and number of people per household. And since vaccination status is a predictive factor for ILI, this might be the reason why variables that correlate with age are also predictive factors for ILI. In theory the independent variables in a regression should be independent of each other to prevent correlation amongst themselves, which might influence the regression output. Yet, when dealing with survey data, this is often not possible to avoid. Therefore, it is useful to also check the results of the regression and run some Chi^2-tests with the predictive factors. This gives a better understanding of which variables are correlated with each other and what truly predicts the likelihood of someone getting an ILI.

Table 7 Potential determinants for ILI according to WHO definition (univariable and multivariable analysis)
(source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

			Univariable			**Multivariable** (forward LR stepwise selection method) n=3089, 5 steps			**Multivariable** (backward LR stepwise selection method) n=3089, 11 steps		
	Variables (reference category)	**n-value**	**OR**	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
Socio-economic status	Educational level (compulsory)	7731	0.680	0.387-1.194	0.180						
	Income (≤ CHF 6000.- /household)	6126	1.001	0.791-1.266	0.995						
	Gender (male)	7979	0.913	0.733-1.139	0.422						
	Age (≥65 years)	7804	0.243	0.171-0.344	<0.001*	0.332	0.171-0.643	0.001	0.332	0.171-0.643	0.001
	Nationality (foreign population)	7931	1.434	1.124-1.829	0.004*	-	-	-	-	-	-
Working environment	Health care worker	7402	1.077	0.778-1.492	0.655						
	Work with children	7395	1.238	0.881-1.739	0.218						
	Work in an open plan office	7349	1.786	1.421-2.241	<0.001*	-	-	-	-	-	-
	Contact with people (>50 people/day)	7827	1.604	1.248-2.060	<0.001*	-	-	-	-	-	-
	Employment status (upper/middle management)	5072	0.813	0.610-1.084	0.159						
Health and health-related behaviour	Chronic illness°	7341	0.571	0.423-0.771	<0.001*	-	-	-	-	-	-
	Smoker (daily)	7966	1.748	1.314-2.324	<0.001*	1.604	1.043-2.468	0.031	1.604	1.043-2.468	0.031
	Alcohol consumption (daily)	7940	0.406	0.241-0.684	0.001*	-	-	-			
	Influenza vaccination	8023	0.319	0.226-0.450	<0.001*	0.339	0.186-0.620	<0.001	0.339	0.186-0.620	<0.001
	Hand washing (regular)	7829	1.175	0.830-1.663	0.364						
	Health check-ups (regular)	7360	0.598	0.471-0.759	<0.001*	-	-	-	-	-	-
	Healthy diet	7840	0.892	0.686-1.159	0.392						
	Physical activity (regular)	7746	0.750	0.602-0.935	0.011*	-	-	-	-	-	-
Personal environment	Public transport use (daily)	7692	1.414	1.136-1.759	0.002*	-	-	-	-	-	-
	Living space (≤ 30m^2/capita)	4080	1.776	1.270-2.482	0.001*	-	-	-	-	-	-
	No. of people / household (≥ 3 people)	7946	2.147	1.723-2.675	<0.001*	1.448	1.030-2.037	0.033	1.448	1.030-2.037	0.033
	Children >7years in same household	7784	2.063	1.548-2.749	<0.001*	-	-	-	-	-	-
	Living with chronically ill persons	7850	0.999	0.664-1.503	0.995						
	Looking after care dependent person at home	7811	0.935	0.583-1.500	0.780						
	Regular visits to hospital and care home	7748	0.455	0.270-0.768	0.003*	0.035	0.153-0.932	0.035	0.378	0.153-0.932	0.035
Quarter characteristics	Exposure to negative environmental influences	7466	0.878	0.690-1.118	0.291						
	Green space (≤ 20% / block)	7563	1.221	0.948-1.572	0.122						
	Built up area (≥ 60% / block)	7628	0.867	0.588-1.278	0.471						

°chronic illnesses that pose an increased risk if infected with influenza, classified according to Anatomical Therapeutic Chemical Level (WHO definition)
*variables with p-value ≤0.05 in the univariable analysis were selected for the multivariable analysis

Improving the model. The model above is not bad but can still be improved, especially as this is an exploratory analysis. A disadvantage of the approach above, is the over-emphasis on the significant variables from the single regression. By only selecting the variables with a significant p-value from the univariable analysis, one gets biased estimates of the odds ratios. This is because variables that might just be randomly significant in the univariable analysis, get overestimated in the multivariable analysis. Considering this, and the fact that some variables had low n-values, especially income (n=6126), employment status (n=5072) and living space (n=4080), a better approach might be to exclude these three variables and enter all others into one single model with the forced entry method. This yields a regression model (Table 8) with significantly more cases included (n=4939) than the approach above. The improved regression model now features seven significant determinants that explain the vaccination status versus five determinants for the model above (Table 7). This is most likely because the improved model includes more than twice as many cases for the analysis, and is therefore likely to be the better model. The Hosmer-Lemeshow-Test yielded a high p-value (0.852) showing that this improved model also fits the data well.

Improved predictors for ILI. Daily smoking and living in a household with three or more people are good predictors that someone gets an ILI (both have a p-value ≤0.05). Those who smoke daily and those living in larger households (three or more) are also less often vaccinated. Chi^2-tests found both correlations to be significant ($p<0.05$). Those who are not vaccinated have a higher likelihood of getting an ILI. Additionally, these determinants are also good predictors for not having an ILI (all have a p-value ≤0.05): being ≥65 years and regular visits to the hospital or care home. Old age correlates with being vaccinated (as shown in the next chapter, Figure 18, p.96) and this reduces the likelihood of getting an ILI. Those who regularly visit people in hospital or a care home are more often vaccinated, and as mentioned previously, this reduces the likelihood of getting an ILI.

Table 8 Determinants for ILI according to the WHO definition (multivariable analysis, forced entry method) (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

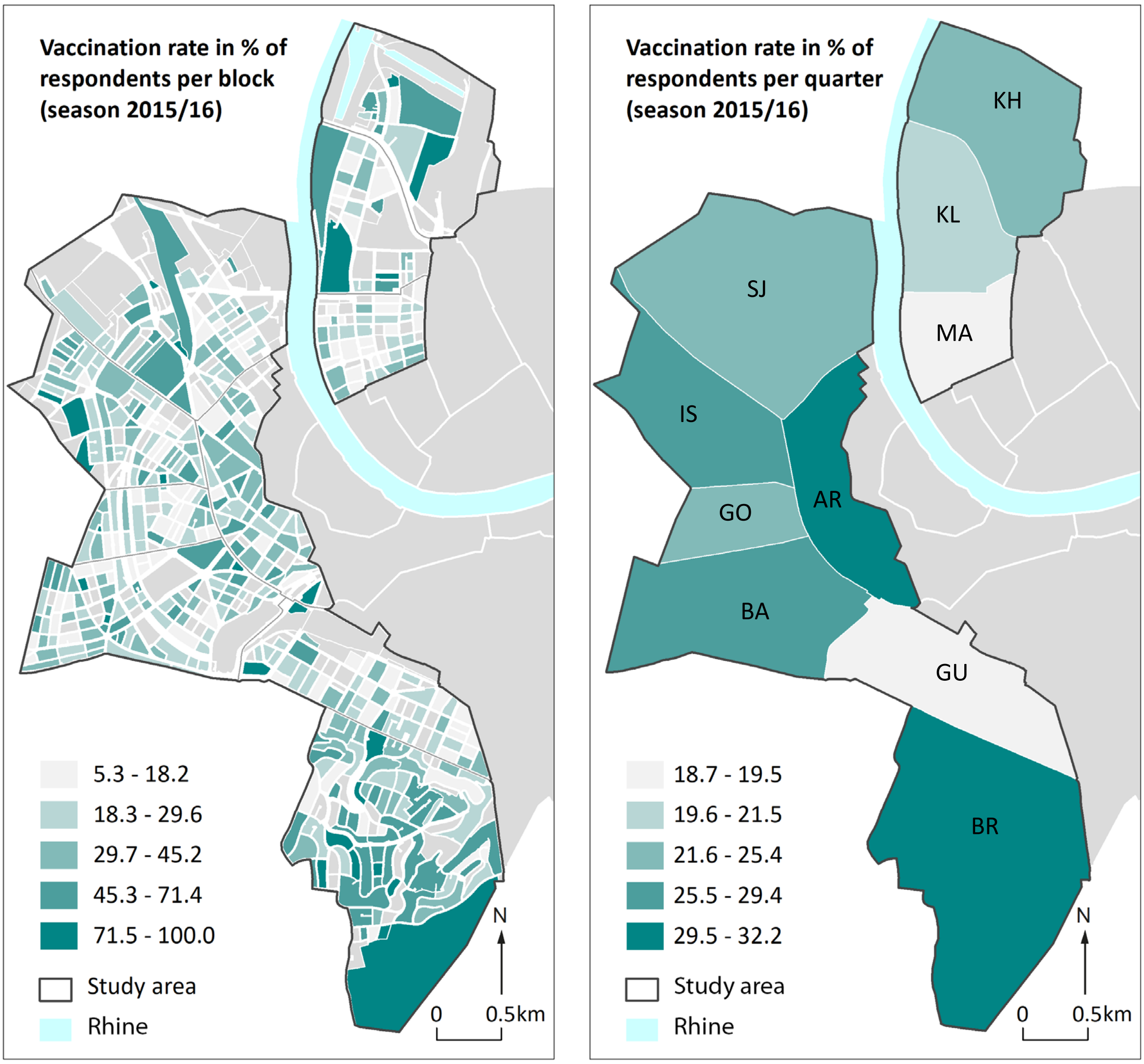
		Multivariable (forced entry method, n=4939)		
	Variables (reference category)	**OR**	**95% CI**	**p-value**
Socio-economic status	Educational level (compulsory)	0.982	0.419-2.299	0.966
	Gender (male)	0.927	0.700-1.227	0.595
	Age (≥65 years)	0.466	0.280-0.777	0.003*
	Nationality (foreign population)	0.990	0.722-1.358	0.951
Working environ-ment	Health care worker	0.948	0.626-1.435	0.800
	Work with children	0.674	0.428-1.060	0.088
	Work in an open plan office	1.051	0.791-1.395	0.733
	Contact with people (>50 people/day)	1.018	0.727-1.423	0.919
Health and health-related behaviour	Chronic illness°	1.341	0.908-1.982	0.140
	Smoker (daily)	1.461	1.004-2.125	0.047*
	Alcohol consumption (daily)	0.476	0.247-0.917	0.026*
	Influenza vaccination	0.464	0.300-0.718	0.001*
	Hand washing (regular)	1.568	1.002-2.454	0.049*
	Health check-ups (regular)	0.668	0.483-0.925	0.015*
	Healthy diet	1.215	0.849-1.738	0.287
	Physical activity (regular)	0.817	0.609-1.094	0.175
Personal environment	Public transport use (daily)	1.487	1.130-1.956	0.005*
	No. of people / household (≥ 3 people)	1.338	0.936-1.914	0.111
	Children <7 years in same household	1.129	0.723-1.764	0.594
	Living with chronically ill persons	0.975	0.543-1.751	0.932
	Looking after care-dependent person at home	0.902	0.452-1.801	0.770
	Regular visits to hospital and care home	0.526	0.270-1.024	0.059
Quarter charac-teristics	Exposure to negative environmental influences	0.764	0.563-1.037	0.084
	Green space (≤ 20% / block)	0.897	0.636-1.266	0.536
	Built up area (≥ 60% / block)	0.876	0.5271-1.457	0.611

°chronic illnesses that pose an increased risk if infected with influenza, classified according to Anatomical Therapeutic Chemical Level (WHO definition)
*significant variables with p-value ≤0.05 (coloured variables)
exclusion of variables income, employment status and living space due to high missing n-values

7.3 Spatial distribution of vaccination rates

Whereas vaccine coverage in the general population was relatively low (25.8%, n=2073) it varied greatly across the study area (Map 10). To visualise the spatial distribution of self-reported vaccination rates, different geographic scales were used. Looking at the pattern of the vaccinated respondents there is a less than 5% likelihood that this clustered pattern could be the result of random chance as the Moran's I is 0.0062 (z-score: 1.961, p-value: 0.05). The percentage of respondents per block that had got an influenza vaccination was used, to account for varying population densities which might influence the Moran's I. Regarding the two maps, it not easy to make out any distinct spatial patterns on the block level, with the exception for Bruderholz and Am Ring. The block level map shows that even within quarters there can be strong spatial variations regarding vaccination take up. Therefore, there are not enough data points for a meaningful analysis on the block level, i.e. if there are on average only 2-3 people per block, the vaccination rate for that block might not accurately reflect the true vaccination rate of the population in that block.

However, it must be considered that the actual number of vaccinated respondents for each quarter is quite low. As for the ILI data, it is more adequate to analyse vaccination rates on the quarter level. The densely populated urban quarters with many children, a large proportion of the foreign-born population and a smaller share of elderly respondents had below average vaccine coverage (most notably Gundeldingen and Matthäus) and the quarters with a high share of elderly respondents (≥ 65 years) had above average vaccine coverage (most notably Am Ring, Bruderholz, Bachletten). Many families whose parents are in the highly qualified international work force, many of whom are from English speaking countries live in the Am Ring quarter. For the high-density urban quarters with many children and a high share of the foreign-born population, it might be worth adapting the vaccination campaigns and related communication strategies, as the current policy does not seem to show the desired effect. As hardly anyone responded to the survey in the dominant languages spoken in such quarters one may assume at this point that vaccine campaigns for such segments of the population and these urban quarters must focus more strongly on inclusiveness.



Map 10 Self-reported vaccination rate per statistical block (left), per quarter (right)
95% CI: AR ± 3.2%, BA ± 2.6%, BR ± 2.7%, GO ± 2.6%, GU ± 2.5%, IS ± 3.1%, KH ± 6.9%, KL ± 4.1%, MA ± 2.7%, SJ ± 3.0%
(Data source: Human Geography Research Group, Department of Environmental Sciences, University of Basel. Base map data: Bau und Verkehrsdepartement des Kantons Basel-Stadt, Grundbuch und Vermessungsamt, Fachstelle für Geoinformatik. Concept and cartography: M. Brunner, N. Goldman 2020)

7.4 Determinants of influenza vaccination

To identify predictors for influenza vaccination, the same variable selection method was used as for the regression analysis in Chapter 7.2. Here too, a univariable and multivariable regression analysis was run. For both multivariable models the Hosmer-Lemeshow-Test yielded high p-values (forward: p-value=0.832 (9th step), backward: p-value=0.667 (17th step)) showing that the models fit the data well.

Predictive factors for vaccination. The summary of the univariable and multivariable logistic regression analysis are shown in Table 9. Individuals who are not Swiss nationals, work in health care, have specific chronic illnesses or live with three or more people are more likely to be vaccinated. These factors were significant predictors for both multivariable models. It might not be surprising that health care personnel and individuals with chronic illnesses have a greater likelihood of being vaccinated, as they both belong to the vaccination target group. However, it is surprising that age was only a significant predictor in the univariable regression, but not in the multivariable model, especially as age correlates with vaccination status (as shown in the next chapter, Figure 18, p.96).

Individuals with a low monthly household income ($\leq$ CHF 6000.-/household), who smoked daily, incorporated physical activity well or very well into their daily lives, had reduced living space or felt exposed to negative environmental influences were less likely to be vaccinated against influenza in the multivariable models. A Chi^2-test found a significant correlation ($p<0.001$) between age and income, i.e. a higher percentage of respondents who had a household income below CHF 6000.- per month were 65 years or older, most likely because they are retired and rely on their pension. Those with less living space are also more often below retirement age, a Chi^2-test found this correlation to be significant ($p<0.001$), and those younger than 65 years show below average vaccination rates.

Table 9 Determinants for influenza vaccination (univariable and multivariable analysis)
(source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

			Univariable			**Multivariable** (forward LR stepwise selection method) n=2063, 9 steps			**Multivariable** (backward LR stepwise selection method) n=2063, 17 steps		
	Variables (reference category)	**n-value**	**OR**	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
Socio-economic status	Educational level (compulsory)	7826	2.047	1.673-2.504	<0.001*	-	-	-	-	-	-
	Income (≤ CHF 6000.- /household/month)	6195	0.727	0.646-0.817	<0.001*	0.481	0.365-0.634	<0.001	0.487	0.369-0.641	<0.001
	Gender (male)	8076	1.180	1.065-1.306	0.001*	-	-	-	-	-	-
	Age (≥65 years)	7903	4.195	3.771-4.667	<0.001*	-	-	-	-	-	-
	Nationality (foreign population)	8026	0.833	0.733-0.946	0.005*	1.570	1.191-2.068	0.001	1.577	1.196-2.079	0.001
Working environment	Health care worker	7489	1.481	1.281-1.711	<0.001*	3.951	2.992-5.217	<0.001	3.551	2.633-4.789	<0.001
	Work with children	7482	0.436	0.354-0.537	<0.001*	-	-	-	-	-	-
	Work in an open plan office	7436	0.513	0.454-0.581	<0.001*	-	-	-	-	-	-
	Contact with people (>50 people/day)	7917	0.728	0.631-0.839	<0.001*	-	-	-	-	-	-
	Employment status (upper/middle management)	5125	1.425	1.221-1.664	<0.001*	-	-	-	-	-	-
Health and health-related behaviour	Chronic illness°	7431	4.157	3.702-4.668	<0.001*	3.786	2.760-5.192	<0.001	3.732	2.720-5.121	<0.001
	Smoker (daily)	8063	0.461	0.380-0.560	<0.001*	0.407	0.247-0.670	<0.001	0.411	0.249-0.679	0.001
	Alcohol consumption (daily)	8039	1.468	1.252-1.722	<0.001*	-	-	-	-	-	-
	Hand washing (regular)	7926	1.210	1.030-1.421	0.021*	-	-	-	-	-	-
	Health check-ups (regular)	7447	2.709	2.436-3.013	<0.001*	-	-	-	-	-	-
	Healthy diet	7935	0.704	0.622-0.796	<0.001*	-	-	-	-	-	-
	Physical activity (regular)	7840	0.748	0.671-0.833	<0.001*	0.564	0.437-0.727	<0.001	0.560	0.434-0.723	<0.001
Personal environment	Public transport use (daily)	7786	0.953	0.855-1.062	0.381						
	Living space (≤ 30m^2/capita)	4119	0.490	0.387-0.621	<0.001*	0.654	0.448-0.954	0.027	0.656	0.449-0.957	0.029
	No. of people / household (≥ 3 people)	8042	0.620	0.546-0.705	<0.001*	1.540	1.163-2.040	0.003	1.560	1.177-2.068	0.002
	Children >7 years in same household	7882	0.702	0.583-0.845	<0.001*	-	-	-	-	-	-
	Living with chronically ill persons	7948	1.542	1.289-1.843	<0.001*	-	-	-	-	-	-
	Looking after care dependent person at home	7909	1.591	1.301-1.944	<0.001*	-	-	-	-	-	-
	Regular visits to hospital and care home	7841	1.809	1.534-2.133	<0.001*	-	-	-	-	-	-
Quarter charac-teristics	Exposure to negative environmental influences	7550	0.787	0.701-0.883	<0.001*	0.713	0.538-0.943	0.018	0.722	0.545-0.956	0.023
	Green space (≤ 20% / block)	7652	0.770	0.677-0.875	<0.001*	-	-	-	-	-	-
	Built up area (≥ 60% / block)	7717	0.755	0.630-0.906	0.003*	-	-	-	-	-	-

°chronic illnesses that pose an increased risk if infected with influenza, classified according to Anatomical Therapeutic Chemical Level (WHO definition)
* variables with p-value ≤0.05 in the univariable analysis were selected for the multivariable analysis

Improving the model. It seems a little odd that living with 3 or more people increases the likelihood of being vaccinated, whereas having limited living space (<30sm/person) decreased the likelihood of a respondent to be vaccinated. Especially as increased living space per person correlates ($p<0.001$) with number of people in the household, i.e. the greater the living space per person, the higher the rate of single or 2-person households. This might be the result of the way the analytical analysis was set up. By only selecting the variables with a significant p-value from the univariable analysis, one gets biased estimates of the odds ratios. This is because variables that might just be randomly significant in the univariable analysis get overestimated in the multivariable analysis. Considering this, and the fact that some variables had low n-values, especially income (n=6195), employment status (n=5125) and living space (n=4119), a better approach might be to exclude these three variables and enter all others into one single model with the forced entry method. This yields a regression model (Table 10) with significantly more cases included (n=4988) than the approach above. It is striking that the improved regression model now features 14 significant determinants that explain the vaccination status versus nine determinants for the model above (Table 9). This is most likely because the improved model includes more than twice as many cases for the analysis, and is therefore likely to be the better model. The Hosmer-Lemeshow-Test yielded a high p-value (0.408) showing that this improved model also fits the data well.

The following variables are good predictors that someone is vaccinated: compulsory education, those ≥65 years, of foreign nationality, with a chronic illness, those who regularly go for health check-ups, have children under seven years living in the same household, looking after care-dependent person at home, or those who regularly visit people in hospital ore care homes. On the other hand, these variables are good predictors for not being vaccinated: working with children, daily smokers, those who implement a healthy diet and physical activity well or very well into their daily life, as well as those who feel exposed to negative environmental influences at home.

Table 10 Determinants for influenza vaccination (multivariable analysis, forced entry method)
(source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

		Multivariable (forced entry method, n=4988)		
	Variables (reference category)	**OR**	**95% CI**	**p-value**
Socio-economic status	Educational level (compulsory)	1.586	1.091-2.308	0.016*
	Gender (male)	1.110	0.952-1.294	0.182
	Age (≥65 years)	3.792	3.096-4.644	<0.001*
	Nationality (foreign population)	1.408	1.170-1.694	<0.001*
Working environ-ment	Health care worker	3.254	2.637-4.016	<0.001*
	Work with children	0.700	0.533-0.920	0.010*
	Work in an open plan office	1.155	0.965-1.383	0.115
	Contact with people (>50 people/day)	1.166	0.953-1.426	0.136
Health and health-related behaviour	Chronic illness°	2.630	2.210-3.131	<0.001*
	Smoker (daily)	0.440	0.332-0.583	<0.001*
	Alcohol consumption (daily)	1.078	0.850-1.369	0.535
	Hand washing (regular)	1.128	0.897-1.417	0.302
	Health check-ups (regular)	1.786	1.529-2.088	<0.001*
	Healthy diet	0.638	0.529-0.769	<0.001*
	Physical activity (regular)	0.781	0.663-0.921	0.003*
Personal environment	Public transport use (daily)	0.971	0.829-1.137	0.716
	No. of people / household (≥ 3 people)	1.155	0.923-1.445	0.208
	Children <7 years in same household	1.420	1.063-1.896	0.018*
	Living with chronically ill persons	1.214	0.916-1.608	0.177
	Looking after care-dependent person at home	1.719	1.266-2.333	0.001*
	Regular visits to hospital and care home	1.416	1.111-1.805	0.005*
Quarter charac-teristics	Exposure to negative environmental influences	0.685	0.580-0.808	<0.001*
	Green space (≤ 20% / block)	0.920	0.757-1.117	0.399
	Built up area (≥ 60% / block)	0.833	0.627-1.108	0.210

°chronic illnesses that pose an increased risk if infected with influenza, classified according to Anatomical Therapeutic Chemical Level (WHO definition)
*significant variables with p-value ≤0.05 (coloured variables)
exclusion of variables income, employment status and living space due to high missing n-values

Summarising the regression results. Figure 16 summarises the results from all the multivariable regression analyses (Table 7, Table 8, Table 9, Table 10) which found determinants for ILI (chapter 7.2) and vaccination (chapter 7.4). To make it clear which results came from which kind of selection method, different coloured lines were used. All the green dotted arrows are results from the multivariable regression with the forward and backward variable selection and all the red arrows are results from the multivariable regression with the enter method. Some variables, e.g. age (≥65 years), non-Swiss, daily smoking, etc., were significant for both variable selection methods, while others were only significant for one or the other variable selection method. The plus and minus symbol indicate whether the specific variable increased or decreased the likelihood of being vaccinated or getting an ILI. The visualisation below is an attempt to capture the dynamics of vaccination behaviour and the likelihood of getting an ILI. Most likely, it is vaccination status that determines a person's likelihood of getting an ILI, as most variables predict a person's propensity to be vaccinated. Variables that come out as significant in all selection methods (backward, forward, enter) are considered the most reliable predictors. Based on this, the respondents who were ≥65years old, non-swiss, health care workers, having a chronic illness are more likely to be vaccinated, whereas respondents who regularly engaged in physical activity or felt exposed to negative environmental influences at home were less likely to be vaccinated. Daily smoking was the only predictor that increased the likelihood of an ILI, whereas being vaccinated or 65 years or older decreased the likelihood, considering only the variables that were significant for all selection methods. The fact that regular hand washing was a good predictor for ILI, where one would expect the opposite, might indicate that there is an overestimation of the frequency. Especially as the respondents were asked how well they implement hand washing in their day to day life (from very well to very badly), the clear majority (85.8%, n=6993) indicated that they did this well or very well. This leaves a lot of room for interpretation, where good implementation of hand washing in a daily routine might only include washing hands after a visit to the toilet, whereas for others this might also include hand washing before eating food and/or after petting animals for example. Concluding, some variables, especially the self-reported health behaviours, should be interpreted with care, as everyone may have their own definition of what constitutes good implementation. In future it might be worth considering asking respondents for frequencies of various health related behaviours to make it a little more quantifiable.

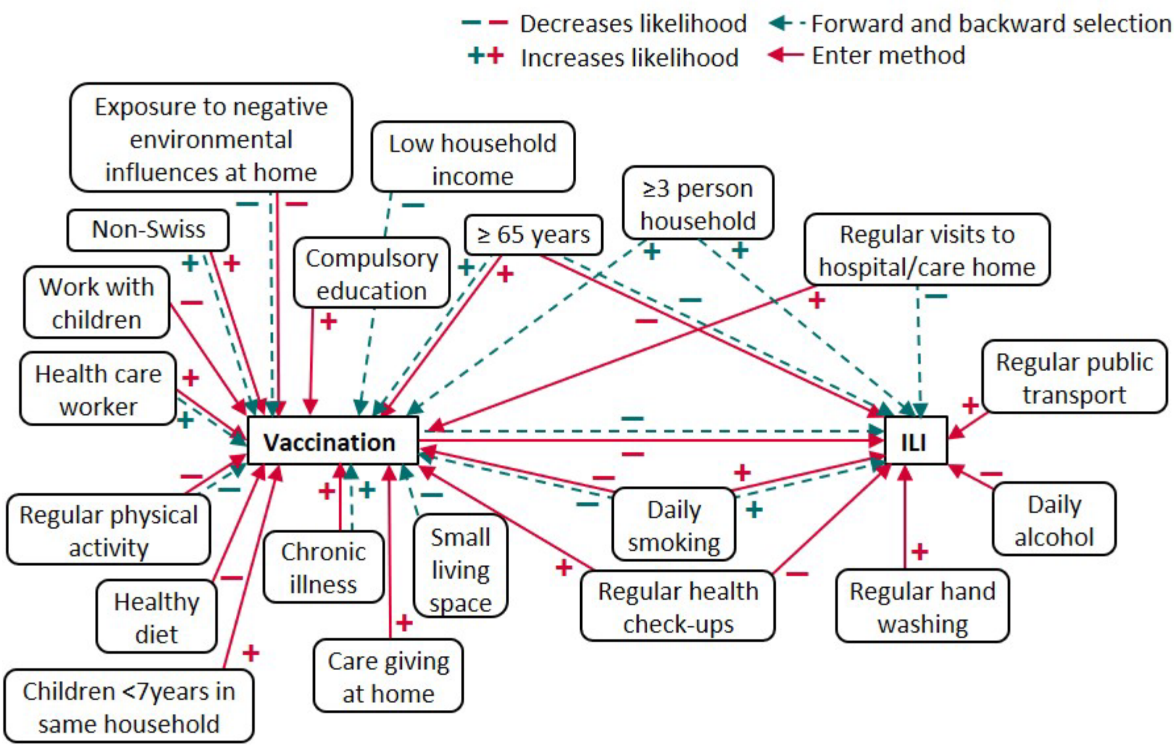


Figure 16 Visualised results from all regression analyses
(source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

8 Varying health behaviours between different population groups

Risk group. Certain population groups are at particularly high risk for medical complications and a worse outcome. These population groups include mainly patients with chronic illness and immunosuppression. More than one third of respondents were classified as belonging to the risk group (38.3%, n=3124), see pie chart in Figure 17. This group is made up of individuals with certain chronic diseases (56.3%, n=1759) and individuals 65 years and older (77.8%, n=2430), naturally some individuals are both older and have a disease. If this group catches influenza, they are at greater risk of having a more severe disease progression and a higher probability of needing to be hospitalised. The influenza vaccination is covered by the general health insurance for individuals at risk. Concerning the gender distribution, only 38% of all women are classified as belonging to the risk group in comparison to 43.9% of all males. Overall, the risk group is made up of 58.5% women and 41.5% men, which reflects the gender bias in the sample.

Target group. The target group is made up of the risk group and respondents who are in close contact with the risk group, which amounts to 57.3% of all respondents (n=4669) (pie chart in Figure 17). Thereby, the seniors (≥65years) make up just over half (52%) of all respondents in the target group, closely followed by the chronically ill (37.7%). Further, one in five respondents of the target group works in health care, 16.7% work with children and 14.6% regularly visit the hospital or persons in care homes (Figure 17). Concerning gender distribution, 59.4% of all females are classified as the target group and for the men it is a little lower with 54%. Overall, the target group is made up of 62% women and 38% men, which reflects the gender bias in the data. The true proportion of the risk and target group in the

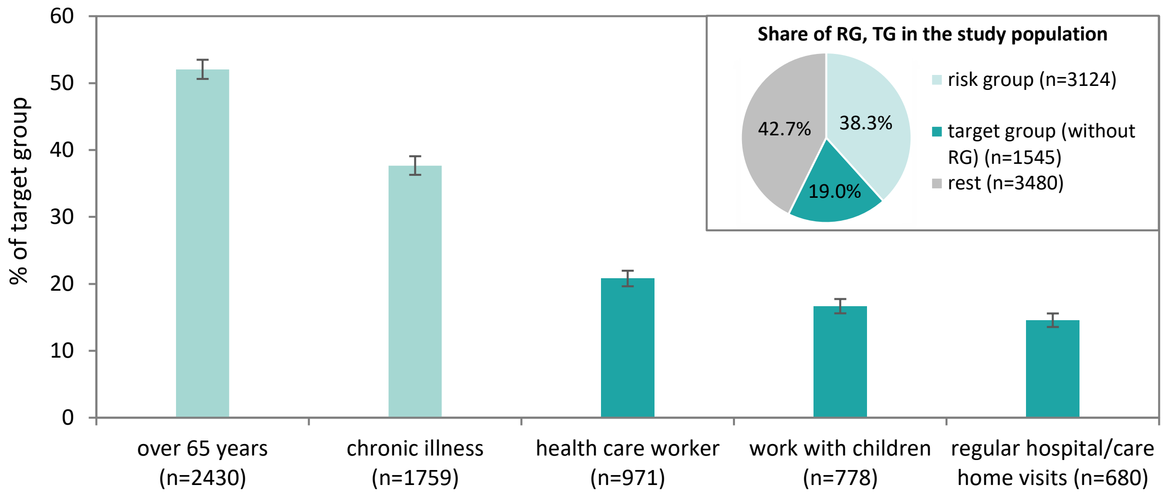


Figure 17 Share of risk and target group within the study population (pie chart) and composition of TG (bar graph)
Bar graph: multiple answer, 95% CI, n=4669, pie chart: n=8149 (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

general population might be a little lower, as there is a slight overrepresentation of respondents above 50 years old (as previously shown in Figure 12).

8.1 Vaccination uptake and beliefs

Vaccination coverage in general. Approximately a quarter of all respondents got an influenza vaccination (25.9%, n=2112) before the influenza season 2015/16. Out of all women 24.7% (n=1234) got an influenza vaccination and out of all men it was 27.9% (n=857). The majority got vaccinated in October or November of 2015 at a medical practice (60.9%, n=1286). The remaining chose to get the vaccine at the hospital (12.5%, n=265), the workplace (11.9%, n=251), pharmacy (9.9%, n=209) or other (4.8%, n=101). The mean age of those who got vaccinated was quite high at 63.8 years (SD 18.5 years) and a median age of 68 years. The youngest person to get vaccinated in this study was 16 years and the oldest was 101 years. Figure 18 shows that with increasing age, the proportion of vaccinated respondents increased, as shown by the linear regression (in black) and has a high degree of certainty (R^2=0.88). A study of influenza vaccination in Germany also observed this correlation (SZUCS ET AL. 2006). When looking at vaccination rates by education we also see the same trend as the above-mentioned study. Namely that the vaccination rates are highest for those with the lowest level of education.

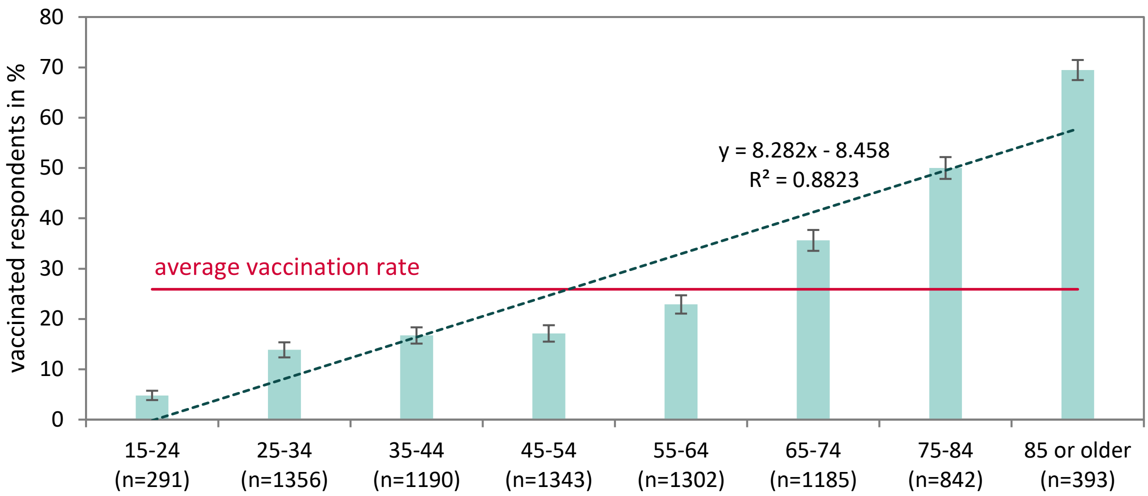


Figure 18 Vaccination rate by age
95% CI, n=2045 (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Risk group. The average vaccination rate of the risk group is 43% (n=1339), which is 1.7 times higher than that of the general population but is still too low, considering everyone in the risk group is advised to get it. The proportion of respondents classified as the risk group varies by quarter. Some quarters (e.g. Gundeldingen, Matthäus, St. Johann) have a low proportion of at-risk population (around 30%) and other quarters (e.g. Klybeck, Bachletten, Am Ring) have higher rates (approximately 45%) of the at-risk population. As the risk group is mainly made up of individuals 65 years and older, the spatial distribution of the risk group reflects the demographics of the quarters, where quarters with a higher degree of elderly population have higher proportions of respondents classified as the risk group. When only looking at the risk group by quarter and their vaccination behaviour one can see a similar pattern as for the proportion of the risk group itself. Figure 19 shows the vaccination rates of the risk group for every quarter and the vaccination potential that has yet to be achieved. However, when taking the confidence intervals into account, the differences between the quarters are within the margin of error.

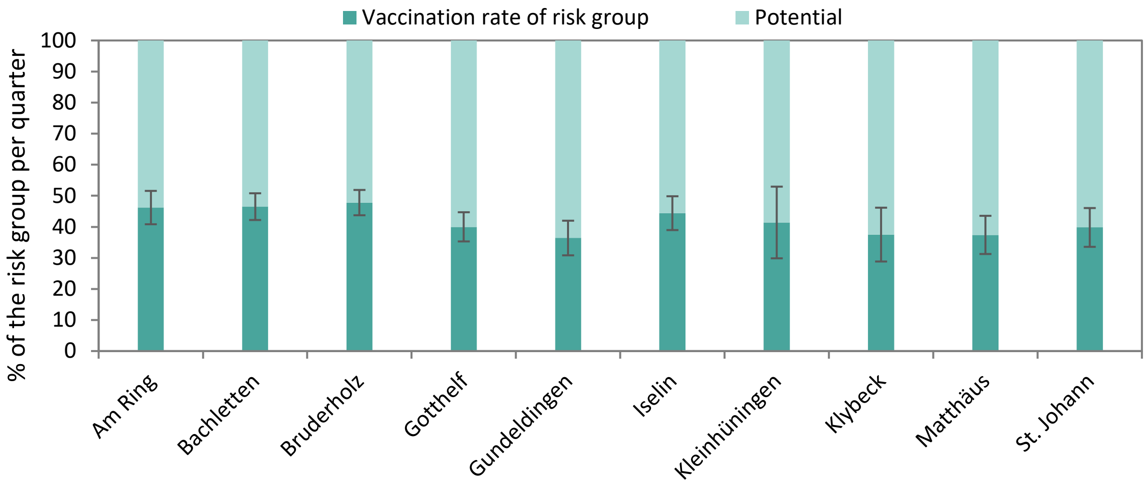


Figure 19 Vaccination rates of the risk group by quarter and the vaccination potential
95% CI for vaccination rate, n=3112 (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Target group. The proportion the target group varies from one quarter to another. Some quarters such as Klybeck, Matthäus and Gundeldingen have fewer inhabitants who belong to the target group in proportion to all inhabitants (just under 50%) and other quarters such as Kleinhüningen, Iselin, Bruderholz and Bachletten have higher rates between 60-70%. This too reflects the quarter demographics, where quarters with a higher degree of elderly population have higher proportions of the target group, with the exception of Iselin which does not have an above average proportion of elderly people. The variations in vaccination rates are a little more pronounced here. The average vaccination rate of the target group is 36% (n=1676). Figure 20 shows the vaccination rate of the target group by urban quarter and the vaccination potential, i.e. the proportion of the target group that should get an influenza vaccination. The red line indicates the FOHP aim to increase the vaccination rate of the general population to 75% (FOPH 2018c). It is clearly visible that not even the vaccination target group fulfils the FOPH aim, although all individuals of this group are advised to get the vaccination if there are no medical reasons for exemption.

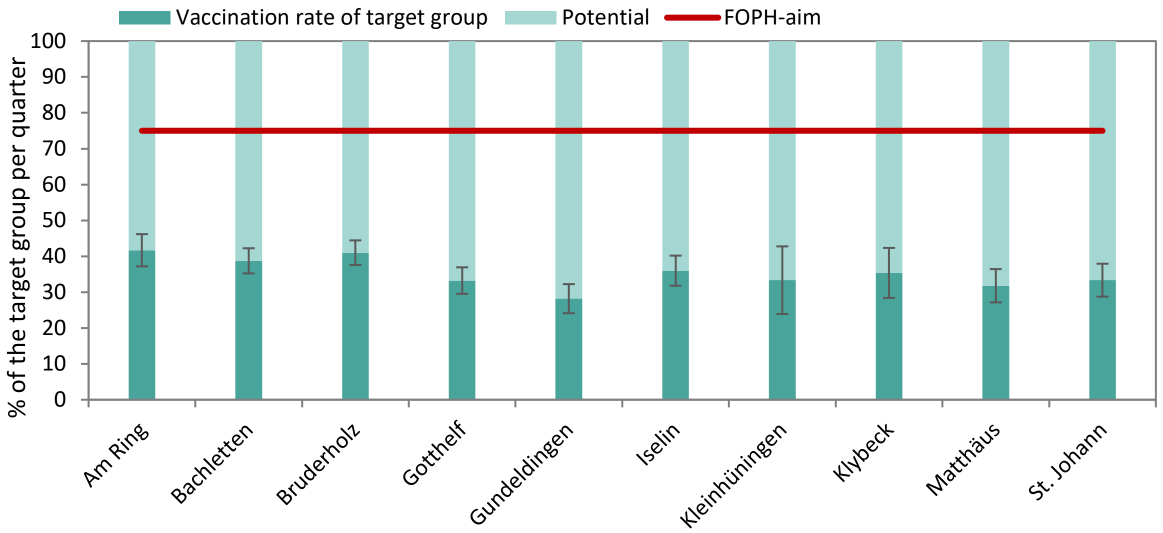


Figure 20 Vaccination rates of the target group by quarter and the vaccination potential
95% CI of vaccination rate, n=4654 (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, FOPH 2018c, own visualisation)

General vaccine adherence. Regarding adherence to vaccination recommendations, it could be shown that the general population (81.7%, n=6125) does not refuse a recommended vaccine for themselves or their children (Figure 21). A few respondents refused certain vaccines (15.7%, n=1178) and a small minority (2.4%, n=196) refused all vaccines for themselves or their children. This emphasises the importance of health care experts (doctors/pharmacists) in giving vaccine advice, because when they do recommend a vaccine, the vast majority of individuals will follow the advice and get vaccinated. There are only small differences between the target, risk group and general population regarding vaccine adherence. An above average proportion of the risk group (85.7%, n=2307) stated to have never refused a recommended vaccination. Concerning gender, the same goes for men

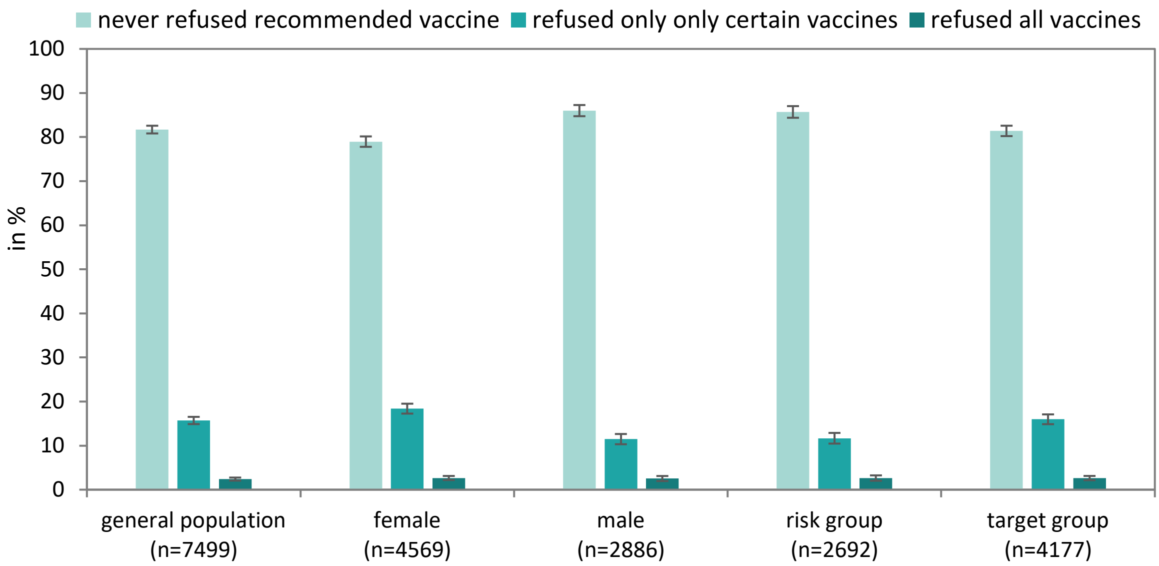


Figure 21 General vaccine adherence by different population groups
95% CI (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

(86.0%, n=2482) and not refusing recommended vaccines. Women on the other hand indicated that they more often refuse certain vaccines (18.4%, n=840) compared to men (11.5%, n=331). Overall, there seems to be a base rate of vaccination refusers regardless of gender or risk and target group.

8.2 Place of vaccination

The place of vaccination varied by quarter (Figure 22). Compared to all possible places of vaccination, most respondents got their vaccination at the medical practice (60.9%), followed by the hospital (12.5%), at work (11.9%), the pharmacy (9.9%) and other/no answer (4.8%). This highlights the importance of general practitioners regarding vaccination administration and consultations. In most quarters with low vaccination rates, the proportion of respondents who got vaccinated at a medical practice is smaller than in quarters with above average vaccination rates, with the exception of Kleinhüningen and Klybeck. The differences between the quarters are within the 95% confidence interval, so it is not feasible to look at the place of vaccination on the quarter level.

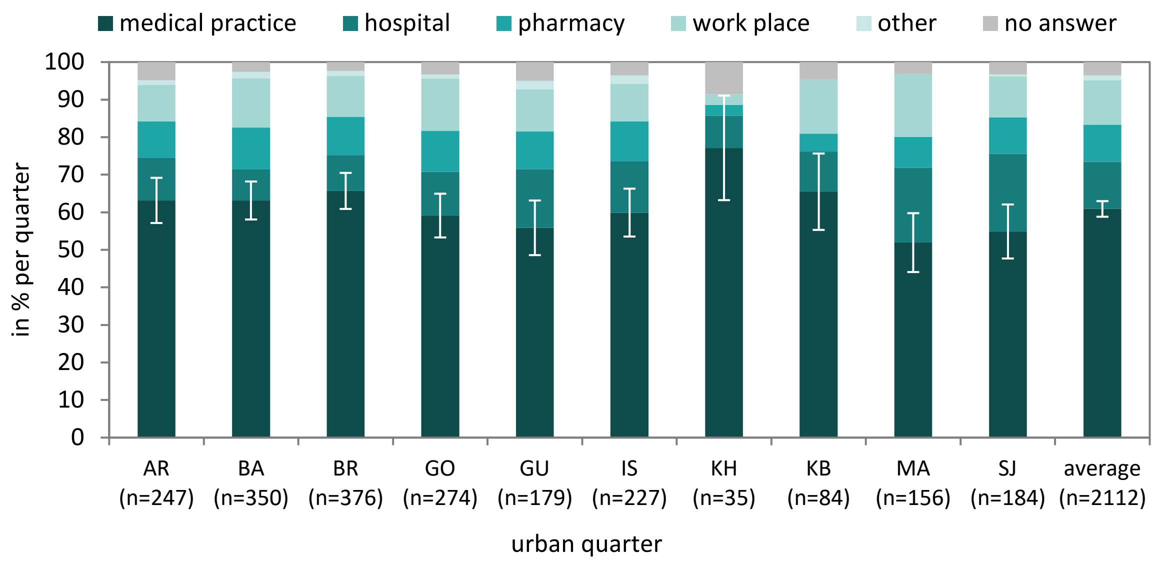


Figure 22 Place of vaccination by quarter
95% CI for medical practice, AR=Am Ring, BA=Bachletten, BR=Bruderholz, GO=Gotthelf, GU=Gundeldingen, IS=Iselin, KH=Kleinhüningen, KB=Klybeck, MA=Matthäus, SJ=St. Johann (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Vaccination behaviour and location. Here it is also interesting to look at vaccination behaviour and the preferred place of vaccination. Figure 23 shows where the regular and irregular vaccinators choose to vaccinate. For the irregular vaccinators, alternatives to the medical practice are more important than for the regular vaccinators. Despite this, the medical practice was still the primary location for both regular and irregular vaccinators. It will be interesting to see if the rate of administered vaccinations in medical practices will decrease as pharmacists in Basel were given permission to administer certain vaccines in 2018.

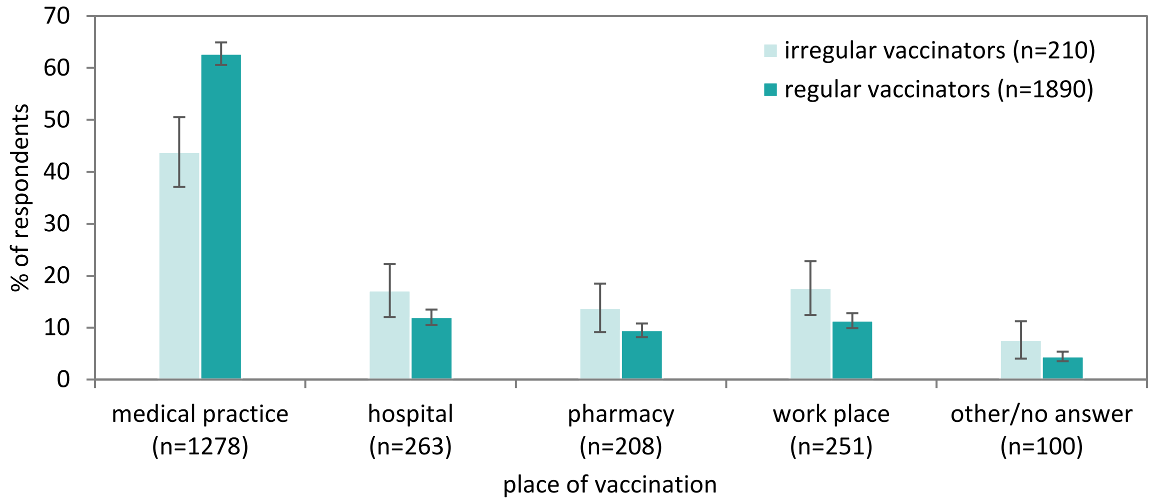
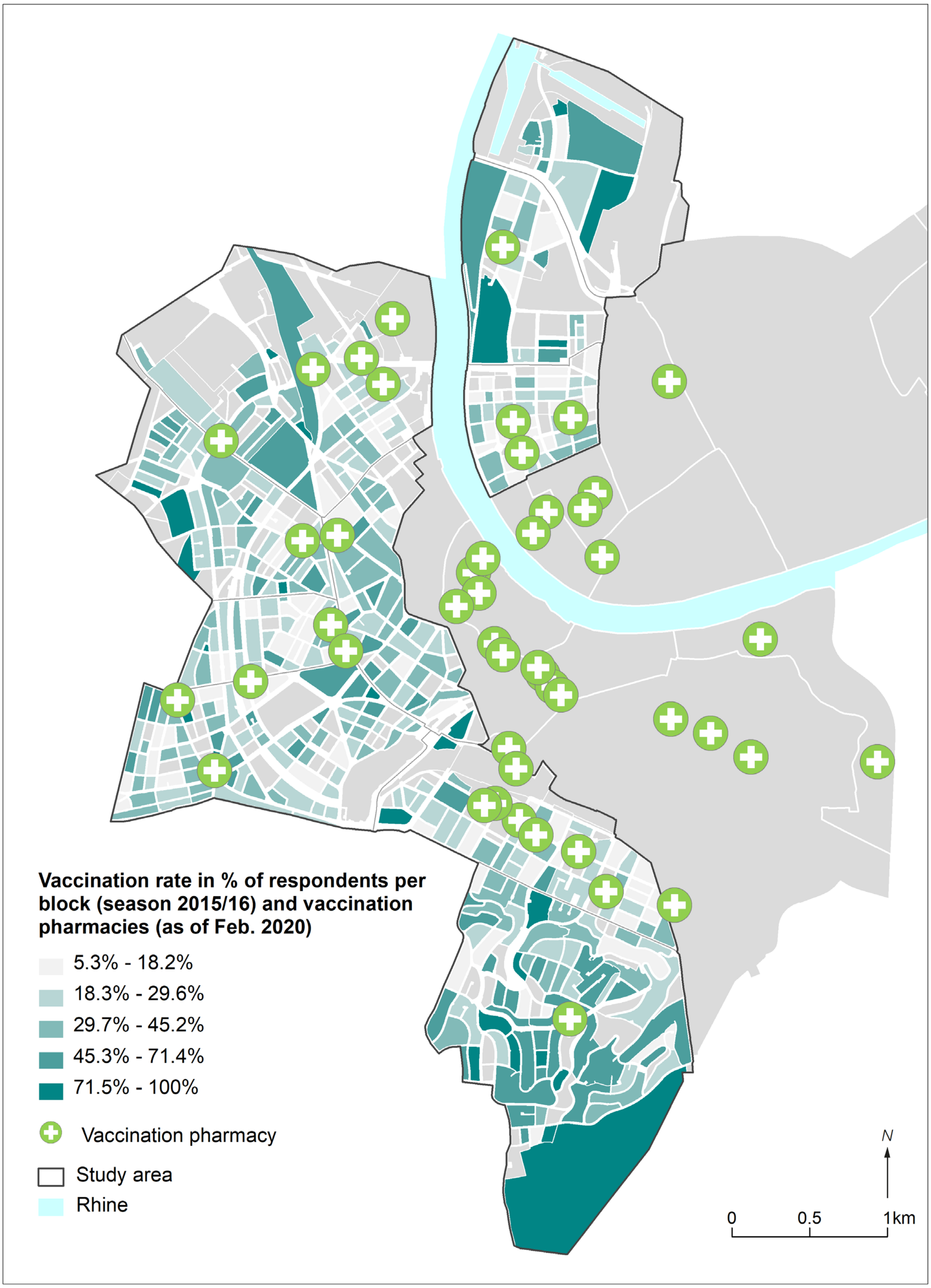


Figure 23 Vaccination behaviour of the regular and irregular vaccinators
95% CI (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Alternative locations for vaccination. Looking at data from pharmacies across Basel, provided by PharmaSuisse for the last two years reveals that the number of administered vaccines in pharmacies has increased by 61.5% (from 1735 to 2802) between 2018 and 2019 alone. Some of this can be attributed to an increasing number of pharmacies that have introduced the vaccination service in 2019. For both years, 51.9% (n=2354) of all vaccinated individuals were female and 48.1% (n=2183) were male, which reflects the general population and indicates that getting vaccinated in a pharmacy does not correlated with gender. The average age of vaccination was between 55-56 years for both years. For 12.8% (n=222) of people it was the first time they had been vaccinated against influenza in 2018, a year later the proportion of first-time vaccinations increased a little (14.3%, n=401), probably because 18 additional pharmacies offered the vaccination service in 2019. It will be interesting to see whether the numbers of administered influenza vaccines by pharmacies will increase further or if they will stabilise soon. It also remains unclear whether the overall vaccination rate of the population will increase due to the new vaccination service provided by pharmacies or whether there will only be a change of the place of vaccination. The estimated vaccination rates for the general population have not significantly increased for the years 2018 and 2019 as shown in Figure 8 (p. 37). Anyhow, pharmacies provide an important first place of contact regarding health questions for many (more on sources of health information in chapter 8.8). They also complement the existing vaccination services by offering additional opening hours (e.g. Saturdays), which can be beneficial to the working population.

Location of alternatives. Concerning the location of the pharmacies that offer this service, they are distributed across the city (Map 11). The following map shows the vaccination rates per block for the season 2015/16 and the location of the pharmacies, which offer vaccinations (as of Feb. 2020). The list of pharmacies who offer this service was taken from Pharmacists'

Association Basel and PharmaSuisse. Since the vaccination rates of the general population have not strongly increased, with an exception during the 2016/17 season, it can be assumed that the spatial pattern did not vary substantially. This shows that almost all respondents in the study area are now within walking distance of a vaccination pharmacy and could have easy access to influenza vaccinations. As the increasing number of administered vaccines in pharmacies shows, there is a demand for this service but it yet remains to be seen if this leads to an overall increase of the vaccination rate of the population or if this is merely a redistribution of the place of vaccination.



Map 11 Vaccination rate in % of respondents and vaccination pharmacies
(Data source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Vaccination pharmacies: Pharmacists' Association Basel and PharmaSuisse. Base map data: Bau und Verkehrsdepartement des Kantons Basel-Stadt, Grundbuch und Vermessungsamt, Fachstelle für Geoinformatik. Concept and cartography: M. Brunner, N. Goldman 2020)

8.3 Reasons against vaccination

The questionnaire allowed for several reasons why the respondents did not get vaccinated against influenza. Figure 24 shows the reasons for the general population and by gender. There was also the possibility for an open text answer to capture other reasons. Of the people who did not get a vaccination (n=5972), the majority did so because they strengthen their immune system with alternative means (41.1%, n=2452). A larger proportion of women stated this as the main reason not to get vaccinated. For the other reasons, gender did not seem to make a strong difference, so the results are discussed for the general population. Many also reported they did not know why they should get vaccinated (28.6%, n=1708), that they did not believe in its effectiveness (21.5%, n=1283) or that the real influenza would strengthen their immune system better than the vaccine (17.8%, 1065). The cost of the vaccine was not considered a main reason for not getting vaccinated (3.2%, n=189, thought it was too expensive). About one quarter also gave additional reasons for not vaccinating. These reasons were grouped into five categories: perception that vaccine is unnecessary (15.7%, n=935), bad experience with the vaccine (2.3%, n=140), carelessness (2.3%, n=140), scepticism about vaccine (2%, n=120) and medical reasons (1.1%, n=67). Summing up, the main reasons seem to be a lack of the perceived danger of influenza, and therefore many do not know why they should get vaccinated, perceive it as unnecessary or report that they strengthen their immune system with other measures.

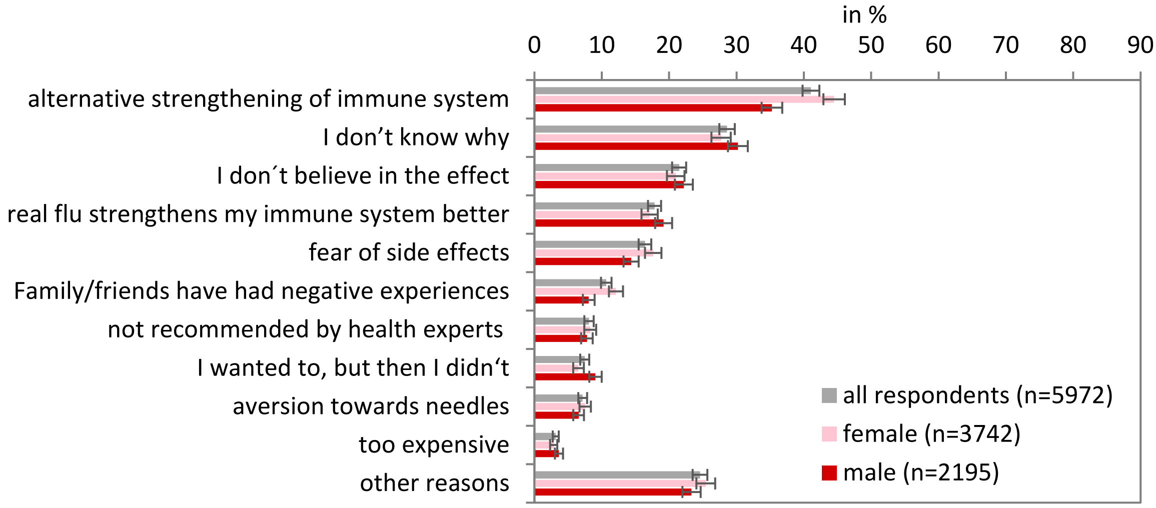


Figure 24 Reasons for not vaccinating against influenza by gender and general population
multiple answer, 95% CI (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Risk and target group. The risk and target group only differ a little from the general population regarding the reasons for not getting vaccinated (Figure 25). The most common answer for not getting vaccinated was the same as for the general population, strengthening the immune system by other means. The most pronounced difference can be found for not knowing why one should get a vaccination, where the risk and target group less often indicated this than the non-risk and non-target group. This shows that the risk and target group might be more aware that there are good reasons for them to get vaccinated. However, it is a little surprising that a higher proportion of the risk and target group do not believe in the effect of the vaccine, compared to the non-risk and non-target group. One might think that this is due to increased negative vaccination experiences for the risk and target group, as shown in chapter 8.5, this is not the case. Regarding other reasons, the rate of the risk and target group who consider the vaccine to be unnecessary or are sceptical about the benefits of it is less than for the general population.

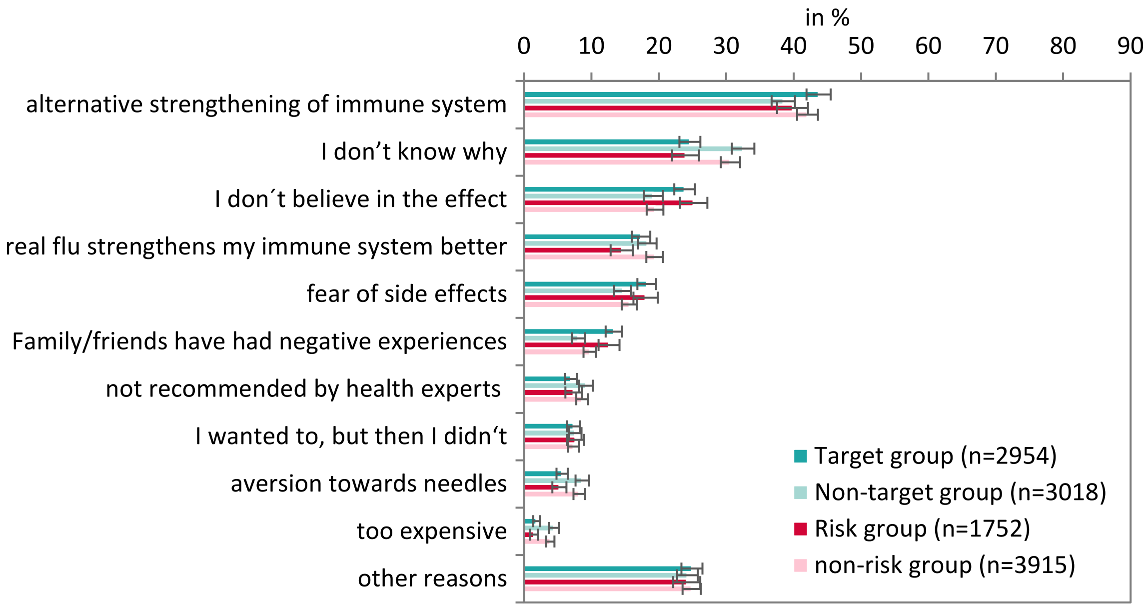


Figure 25 Reasons for not vaccinating against influenza by risk and target group
multiple answer, 95% CI (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

8.4 Reasons for vaccination

The questionnaire also offered multiple answer possibilities, including a free text option, for respondents who had chosen to vaccinate (Figure 26). The vast majority stated that they wanted to stay flu free (75.1%, n=1515). For almost half, a vaccination recommendation from a health professional was the decisive factor (43.4%, n=876). This highlights the importantce of health care specialists (doctors or pharmacist) in providing a good vaccination consultation, as their opinion is important in the decision-making process of many people. One third of all vaccinated individuals wanted to protect family and friends (31.8%, n=642). This shows that protecting the self with a vaccination was deemed more important than the protection of others. Further, one in five had the vaccination recommended at the workplace (19.8%, n=400) and did not want to miss work (18.1%, n=366). Other reasons for getting the vaccine (from the free text answers) included belonging to the risk group (7.7%, n=152), being firmly convinced about vaccinations as a preventative measure (6.4%, n=130), being a member of a medical profession (4.4%, n=88) or working with children (0.5%, n=11). There are no significant differences for men and women as to why they chose to vaccinate, i.e. the differences between the genders are all within the 95% confidence interval. Concluding, the main reasons to get an infleunza vaccination was to stay flu free and/or because it was recommended by a health specialist.

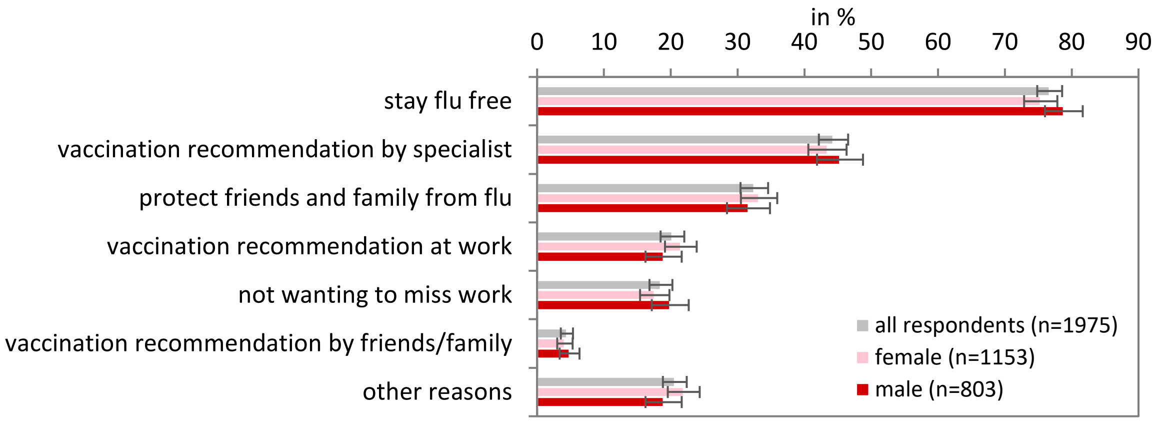


Figure 26 Reasons for vaccinating against influenza by gender and general population
multiple answer, 95% CI (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Risk and target group. There are some differences between individuals classified as the risk and target group concerning reasons for vaccination (Figure 27). About half of the risk group (56.9%, n=724) and target group (49.0%, n=773) who got vaccinated did so because it was recommended by a health specialist (doctor/pharmacist). This might be ascribed to the fact that the risk group are probably in more frequent contact with health care providers due to their age and health status. A study on adults with asthma showed that health professionals recommending the influenza vaccine, the belief that the vaccine would protect from the flu and the idea that a flu vaccine could cause a cold were driving determinants of vaccination uptake (LYN-COOK ET AL. 2007). This underlines the importance of health professionals for respondents in the risk and target group. Only a small proportion of the risk and target group stated not wanting to miss work as a vaccination reason or that the vaccine was recommended at work. This is most likely due to their age, since three quarters of the risk group and half of the vaccination target group are made up of respondents over 64 years of age, i.e. not in the workforce anymore. A larger proportion of the non-risk and non-target group indicated that they wanted to protect family and friends from influenza by getting a vaccination, compared to the risk and target group. As the latter two groups are the ones that need protecting, they might vaccinate more for themselves rather than for others, which is reflected by the fact that most respondents stated they want to stay flu free.

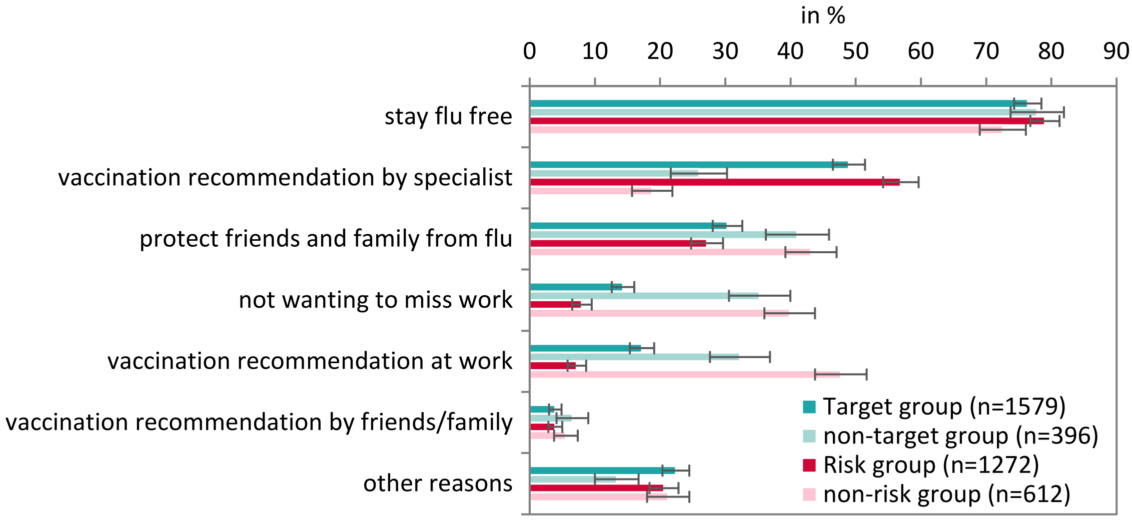


Figure 27 Reasons for vaccinating against influenza by risk and target group
multiple answer, 95% CI (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

8.5 Vaccination experience

Positive. The respondents who had received a vaccination could indicate their experience after this year's vaccination on a scale of 1 to 10 (10=very positive, 1=very negative). Half of the vaccinated respondents (51%, n=978) rated their experience as very positive (10) and overall the vast majority (90.9%, n=1742) had evaluated their experience as generally positive (6 or higher). Some respondents specifically indicated which positive experiences they had. These included the belief that the vaccine provided good protection, had no side effects or a combination of both. **Negative**. Only a small proportion of respondents (9.1%, n=174) rated their experience with the influenza vaccine with 5 or lower. The reasons given for having a bad experience were exactly the opposite, namely that the influenza vaccination provided poor protection, had side effects or a combination of both. There are no significant differences between the vaccination experiences of the general population, the risk and target group, i.e. the differences are all within the 95% confidence interval.

Regularity of vaccination. A quarter of all respondents (25.2%, n=2054) reported regularly vaccinating against influenza. This reflects the vaccination rate of the season 2015/16, meaning that almost all respondents who got a vaccine regularly do so (90%, n=1890). Only 10% (n=210) of those who got a vaccination during this season reported not regularly vaccinating. Concerning the regular vaccinators, 29.5% (n=527) had been getting the flu shot for up to 5 years, 37.8% (n=676) between 6 and 10 years, 13.5% (n=241) between 11 and 15 years and 11.6% (n=207) had been getting the vaccination for 16 to 20 years. 13% (n=266) did not specify the time period. Of those who got vaccinated, 10% (n=210) indicated that they do not regularly vaccinate against influenza. It is not clear from the questionnaire whether these respondents are first time vaccinators and they intend to do this on a regular basis or whether it was just a one-time immunisation. There is no significant difference between the risk group, target group, general population, and gender regarding the number of years of regular influenza vaccinations, with one exception. Individuals of the risk group who regularly vaccinate have been doing so for a longer time than the all the others.

8.6 Perception of own health and health behaviours

Self-reported health status. Respondents could report on their health status by using a scale from 1 to 10 (10=very positive, 1=very negative). About three quarters (76%, n=5983) of the general population reported having very good health (8 or higher) but for the target group it was 70.7% (n=3157) and for the risk group it was only 61.8% (n=1816) (Figure 28). The latter reflects the fact that half of the risk group has a chronic illness and three quarters are over 64 years old, at which age respondents might not report very positive health any more. Overall, the vast majority (92.6%, n=7292) of the general population rated their health status as generally positive (6 or higher) and only 7.4% (n=584) ranked their health status as generally negative (5 or lower). Correlating self-reported health with ILI did not show a significant correlation, but correlating it with vaccination uptake yielded a significant correlation (Chi^2, Phi, Cramer-V: $p<0.001$ for all), whereby the higher the self-reported health, the lower the self-reported vaccination rates.

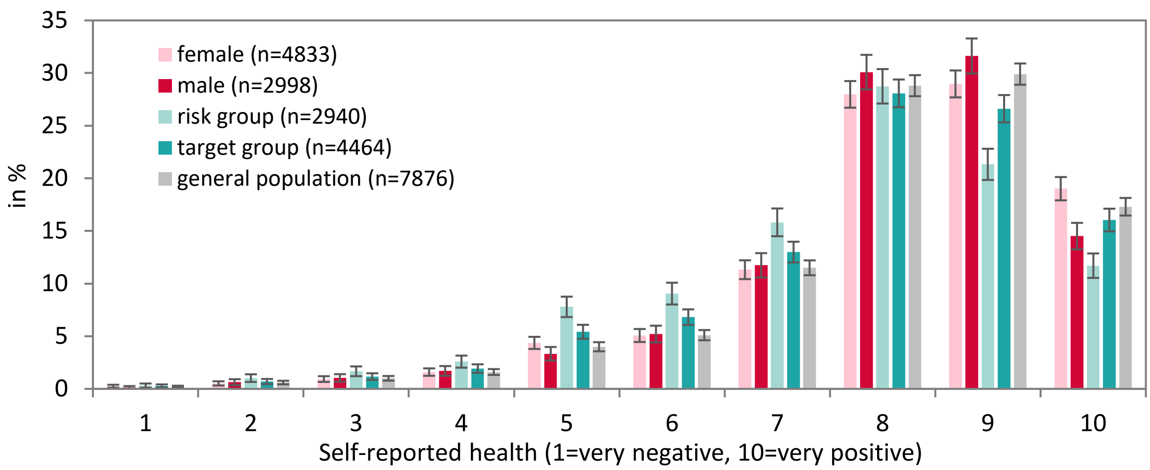


Figure 28 Self-reported health by different population groups
CI 95% (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

General practitioner (GP). The majority of respondents (85.1%, n=6832) also reported having a general practitioner, which emphasises their importance as primary health professionals for the general population. From the risk group, almost everyone reported having a GP (94.7%, n=2893), most likely due to the characteristics of the group and from the target group also most reported having a GP (90.4%, n=4147). There was no significant gender difference.

Chronic illness. One third of respondents (34.8%, n=2766) reported having a **chronic illness** for which they required daily medication, for the previous six months at the time of returning the questionnaire. Naturally the risk group (73.3%, n=2201) and target group (52.3%, n=2366) more frequently reported having a chronic illness than the general population. There was no significant difference between the genders. Based on the medication, the team at the University Hospital Basel could infer which illnesses the respondents had, and classified these according to the ATC classification system. Half of those with a chronic illness (50.4%, n=1139) reported having issues with the cardiovascular system (C), many also reported having issues with blood and blood forming organs (B) (19.8%, n=447), alimentary and metabolism (A) (17.7%, n=445) or the nervous system (N) (19.2%, n=434). Based on which illness a respondent has, they face a higher risk of complications if they get influenza. These are further referred to as the **at-risk chronic illness** respondents and make up 77.7% (n=1759) of all respondents with a chronic illness.

Perception of preventive measures. Respondents could evaluate the importance of various health behaviours as a prevention strategy against influenza (Figure 29). The majority of all population groups regarded regular hand washing, having a healthy diet and regular physical activity as important or rather important health measures to prevent influenza. Regarding healthy diet, a smaller proportion of men regarded this as important compared to the other groups. In comparison, regular health check-ups were less often considered to be important by most except for the risk group, 50.6% (n=1308) of whom thought it was quite important. Vaccination, on the other hand, was only regarded as important or rather important by 38.4% (n=2819) of the general population. Here too, the risk group and target group more often stated that getting regular vaccinations was important, compared to the general population. This might be because they need to have regular health check-ups due to their age or chronic conditions and therefore more often perceive it as important. The low values for the perceived importance of vaccination as a good preventative measure highlights the importance of communication strategies that propagate vaccination as an important preventive measure against influenza. Almost one fifth of all respondents (19%, n=1547) also made use of the free text option and indicated additional reasons they perceived to be good preventative measures, such as mental health, enough sleep, good nutrition (keeping hydrated and taking supplements) and minimising contact with (sick) people.

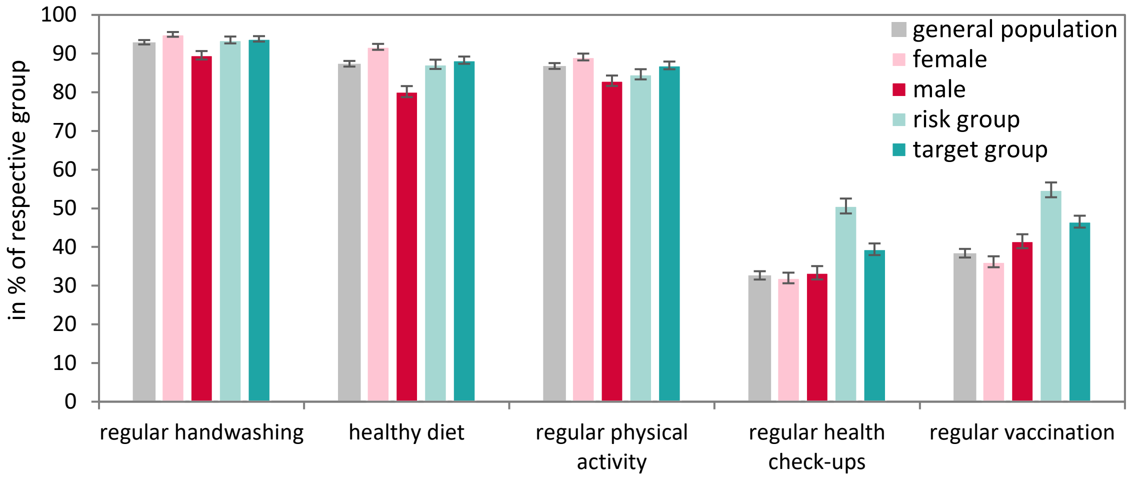


Figure 29 Perceived importance of different health behaviours by different population groups
summed values for important and rather important, 95% CI (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Implementation of health behaviour. An overview of all self-stated health habits is given in Figure 30. Each bar represents the summed values for good or very good implementation of the corresponding measures. Therefore, each bar has its own n-value and for the purpose of clarity it is not shown in the figure. Regarding the implementation of selected preventive measures, 40.3% (n=2856) of the general population indicated that they implemented the vaccination recommendation good or very good. As stated above, the actual vaccination rate of the general population was only 25.9% (n=2112), which illustrates the point made above about the differences in defining the own health behaviour. The perceived importance and the self-reported implementation of these habits matched quite well, with the exception of healthy diet and physical activity. 87.4% (n=6954) of the general population regard having a healthy diet as an important prevention strategy, yet only 79% (n=6438) report implementing this well or very well. For physical activity of the general population the difference in perceived importance and actual implementation was even higher. 86.8% (n=6802) perceive regular physical activity to be important, but only 69.4% (n=5451) manage to implement this well or very well in their day-to-day life. However, these results should be treated with care as they are self-reported and respondents might not answer completely truthfully to present themselves in a better light. It is also not possible to know if all respondents define their implementation of health habits the same way. The mismatch between perception and implementation of health measures shows that people are aware of recommendations and “must do’s” but do not fully apply it in their day-to-day life. The differences between the population groups are not substantial regarding handwashing, diet or physical activity. However, the proportion of men who regularly wash their hands or eat healthily is lower for both these habits compared to the other population groups.

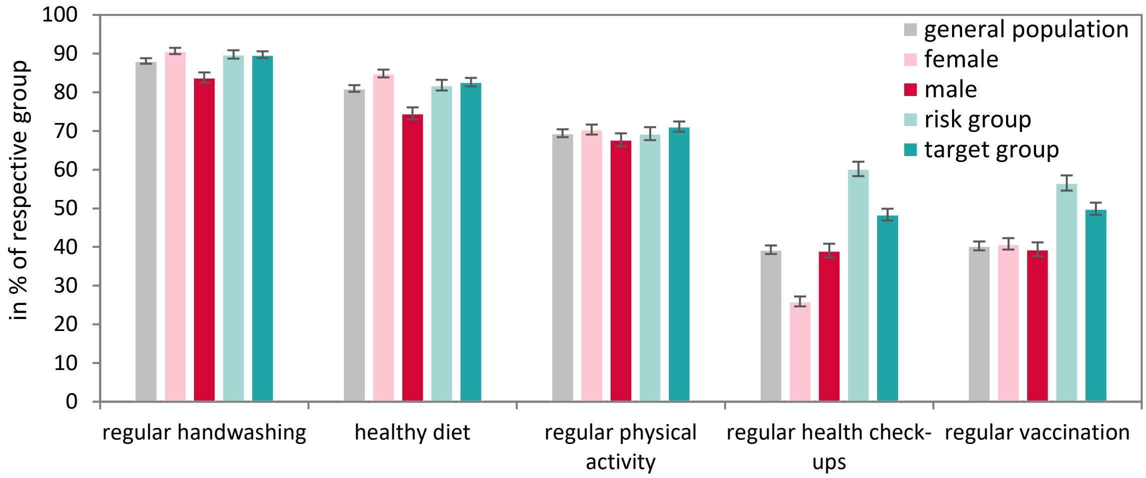


Figure 30 Prevalence of different health behaviours by different population groups
summed values for good or very good implementation, 95% CI (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Smoking and drinking behaviour. In general, alcohol consumption was far more prevalent among all respondents than smoking, with most respondents (78.1%, n=6304) reported to be non-**smokers**, 11.1% smoked occasionally and another 10.8% smoked daily (Figure 31). Of the latter group, most smoked between 0.5-1 packet of cigarettes per day (79.9%, n=635) and were male. A higher proportion of women (79.8%, n=3966) than men (75.5%, n=2300) stated that they were non-smokers and for the risk group and target group it was even higher (83.2%, n=2573 and 80.9%, n=3746). The consumption of **alcohol** was more prominent among respondents than smoking with more than 2/3 of respondents (69.4%, n=5586) who reported drinking alcohol sometimes, 9.5% (n=767) daily consumers and 21.1% (n=1697) abstaining from drinking alcohol. Here too the rate of non-drinking respondents was highest for women (24.8%, n=1231), the risk group (24%, n=739) and the target group (22.8%, n=1050), whereas the rate of men who daily drank alcohol was three times as high as that of women.

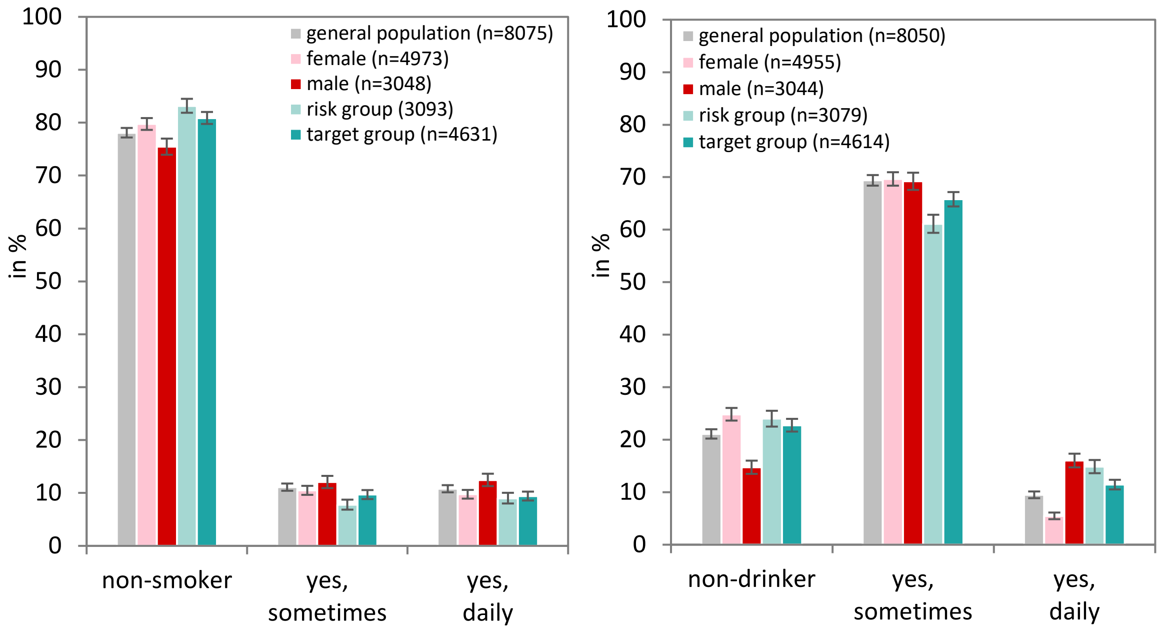


Figure 31 Smoking habits (left) and drinking habits (right) of different population groups
CI 95% (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

8.7 Exposure and close contact environments

Transmission of influenza happens if an infectious person is close to another person. Therefore, it is important to study the various environments where such transmission could take place. The following looks at different modes of transport, various activities as well as the working and living environment.

Transport and activities. Figure 32 gives an overview of the rate of respondents who frequently used (daily or several times a week) various means of transportation and undertook different activities. Most respondents (85.7%, n=6984) indicated being on foot frequently. This might be a result of the pedestrian friendliness of Basel, which was ranked number one of 16 cities in Switzerland (UMVERKEHR ET AL. 2020). A majority of respondents (57.4%, n=4681) used public transport on a regular basis, almost half (43.7%, n=3561) were frequently biking and one in five (22.1%, n=1797) used motorised private transport regularly. Regarding frequently undertaken activities, shopping in supermarkets was very dominant (73.2%, n=5967) among the respondents. This might be because many people are regularly on foot, public transport or bike and cannot carry a whole week's shopping with them, so they might go multiple times a week. Shopping more frequently, rather than just once a week or less, increases the number of contacts with other people and thus the possibility of infection, the same also applies to public transport. Among the activities listed in the questionnaire, going out to restaurants, cafés or bars was most frequently mentioned, with 16.3% (n=1327) doing this daily or several times a week and another 42.8% (n=3484) going out several times a month. These places are also close contact environments where people often spend their time. About a third of respondents go to cultural events several times a month, but cinema and sporting events were only visited rarely or never by most respondents.

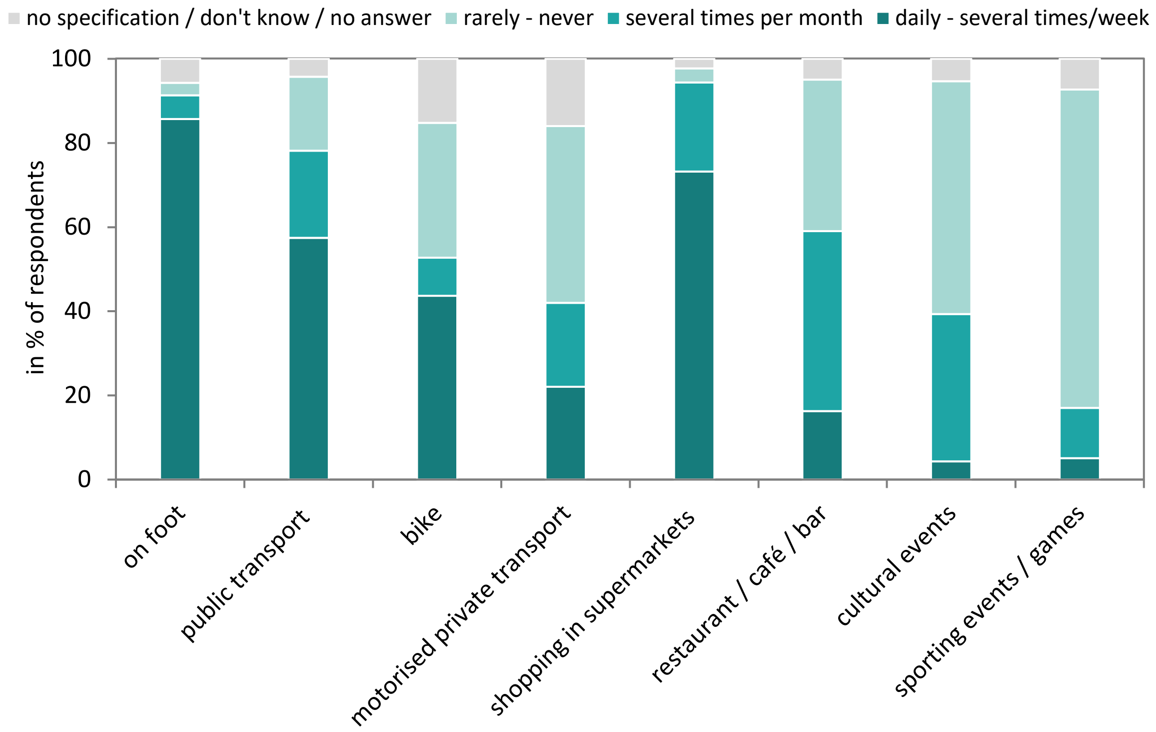


Figure 32 Modes of transport and various activities of the general population
multiple answer (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Work and living environment. During a regular weekday, about one third of respondents (35.1%, n=2859) have contact with 0-10 people and another 45.7% (n=3721) with 11-50 people. These contacts include people from work environment, family, friends, or club/association. A small proportion of respondents (11.4%, n=925) have contact with 51-100 people and a minority (5.2%, n=427) with more than 100 people, presumably at work. This is confirmed by about half of respondents (54.1%, n=4406) who stated having frequent contact with other persons at work. Of those respondents working, 19.7% (n=971) work in the health sector with patient contact, 15.8% (n=778) were working with children and 45.3% (n=2207) in open-plan offices or in rooms with many people. This emphasises the importance of targeting work environments for vaccination campaigns.

Almost half of all respondents (46.9%, n=3819) had visited people in hospital or an old people's home during the influenza season 2015/16. The majority (61.6%, n=2269) of these respondents visited 1-4 times, 20% (n=735) visited more than 5 times and another 18.5% (n=680) visited these institutions on a regular basis. Only very few respondents look after care-dependent family members at home (5.6%, n=455) or live with people who suffer from a chronic disease (7.2%, n=590).

Environmental influences. At home, 28.6% (n=2331) of all respondents indicated feeling exposed to harmful environmental influences, whereby their self-stated answers could be grouped into two main categories. The first deals with influences that affect the respiratory tract such as exhaust fumes, smoke, particulate matter, ozone, etc. which was indicated by 64.9% (n=1512) of those who felt exposed, and the second encompassed general well-being, which was affected by noise, light, electro smog, etc. which was reported by 58.6% (n=1365). But on the quarter level, there are clear differences in levels of perceived exposure to harmful environmental influences (Figure 33). Respondents could indicate if they felt negative influences in their living environment and if so state what kind of influence in a free text answer. These were then grouped into two categories of exposure, one influencing the respiratory tract (e.g. exhaust fumes, smoke, fine dust, ozone, chemicals) and the second influencing general wellbeing (e.g. noise, light, electro smog). Some respondents mentioned multiple exposures that spanned both categories, others did not elaborate on the type of negative exposure, especially respondents living in MA. There was a significant correlation between all types of exposure and residence of the respondents on the quarter level (for all $p<0.001$, Phi/Cramer-V $p<0.001$). It is striking that some quarters which have high levels of reported negative environmental exposures also show above average ILI rates, e.g. Am Ring, Kleinhüningen, Klybeck, Matthäus. However, there was no statistically significant correlation (with Chi^2) between environmental stressors and higher ILI rates. This might be because the number of overall ILI incidents is quite low and therefore not significant.

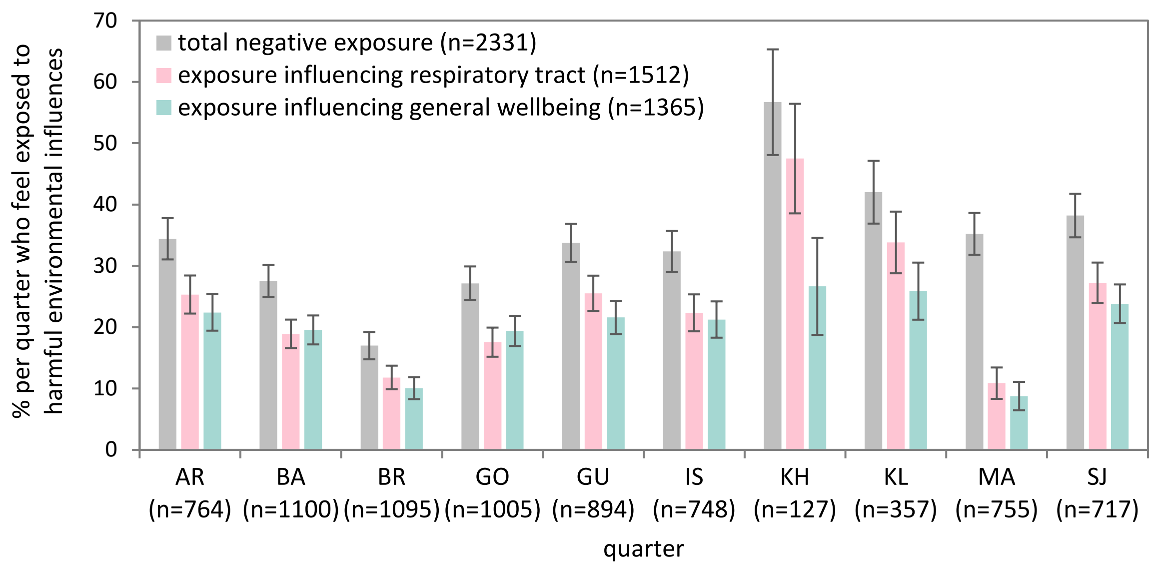


Figure 33 Perceived harmful environmental influences in living environment by quarter
Free text answer, grouped into two categories of exposure (respiratory tract, general wellbeing), 95%CI (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

8.8 Source of information on health issues and perceived helpfulness

Respondents could indicate where they usually attain their health information and choose all relevant sources from an extensive list (Figure 34). On average, respondents indicated four different sources, as calculated by total number of answers divided by all respondents. Most respondents reported that their doctor was the main source for health information, and for the risk group it was even more so. This may not seem that surprising, as they are made up of older individuals and those with chronic illnesses and might require more frequent medical attention compared to the general population. This attests to the significance of physicians as propagators of vaccination messages for the general population as well as the risk and target group. More than half of all groups obtained their health information from their social circle, except for the risk group who less often relied on their peers (48.2%, n=1465). Women on the other hand more often acquired health information from their social circle (64.1%, n= 3159).

Newspapers or magazines are as frequently used as a source of information as the social circle, especially by the risk group (63.0%, n=1915) and the target group (54.2%, n=2815), probably due to their demographic, as the elderly more often use classical media outlets as opposed to digital media. That is probably also why the risk group more often turns to TV for getting health information compared to all other groups. The lower rates of both risk and target groups using official websites and online experience reports as their source for health information also supports the claim of differences in media usage. For almost half the respondents (43.2%, n=3520) pharmacies were also an important source of health information, providing a low-threshold service for health-related questions. Approximately 40% of respondents also got their health information from watching television or looking up official websites. Only a very small proportion of respondents reported not informing themselves (0.8%, n=68).

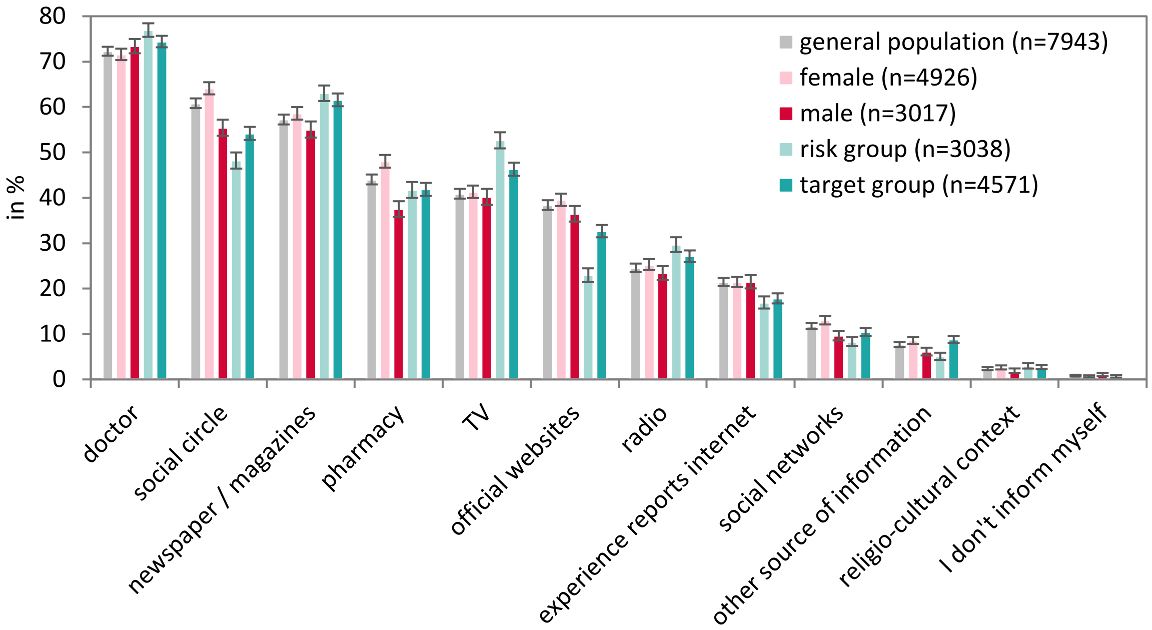


Figure 34 Source of health information for various groups
multiple answer, 95% CI, n=7943 (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Helpfulness of health information sources. Not all sources of health information are regarded as equally useful. The respondents rated the usefulness of the various sources discussed above (Figure 35). Health information provided by a doctor was reported to be helpful or very helpful to most respondents (75.5%, n=6155). The pharmacy was also considered a good information source for the majority (54.1%, n=4405) and highlights the importance of their service. This may have become even more important since 2018, when the pharmacies were allowed to administer influenza vaccinations and provide vaccination counselling in Basel. Interestingly, the social circle and official websites were perceived as almost equally helpful or very helpful regarding health-related questions. Television, radio, experience reports or social media were not considered helpful information sources. Therefore, it might not be worth using these channels to convey health information.

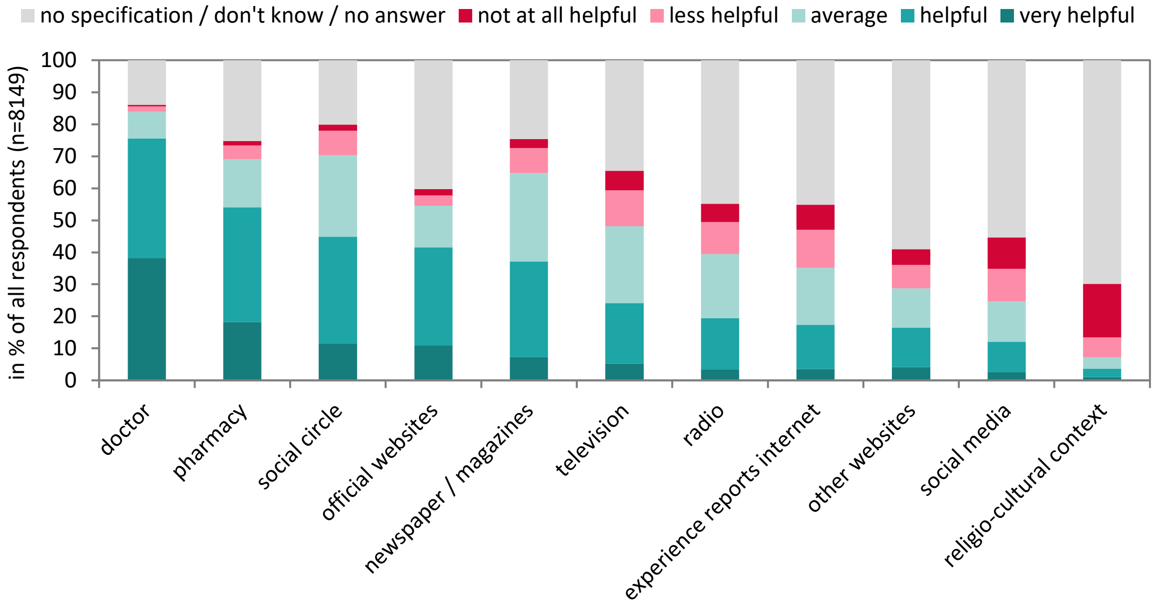


Figure 35 Helpfulness of various health information sources in % of all respondents
n=8149 (source: Human Geography Research Group, Department of Environmental Sciences, University of Basel, Household survey 2016, own visualisation)

Part IV – Discussion and Conclusion

9 Discussion and limitations

This study focused on understanding the spread of influenza and the vaccination behaviour of the general population. This is of special interest to the public health sector as the annual disease burden puts a strain on the health care system, especially during a pandemic like COVID-19. However, public confidence in the vaccine is quite low in Switzerland, hence the low vaccination rates. More specifically the study wanted to analyse the spatial patterns of influenza, ILI, and vaccinated individuals within an urban context, using Basel as an example city, and identify the predictive factors that influence the likelihood of individuals getting an ILI or an influenza vaccination. Further, the study also focused on understanding which factors may determine an individual's propensity to get vaccinated and in what ways and why does the vaccination behaviour of different population groups vary across the study area. The following briefly answers all research questions set out in chapter 1.1, discusses the results considering previous research and addresses the limitations and weaknesses of the study.

9.1 Understanding spatial patterns and individual determinants

The high-volume survey of the general population has enabled an analysis of ILI of the general population and various subgroups on an intra-city level and has helped to understand the spatial variation and individual determinants for ILI and vaccination rates of the general population.

9.1.1 Spatial variation of ILI and influenza across the study area (RQ 1.1)

The vaccination rates of the respondents varied greatly across the study area. Quarters with high population densities and low socio-economic position have the highest rates of ILI, even when correcting for population density. The spatial pattern of quarters with a high burden of influenza infections observed for this study were similar to other seasons as shown by Egli et al. (2020), indicating that the observed pattern in this study recurs every season. The spatial resolution down to the quarter level is unique and can help to tailor campaigns to the small scale. In quarters with higher ILI rates, it is more likely to spread faster within that quarter, e.g. through household transmission. This study showed that two thirds of the ill respondents reported that family members had similar symptoms to themselves. This is consistent with results from other studies which found that families can be a contributing factor in the spread of influenza (ENDO ET AL. 2019; TEO ET AL. 2007).

The study also found that quarters with a high index value of socio-economic position had fewer influenza and ILI cases in comparison to quarters with lower socio-economic position. This could also be observed by Egli et al. (2020) who used their own index for socio-economic position. Other studies have also found that lower socio-economic status could be associated with increased influenza rates (SLOAN ET AL. 2015). The spatio-temporal resolution of the survey data does not allow for an analysis of transmission routes, but one can make estimates of high-risk quarters based on the influenza data from the hospital and ILI data from the household survey. The high-risk quarters might therefore include Matthäus, Klybeck, Gundeldingen as well as parts of Iselin, St. Johann and Am Ring. However, linking socio-economic status on a spatial level with a disease outcome is not new and has been done previously, especially when studying mortality rates (MORRIS ET AL. 1996; TOWNSEND ET AL. 1988; WING ET AL 1992).

Although the spatial analysis was useful to document the differences in ILI rates within the study area, it cannot be determined whether the observed spatial patterns are a result of the physical quarter characteristics or the differences between the residents of those quarters. This idea is taken from Diez-Roux's (2001) observations concerning area-level properties and health outcomes. As it is difficult to attribute the spatial patterns to the physical properties of the quarters, it might be useful to discuss the variability between the quarters with individual and quarter-level factors as described in the next section. But other studies could also show varying influenza incidence across space and attributed these differences to the spatial diversity in the population and individual travel behaviours (MAO, BIAN 2010).

9.1.2 Predictive factors for getting an influenza-like illness (RQ 1.2)

The multivariable model found that individuals who are 65 years or older or have a vaccination are good predictors for not getting an ILI. This might seem a little counter intuitive but may be because the vaccination rate increases with age, whereby respondents above 64 years show higher vaccination rates than those younger. Additionally, the vaccination does provide a good preventative effect, so those who got a vaccination are also less likely to get an ILI, as shown by the multivariable model. This was also shown by Egli et al. (2020), who found that the influenza vaccination rate correlated negatively with the likelihood of getting an ILI, by using the same survey data. Despite this correlation, a reduced rate of ILI among vaccinated respondents should not be used as a measure for vaccine effectiveness. This can only be done when studying patients with PCR-confirmed influenza cases (THOMAS 2014).

The multivariable model also showed that individuals who smoke daily or do not have a large living space ($30m^2$ or less) are more likely to get an ILI. A systematic review by Lawrence et al. (2019) found that cigarette smokers were more likely to develop an ILI and have PCR-confirmed influenza than non-smokers, which matches the results of this study. For those respondents with a small living space, there might be two reasons why it is small. On the one hand respondents might live in a small space on their own or share a larger space with family or friends, thereby decreasing the living space per person. The living space may therefore act as a proxy for crowded living especially in connection with the number of people per household. Some studies found that child-to-parent or child-to-child transmission paths might be the primary source of transmission (ENDO ET AL. 2019; TEO ET AL. 2007). Therefore, the higher the number of individuals in a household the higher the likelihood of getting influenza if a person of the same household is infected. Yet, living with 3 or more people in a household, as opposed to a single or double household, did not turn out as a significant variable in the multivariable model. Egli et al. (2020) used a Poisson regression model to estimate the relative risk for ILI on the same survey data and "found that ≥3 people per household and daily use of public transport were associated with increased relative risks for self-reported influenza-like illness" (EGLI ET AL. 2020:9). The logistic regression model used in this study did not indicate that living with three or more people was a good predictor for getting an ILI. The results of Egli et al. (2020) should not directly be compared to this study, as the relative risk (Egli study) measures the association between respondents with an ILI and the non-vaccinated whereas the odds ratio (this study) gives the likelihood of people who are not vaccinated to get ILI.

9.1.3 Spatial variation of vaccination rates across the study area (RQ 1.3)

Average vaccination rate amongst the general population was quite low and varied considerably within the study area. Quarters with lower population density and a high socio-economic position have the highest rates of vaccinated respondents, even when corrected for population density and vice versa. On average, ILI rates are highest where vaccination rates are lowest, supporting the fact that the vaccination is a good preventative measure. As the vaccination rate increases with age, this study suggests that the observed vaccination pattern across the city reflects the demographic composition of the quarters, i.e. that those quarters with a higher rate of elderly population (≥65 years) also have higher vaccination rates. Despite our dataset having an over representation of over 50-year olds and an underrepresentation of under 30-year olds, spatial distribution of the population proportion ≥65 years reflects that of the official city census (STATISTICAL OFFICE BASEL-CITY 2016). Kleinhüningen is the exception, but as there were not enough returned questionnaires to make it a statistically significant representation of the quarter, one may neglect this quarter.

The vaccination rate of the risk and target group varied by quarter, but the differences were mostly within a 95% confidence interval (RG: Figure 19, p.97; TG: Figure 20, p.98). This translates to varying vaccination potentials across the study area, as measured by the difference between the vaccinated and non-vaccinated individuals in the risk and target group. Generally, more respondents of the target group got a vaccination compared to the risk group. The quarters with the highest potential for increasing the vaccination rates of both the risk and target group are Gundeldingen, Gotthelf and Matthäus. So far, there could not be any studies identified that looked at the small-scale spatial distribution of vaccinated individuals concerning the influenza vaccination.

9.1.4 Predictive factors for getting an influenza vaccination (RQ 1.4)

Decreased vaccination rates. The multivariable model found that individuals with a low monthly household income (≤ CHF 6000.- /household), who smoked daily, took regular physical activity or felt exposed to negative environmental influences were less likely to be vaccinated against influenza. Other studies using regression analysis also found that low income (TAKAYAMA ET AL. 2012, YUE, TARRANT 2014) and smoking was associated with lower vaccination rates (WADA, SMITH 2013), despite smokers having a higher risk of hospitalisation after infection with influenza than non-smokers (HAN ET AL. 2019). Contrary to this study, others have found that regular physical activity was a predictor for increased vaccination uptake (TAKAYAMA ET AL. 2012; TIAN ET AL. 2019). Most quarters in this study whose respondents reported feeling exposed to environmental influences also showed high ILI rates, even if not statistically significant, and quarters with high ILI rates had low vaccination rates. A study from China found that there is likely a strong positive relationship between fine particulate matter ($PM_{2.5}$) and the risk of getting an ILI (FENG ET AL. 2016). Regarding this study, the data also showed that some quarters with high levels of reported negative environmental exposure had above average ILI rates and as established previously, where ILI rates were high, the vaccination rate was low. This might be why perceived environmental exposure was a significant predictor. However, there was no statistically significant correlation (with Chi^2) between environmental stressors and higher ILI rates. This might be because the number of overall ILI incidences is quite low. Concluding, it is probably best not to rely on reported exposure to environmental stressors as a predictor for vaccination uptake.

Increased vaccination rates. On the other hand, the multivariable model found that individuals who were not Swiss nationals, worked in health care, had specific chronic illnesses, living with three or more people in the same household were more likely to be vaccinated. Some of these findings are consistent with other studies estimating associations of socio-economic factors and health-related behaviours with vaccination uptake. For example, studies showed that immigrants (RODRIGUEZ-RIEIRO ET AL. 2011), health care workers (VAUX ET AL. 2011), the chronically ill (BLANK ET AL. 2009; BÖHMER ET AL. 2011B), or households with children (WADA, SMITH 2013) were associated with having higher vaccination uptake. However, data from 2009 in Germany found that health care workers were less frequently vaccinated than the general population (BÖHMER ET AL. 2011B). The fact that gender was only a predictive factor in the univariable analysis but not in the multivariable model has also been observed by others (NAGATA ET AL. 2013). It is a little surprising that age did not appear as a significant determinant in the multivariable model, despite the correlation of age and vaccination status (as shown in Figure 18, p.96) which was also found in other studies (YEUNG ET AL. 2016). In sum, this shows that it is important to know the local context, as vaccination uptake might vary in time and space. However, as this regression only included around 2,000 cases (out of 8,149 total cases) into the analysis, some adjustments were made to increase the reliability of the results.

The improved regression model, excluding variables with more than 10% missing values and using the forced entry model, yielded some additional predictors. On the one hand, working with children, daily smoking, a healthy diet, regular physical activity and feeling exposed to negative environmental influences at home were identified as predictors for **not** getting a vaccination. On the other hand, compulsory education, being ≥65 years, non-Swiss, a working in health care, having a chronic illness, going for regular health check-ups, having children under 7 in the same household, looking after a care dependent person at home or regularly visiting someone in a care home/hospital were identified as predictors for getting a vaccination. These results might be more reliable as almost 5,000 cases were included in the analysis. The different results from both regression analyses indicate that some variables seem to be consistently significant (age, smoking, non-Swiss, regular physical activity, chronic illness, feeling exposed to negative environmental influences) and might therefore be the best overall determinants for getting a vaccination. The overall results from the regression analyses with vaccination as the independent variable might indicate that respondents who engage in a healthy lifestyle (healthy diet, regular physical activity, not smoking) might be less inclined to get vaccinated as they perceive themselves healthy and do not deem the vaccination to be necessary. Those respondents who have lower educational levels or are non-Swiss might have more trust in health care experts, when these suggest having a vaccination. Yet this relationship might need some further investigation.

9.2 Understanding vaccination behaviour

So far there has been no extensive analysis concerning ILI and influenza vaccination behaviour of the general population, as most studies were concerned with a specific population group or used general influenza surveillance methods (as described in chapter 3.3) to understand its spread across the population.

General findings. The survey data reports a general vaccination rate of 25.9%, whereas data from the FOPH (2016B) estimated the vaccination rate of the general population at 13% for the same season. However, the 13% is a Swiss average and Zürcher et al. (2019) also found that living in urban areas was positively associated with vaccination uptake. Therefore, the true difference between the actual and reported vaccination rate might not be that strong. The observed differences might be a consequence of the overrepresentation of elderly respondents and an underrepresentation of younger respondents. Considering gender, the proportion of vaccinated men was slightly higher, compared to the proportion of vaccinated women which is also true in some other European countries, e.g. France, Italy, UK, Spain, Czech Republic, Poland or Portugal (ENDRICH ET AL. 2009). Another study in Germany showed that women had a higher vaccination rate (28.6%) than men (24.2%) (SZUCS ET AL. 2006). As gender was not a significant predictor in this study and the vaccination rates of men and women varied across different countries, it suggests that gender is not a useful predictor for an individual's choice to get vaccinated.

Alternative places of vaccination, besides the medical practice, are especially important for those who vaccinate irregularly. But still, the medical practice was the main place of vaccination for all population groups and across the study area. Uscher-Pines et al. (2014) had very similar findings and suggested that by knowing the vaccination behaviour, interventions can be adapted to either focus on maintenance of desired behaviour or encourage first-time use. A study from the U.S.A. (LEE ET AL. 2009) found that alternative vaccination locations, e.g. workplace or retail stores, may increase the vaccination rate of certain population segments (e.g. young, working individuals in metropolitan areas). Lin et al. (2010) suggest that workplaces should encourage the first-time vaccination by using incentives (education, no cost, easy access), increasing publicity for the service (e-mail as most cost-effective) and give a choice of vaccines (injectable and intranasal) to improve long-term uptake.

9.2.1 Main reasons for and against getting an influenza vaccination (RQ 2.1)

The study could clearly identify that the rate of vaccination is too low, even for the risk group and the target group. In comparison to the general population, their vaccination rates were higher, but still far too low. This begs the question why are people who are exposed to higher risks of complications and those who are in contact with the people at risk reluctant to get the influenza vaccination.

Reasons for vaccination refusal. Access to the vaccination cannot be a defining factor why many people did not get it. Even before the pharmacists were allowed to administer vaccinations, one could get vaccinated in a pharmacy on specific dates, make an appointment with a general practitioner or even get a free vaccination at work. Not every employer offers this service, but a number of respondents indicated that they had got their vaccination at work. Therefore, this study concludes that in Basel, access to the influenza vaccination is not a barrier to vaccination uptake.

It was quite surprising that the reason most often stated for not getting a vaccination was because the respondents felt that they strengthen their immune system sufficiently with alternative means. This response was made regardless of population group (risk group, target group, general population) with a little more women giving this reason. People may know that their lifestyle choices affect their health (LOEF 2012) and adjust their own health behaviour to stay healthy. Many people have also given this reason as they may feel a strong connection to natural medicine, which has a long-standing tradition in Switzerland. For example Alfred Vogel (1902-1996), who was well-known for his naturopathy, a form of alternative medicine, to which he was very committed. His products contributed significantly to the recognition of the special role of herbal medicine in the modern world (VOGEL 2019). This reason for not vaccinating also reflects the work from the SAGE Working Group (2014) which lists individual beliefs and attitudes about health and prevention as a determinant for vaccine hesitancy (chapter 3.5). So maybe there should be an increased focus from the public health authorities and health professionals, that transmittable diseases such as influenza cannot be prevented by such health behaviours and that vaccination is still the most effective prevention method.

The fact that many respondents also did not know why they should get vaccinated might attest to the lack of knowledge of the potential dangers of influenza and how immunisation works (NAGATA ET AL. 2013; YUEN, TARRANT 2014). Mayrhuber et al. (2018) studied laypersons' knowledge on common colds and influenza and concluded that the symptoms of these diseases were well understood, but the risk perception and some other misconceptions were largely based on the individual's personal experience. Knowledge and awareness about the vaccine as well as a social perception that the vaccine is not needed, is also listed as a determinant for vaccine hesitancy by the SAGE Working Group (2014). However, Nyhan and Reifler (2014) found, that even if there are interventions that address myths about the influenza vaccine, it does not increase vaccination uptake. But a 2006 study on influenza vaccination in Germany found that better education regarding the efficacy and tolerability of the vaccine could positively influence the public's motivation to vaccinate (SZUCS ET AL. 2006). These contradictory findings suggest that improving knowledge about influenza and the vaccine, which are barriers to immunisation, are dependent on the context. Therefore, it is important to understand the local context to tailor prevention strategies.

Many respondents also indicated that they did not believe in the effectiveness of the vaccination, indicating a lack of public confidence in it. This has also been observed in other contexts (CDC 2004; NAGATA ET AL. 2013; POLAND 2010) and might contribute to the low vaccination rates of the general population (POLAND 2010). The non-belief in the effectiveness might also be due to a result of lack of knowledge as addressed above.

Another contributing factor to why people do not feel the need to vaccinate, may be because of those who fell ill during the influenza season, most self-medicated and only a small proportion actually sought medical advice from an expert (as shown in chapter 6.2). Since most with an ILI did not see a health professional, this suggests that they do not consider influenza to be severe. And as shown in other studies, those who perceive influenza as a non-severe illness are less likely to be vaccinated (SHARABANI, BENZION 2012).

Reasons for vaccination acceptance. A lot of attention has been directed towards analysing determinants for vaccine hesitancy. But it is also worth considering the reasons why individuals get a vaccination as this might inform the design of vaccination campaigns focusing on a positive message. For all population groups (risk and target group, general population, both genders), the main reason to get vaccinated is to stay flu free. This is not surprising, as it is the purpose of the vaccine. The risk and target group more often stated that the vaccine had been recommended to them by a health professional, compared to the non-risk group or non-target group. This is probably because the risk group is made up of people aged ≥65 years as well as people with a certain chronic disease who, due to their predisposition, may visit a health specialist more often. This increases their exposure to health professionals who may recommend the vaccination. Protecting friends and family from the flu with a vaccination was a priority among the non-risk group and non-target group, but not so much for the risk and target group as they usually get the vaccine for their own personal health. Other studies have shown that those who do get the vaccination, perceive influenza to be a more serious illness than those who did not (SHAHRABANI, BENZION 2012).

9.2.2 Differences in vaccination experience, perceptions of own health and health related behaviours (RQ 2.2)

Vaccination experience. The clear majority of the vaccinated individuals reported having had a good vaccination experience. Additionally, most of those who vaccinated do so regularly. Other studies also showed that individuals with a previous vaccination history were more likely to get vaccinated again (BÖHMER ET AL 2011B; LIN ET AL. 2010) and that recommendations by health professionals for first-time vaccination may increase uptake (SHAHRABANI, BENZION 2012). Therefore, getting individuals to vaccinate a first time might have a long-lasting effect on vaccination uptake of the general population as suggested by this and other studies.

Perception of own health. Most respondents reported good or very good health and only very few (1 in 13 respondents) reported having bad health. This fits the observations from the Swiss Health Observatory (OBSAN) report on the health status of the population of Basel (OBSAN 2014). On average the risk group reported lower levels of health than the target group or the general population. This is not surprising, as the target group consists of those with chronic illnesses and/or those above 64 years old. Concluding, the risk-group reports worse health but gets vaccinated more often than the general population and those who report having good or very good health. A study of 57 countries also found that health status declined over age and that better education was positively associated with higher levels of self-reported health (HOSSEINPOOR ET AL. 2012). However, this study did not find that women reported lower levels of health as Hosseinpoor et al (2012) observed. An explanation might be the good quality of the Swiss health care system and high satisfaction of the population with it (DE PIETRO ET AL. 2015) as well as, in the cantonal comparison, Basel has the highest density of doctors and the second highest density of pharmacies (OBSAN 2014). Additionally, the data from this study only included people living in an urban environment, who consistently report better health than the rural population (HOSSEINPOOR ET AL. 2012).

Perception of preventive measures. On average, regular handwashing, healthy diet and regular physical activity were most often perceived as important preventative measures against influenza. The proportion of the general population who perceived the vaccination to be a good preventative measure was quite low and highlights the importance of communication strategies that propagate the idea that the vaccination is a very effective preventive measure against influenza. This might be because the effectiveness of the influenza vaccine varies, which leads to vaccine hesitancy (WHO 2019A) and reduces public confidence in the vaccine (POLAND 2010). However, the fact that many people perceive regular handwashing as important is quite encouraging. Regular hand washing is also regularly promoted in vaccination campaigns as a way of mitigating transmission (FOPH 2014A).

Implementation of health behaviour. Of all the listed health behaviours, respondents (regardless of group or gender) most often reported regularly washing their hands. This is not very surprising, considering most thought it to be an important preventative measure. Regarding eating healthily, the pattern follows the observations made in the Swiss Health Observatory (OBSAN) report (2014), where the clear majority report having a healthy diet, women more so than men. The respondents within this study even reported slightly higher compliance than observed by OBSAN. Regarding physical activity, the OBSAN reported slightly higher values for the Basler population than this study (4% difference). These variations, although small, might be due to measuring differences and/or time differences. Overall, it seems as if this study could accurately measure the implementation of various health-related habits.

Smoking and drinking behavior. This study observed the highest rate of non-smokers amongst the risk and target group. Men more often reported being daily smokers than women or the risk or target group. The OBSAN reports similar patterns in Basel and Switzerland although they report higher rates for smokers (OBSAN 2014). This might be due to measuring differences or that the rate of casual and daily smokers has dropped between 2012 and 2016. Most respondents, regardless of gender or group, drink alcohol sometimes. On average, the daily consumption of alcohol is very similar to the medium to high risk of unhealthy alcohol consumption as defined by the OBSAN, with the latter reporting slightly lower values (OBSAN 2014). However, this study found that the rate of men who drink daily is three times higher (16%) than women and surprisingly the risk group also shows a similar rate to men. This is significantly higher than observed by OBSAN and might be because they only count medium to high risk of unhealthy alcohol consumption, into which daily alcohol consumption might not necessarily fall.

9.2.3 Procurement of health information and perceived usefulness (RQ 2.3)

Alternative vaccination locations. The Observatoire Valaisan de la Santé conducted a pilot study on administering vaccines in pharmacies. They found that customer satisfaction with the service was very high and most who used the service had vaccinated against flu in the past. The main reasons for getting vaccinated in the pharmacy were not having their own general practitioner as well as the easy accessibility. Most pharmacists were in favour of providing such a service, whereas general practitioners are divided on the relevance of vaccination in pharmacies (OVS 2017). In addition, preliminary results from PharmaSuisse (2017) show that 15% of respondents who got an influenza vaccination in a pharmacy would not have gotten the vaccination if it was not possible in the pharmacy. This highlights the importance of vaccine pharmacies to increase the vaccination rate of the general population. Especially in more rural cantons (FSO 2014), where access to a primary care physician or hospitals can be limited, the pharmacy provides easy and fast basic health care needs. Yet, up until now, it does not seem as if the vaccination rates have increased in Switzerland since the revision of the Medical Profession Act, as vaccination trends over the past 10 years suggest (Figure 11, p.72).

Procurement of health information. SAGE lists "Health system and providers – trust and personal experience" (WHO SAGE 2014:12) as a vaccine hesitancy determinant. This study could show that many respondents found the information provided by a health professional to be useful or very useful, suggesting that there is a trust in the Swiss health care system. It is likely true across Switzerland. A study from Germany also showed that advice from the general practitioner was considered most useful and that people who received vaccination advice from a health professional were more likely to be vaccinated than those who did not (BÖHMER ET AL. 2011B). Another study on pregnant women also showed that most were unaware that an influenza vaccination could be beneficial to their health as an infection with influenza during pregnancy can bring serious complications. Not all health professionals recommend the vaccine to pregnant women, but when they do, the women often comply and agree to the vaccine (YUEN, TARRANT 2014).

Accessibility of health care facilities in the urban quarters. In other regions of the world geographic barriers might pose a determinant to vaccine hesitancy, however, this cannot be said for Basel which is a highly walkable city with pharmacies and medical practices located across the city. This was also confirmed by the OBSAN report which stated that the canton Basel-City had a highly developed healthcare system with the highest density of doctors compared to the rest of Switzerland and the second highest density of pharmacies (OBSAN 2014). These are based on cantonal averages, but within the city of Basel there are still some spatial variations. One exception may be the low density of pharmacies in the quarter Bruderholz, as it is loosely built up which means lower population density (Map 5, p.53) and this reduces the number of potential customers. However, respondents living there still showed higher vaccination rates than in quarters with many more pharmacies, such as Gundeldingen (Map 11, p.102).

9.3 Limitations

The results of this study have some limitations and weaknesses. This chapter will briefly discuss their relative importance in relation to the overall results and show the measures that were taken to address these limitations.

Self-selection bias. The survey data showed some over- and under-representations specifically of certain age categories and gender. It is difficult to eliminate these, as the respondents self-select whether to participate in the questionnaire or not. However, it is assumed that this did not impact the overall results too strongly, as the return rate of the survey was substantially higher than expected, which made it easier to compare results within age categories or gender using proportions and confidence intervals. Yet, this over-representation might have led to an over-estimation of the vaccination rate of the general population, especially as it was shown that the vaccination uptake increased with age (c.f. Figure 18, p.96). In addition, the average vaccination rate over the past ten years was 13.7% (SD 2.5%) with no strong variations over time (c.f. Figure 8, p.37), which is clearly below the vaccination rate for the study population (25.9%, 95%CI 25-26.9%). It is not clear to what extent this is due to the over-representation of the above 50-year olds and under-representation of 30-year olds (and no people under 15). An additional reason might be general geographic variability of vaccination uptake along the rural-urban continuum. The over-representation of the vaccinated population might limit the applicability of the results but as stated previously, the high return rate showed that overall the data is still representative. It is unclear if there would have been significantly different results if more people who did not get an influenza vaccination had participated in the survey. Another self-selection bias occurred regarding the nationality of respondents. Despite best efforts to reduce self-selection based on language abilities, by providing the questionnaire in multiple languages dominant in the specific quarters, there was still an overrepresentation of Swiss nationals.

Self-reporting bias. There is no way to verify any of the questionnaire data. The high return rate might make any false statements by individuals less significant. However, especially concerning the self-reporting of health behaviours, it is known that respondents often respond according to social desirability (VAN DE MORTEL 2008). This may affect the self-reported frequency of health promoting and health-risk behaviours. In addition, opinions on what constitutes regular physical activity or a healthy diet, both items on the questionnaire, are also highly subjective. On the other hand, self-reporting of influenza vaccine status has been shown to be highly sensitive (MANGTANI ET AL. 2007) making this a valid option to assess vaccine uptake of the general population.

As the questionnaire was distributed after the influenza season had passed, it might have also been difficult for some individuals to exactly recall how long they had been ill for and what symptoms they had. Also, some might have experienced false attribution of their health behaviour and their health outcome, e.g. regularly undertook physical activity, therefore did not get influenza. This may have been a contributing factor but is not the only reason why that person did not get influenza.

Sample size for intra-quarter analysis. There were enough returned questionnaires to guarantee a statistically significant representation of each quarter to compare differences between quarters, except for Kleinhüningen. The latter does not have a large population compared to the other quarters and many letterboxes were behind closed doors, limiting the distribution of some questionnaires. This problem was also encountered in other quarters. This might have been a contributing factor to the return rate on the block level, which was highly variable ranging from 0-50 returned questionnaires per block. Therefore, an analysis on the block level to find intra-quarter variations is not viable. The next scale up from the block level is the quarter level, arguably still rather small-scale analysis in an international comparison of city neighbourhoods.

Data quality. The data had to be entered manually and by many students to be able to handle the high volume of returned questionnaires. Naturally, both are known to impact the data quality, as mistakes when entering the data cannot be avoided. Additionally, with pen and paper questionnaires it is easier for respondents to miss out a question, especially when there are multiple pages of questions. To reduce the errors, the students worked in teams and were presented with a guide on how to deal with missing answers as well as an entry mask for the data, so the merging of multiple student datasets into one complete dataset would be possible.

10 Implications, recommendations and conclusion

10.1 Implications based on results

This thesis is based on data from the largest household survey undertaken in a single Swiss city. The results may inform public health policies on how to adapt interventions to a city level, offers considerations for public communication and some ideas regarding general prevention strategies that aim at raising awareness, improving vaccination acceptance, and increasing vaccination uptake. The following implications may be tentative suggestions to specifically address the risk group and target group. Some of these points may have already formed the basis for some prevention campaigns. If so, parts of the following implications are a confirmation of pre-existing strategies. Nonetheless, some of these ideas might be easily integrable to current strategies and can be adapted to other cities in Switzerland or elsewhere.

Interventions on a city level. This study may enable the targeting of vaccination campaigns more effectively towards quarters with high ILI incidence. To reach more non-Swiss nationals, it might be advisable to identify key associations or institutions who are in close contact with the migrant population and try to establish a collaboration for a localised vaccination campaign, e.g. in a neighbourhood centre. Dr. Sylvia Pemmerl, working at a hospital in Regensburg, Germany, initiated a campaign to increase the insufficient vaccination coverage of her fellow colleagues. She uses a small trolley holding relevant vaccination materials, informative brochures and chocolate bars. The different departments in the hospital are then spurred on by prizes awarded to the group with the highest vaccination compliance. This initiative has been in operation for the last three years and has led to a 200% increase in vaccination rates of hospital staff (CARITAS-KRANKENHAUS ST. JOSEF 2019). The general population of Basel but also the vaccination target group, which includes health care workers, all show low vaccination rates. Taking the idea from Dr. Pemmerl, it could be further developed into a mobile vaccination station for the general population. One could focus on quarters which are densely populated and have a high influenza burden, such as Matthäus, Gundeldingen or St. Johann. The mobile vaccination station could offer a free medical check-up with a free flu shot, provided there are no medical exemption reasons. It could run under a campaign: “Free health check-up! Be well prepared for the winter”, or “Be faster than the flu! Get your free vaccination now”. However, upon request of a politician, the federal council of Switzerland stated that they were not willing to bear the costs of an influenza vaccine and stated that for the risk group it will be paid by the health insurance (SWISS PARLIAMENT 2020).

Considerations for public communication. It is essential that communication from public health authorities also consider that laypersons may have different chains of reasoning concerning the effectiveness of preventative measures such as an influenza vaccination. A study from Eicher et al. (2014) also stressed this point and added that everyday beliefs of laypersons should be taken into account. They also noticed a rise in alternative views on the current medical system in Switzerland, which might have led to “the emergence of different kinds of infectious diseases in the last 10 years” (EICHER ET AL. 2014:373). Influenza prevention strategies should address the fact that alternative methods of strengthening the immune system, a varied diet and physical activity are essential for a healthy life, but do not fully protect against an influenza infection. Especially as the alternative strengthening of the immune system was the main reason for respondents not to get vaccinated. This might indicate that not all people are convinced by scientific evidence to get vaccinated (NYHAN, REIFLER 2014). Therefore, using a two-pronged approach might help to increase the purview of the vaccination message. On the one hand conveying the message to touch emotions, such as “protect granny by getting your vaccination, so she can enjoy many more family get togethers / birthdays / see her grand-children grow up etc.”, “protect your friend who suffers from cancer by getting your vaccination” and so on. On the other hand, educating people on how an (influenza) virus infection spreads could have positive effects on vaccine uptake, especially as many in this study did not know why they should get the vaccine or do not believe in its effectiveness. Vaux et al. (2011) even suggested that a generalised campaign targeted at the general population might not be very effective in increasing vaccine uptake. They think that directly targeting the at-risk population might yield better results. Overall, there needs to be a cultural change from vaccination for one’s own benefit to protecting others, especially those of the risk group.

Improving vaccination uptake. A qualitative study on complementary and alternative medicine (CAM) providers showed that they take a different approach when counselling parents on vaccinations for their children. The CAM practitioners focused on their own clinical experience as well as on the parent’s wishes and concerns rather than the public health benefit and consequences (DEML ET AL. 2019). This individualized approach to vaccine counselling is very important, especially as most respondents got vaccinated at a medical practice. However, as the vaccination rate was still very low in the general population it might be worth considering implementing the strategies of CAM practitioners during influenza vaccination consultations of general practitioners and pharmacists (as suggested by DEML ET AL. 2019).

In addition, it might be beneficial to have role models who are committed vaccinators, as these can have a positive effect in the population regarding vaccination uptake. It could be marketed like advertisements with famous (local) people, who collectively act as the many faces for various vaccination campaigns. The “role models” could be adapted to every town and range from locally known politicians, public figures, entrepreneurs, to artists, etc. It might be beneficial if the campaign came from the local health authorities, to counteract any anti-big-pharma conspiracy, saying that they are only in it for the profit. For example, vaccinating political leaders against COVID-19 was a way for the government to convince vaccination sceptics (SWISSINFO 2021). The same might hold up for influenza vaccinations.

It is also important to strengthen health professionals (doctors, pharmacists, etc.) as propagators of vaccination messages for the public, as their recommendations are perceived as helpful by many respondents and were one of the main reasons for getting the vaccination. This indicates a high public confidence in these professionals and is in support of the GRIPS strategy, which also focuses on doctors and pharmacists. The FOPH further proposes that health professionals should systematically remind people in the risk group to get the vaccination (FOPH 2014A:9). It might be worth specifically addressing the target group as they are in close contact with the risk group. To increase the likelihood of the target group getting the vaccination, there should be easy access to vaccination services. Now that pharmacies can administer influenza vaccinations, it might be worth focusing on workplace vaccination programmes, as this is a very convenient way for employees to get vaccinated. It is important to get people to vaccinate who have no previous history of vaccinating, because a previous positive experience with influenza vaccination increases the probability of doing it again, as shown by Shahrabani, Benzion (2012). Reminder systems for health professionals might be a way to additionally improve vaccination uptake as suggested by Böhmer et al. (2011B).

Cost coverage. Currently, the cost for the influenza vaccination is only covered by the health insurance (minus franchise) for the risk group and the company for those who, due to their work, are in contact with the risk group (FOPH 2014A). It is unclear if those for whom the vaccination is free, are aware of this. If not, this should be made more public and health professionals should inform those at risk of influenza, as a study found that providing free influenza vaccinations can have a positive effect on the uptake (JIANG ET AL. 2021). Some institutions offer free flu vaccines to all their employees (ETHZ 2021) and others consult companies on initiating an influenza vaccination day at the workplace (AEH 2021) to reduce the risk of frequent absences due to illness. Thought should also be given to easing access and maybe extending the cost coverage to the vaccination target group, as they show vaccination rates far below the FOPH target rate of 75%. It might also be worth directly addressing companies and offering them a vaccination service at an attractive price. One could then focus on the benefit of fewer sick leave days by employees.

10.2 Recommendations for future large-volume surveys

This study has also given some insights regarding the organisation of a large-volume paper-based survey and how various aspects could be improved in the future. The following lists some considerations for planning a survey with a volume of approximately 30,000 questionnaires in a city context. I would also recommend that this kind of questionnaire is done in a regular time interval. It would be particularly interesting to distribute a follow up questionnaire after a pandemic, where everybody is sensitised to health-related habits concerning pandemic prevention.

Planning. When planning a high-volume survey, it is worth considering how it can be distributed as this might be a limiting factor. Especially if the respondents should be a statistical representation of the general population which usually means that many questionnaires need to be distributed. For high-volume surveys it can be desirable to distribute them with the help of university students within the scope of a methodology course. For researchers who do not have access to students it could be useful to establish a partnership with a university research group working on similar subjects as the intended survey. In return one could offer to teach one methodology course on how to conduct high-volume surveys, data management and exploratory statistics. That way students see the process of obtaining primary quantitative data. This approach can achieve two things in a single action. One, the students get to be part of an actual study and get hands on experience of how to conduct such a study, manage large data sets and some basic statistics. And two, the distribution will be more manageable with many students, and does not cost anything. But be aware that coordinating many students also takes some time and effort and that the survey needs to be ready to go before the course starts. This should be accounted for when designing a time plan.

Costs. The cost of conducting a large-volume paper-based survey is quite substantial, which is why it was funded via a Swiss National Science Foundation grant. It is very strongly advised to seek additional funding to cover all the additional costs above the labour costs of the project team, if they are on a university payroll. These additional costs include:

- Translation service, to increase the reach of the questionnaires
- Printing costs of the questionnaire brochure, mailing envelopes and pre-stamped return envelopes
- External labour costs for packaging of questionnaire brochures into envelopes
- Delivery to the defined locations across the study area
- Postage for the returned questionnaires
- Labour costs for students entering all the data into data management software (if not done within a methodology course)

In total, the costs for such a large paper and pen survey can be up to a multiple of 10,000 Swiss francs. However, the total cost for such a survey might be (significantly) lower in a middle to low-income country setting. If there are not enough financial resources it might be worth considering a Computer Assisted Personal Interview (CAPI) System as done by Wehmeyer (2021) for a low-income context.

Online option. For future high-volume surveys, it might be worth considering including an online option for filling out the questionnaire by means of including a QR code that could be scanned with a mobile phone or tablet or providing a short URL link. This has the added advantage, that the data does not need to be entered manually, and that missing data is less of an issue because for the online version one can set it up to say that all questions are mandatory (but providing an option for “prefer not to say”). This ensures that a respondent cannot forget to answer a question.

Maps in for self-disclosed location. If one wants to include a geographic location of the respondents, it is worth including a map at the end of the questionnaire so respondents can locate their place of residence. This presupposes that the included map is adapted to the scale one wants to study. If the block level is of interest, one should provide the map on the quarter/neighbourhood scale including the blocks one wants to use for the analysis. This makes it easier when georeferencing the survey data later, as the respondents can be directly assigned to a block. However, one should not assume that everyone can identify their own address just based on a few street names in their quarter. To make the map as accessible as possible it should include all the street names and different colours for the residential blocks, so that people cannot mistake a park for a block if the map is quite abstract.

Logistics. To start the whole distribution process, it is advisable to identify local partners in each quarter where the pallet full of questionnaires could be delivered to. The place should be shielded from weather exposure but accessible to those who are distributing the questionnaires. If there are students at hand (through a methodology course) it is essential that they have a map of the quarter they are distributing the questionnaires in with highlighted streets along which they will be distributing. If there are multiple groups of students per quarter they should each have clearly assigned roads to eliminate any double distribution of questionnaires. Also make sure to include the distribution key for every quarter, e.g. every household, every second household etc.

10.3 Conclusion

This study filled many gaps in estimations of ILI in the general population as well as vaccination behaviour on a city scale. It has also offered a broad understanding of the geographic variation of ILI and vaccinated individuals in urban quarters of Basel, Switzerland, and found predictors for both ILI and vaccination. It was shown that both ILI and vaccination rates were highly variable even on the quarter scale. The study also analysed the vaccination behaviour of different population groups, to understand why people do or do not get an influenza vaccine. The differences between the population subgroups are not as pronounced as originally assumed.

This study could show that despite the annual influenza vaccination campaigns and easy access to the vaccination, the overall self-reported vaccination uptake for seasonal influenza was significantly below the vaccination target rate set out by the FOPH. The risk group showed the highest vaccination rates but there is still great potential to increase this. The low vaccination rates are not evidence for lack of access to information. Pharmacies for example, put up notices reminding the passers-by that the flu season has started, the media often reports on this issue and official information is very easy to find, provided that a person has access to the internet. Therefore, this study suggests that low vaccination rates are related to individuals' behaviour.

Alternative vaccination locations seem to be especially important for those without a general practitioner and for those who have never had an influenza vaccination. But still, the medical practice was the main place of vaccination across the study area and remains the most important vaccination location. Health professionals are essential as propagators for vaccinations and they are a reliable and trusted source for health-related information for the general population.

There seems to be a problem in translating the empirical evidence to actions on the ground. The findings of this study provide the basis for developing tailored public health strategies, which target specific urban quarters by strengthening and enhancing vaccination recommendations.

Even though more needs to be done to understand what makes people accept and use the vaccination service, one should not postpone action, especially if there is a solid starting point. This is especially true for the current COVID-19 pandemic, where knowledge is incomplete, yet inaction could cost more lives and livelihoods than necessary.

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Data sources

Base map data. Bau und Verkehrsdepartement des Kantons Basel-Stadt, Grundbuch und Vermessungsamt, Fachstelle für Geoinformatik.

Block level data on green space and built up area. Statistisches Amt des Kantons Basel-Stadt. Person of contact: Dr. Björn Lietzke

Census data of Basel. Statistical Office Basel-City. Data use agreement.

Data from vaccination pharmacies in Basel. PharmaSuisse, Department of Pharmaceutical Sciences (Uni Basel). Data use agreement. Person of contact: Dr. Samuel Alemman

Tax year 2014 (for income data). Tax Administration Basel-City; Statistical Office Basel-City; 18.01.2017. Data use agreement.

Influenza data. University Hospital Basel. Person of contact: Prof. Adrian Egli

Survey data. Human Geography research group, Department of Environmental Sciences, University of Basel. Survey, April 2016.

Swiss-SEP index 2.0. Institute for Social and Preventative Medicine (2019): Data of the "Neighbourhood Index of Socio–Economic Position for Switzerland" (Swiss-SEP), University of Bern, Swiss National Cohort (SNC). Data use agreement. Person of contact: Dr. Claudia Berlin

Type of land cover. Bau- und Verkehrsdepartement des Kantons Basel-Stadt (2016): Geoportal. Bodenbedeckung. URL: https://map.geo.bs.ch/?lang=de&baselayer_ref=Grundkarte%20farbig [9.9.2019]

Appendix

Questionnaire

March/April 2016

Questionnaire on Influenza in the City of Basel

Dear Sir / Madam,

Within the scope of the **interdisciplinary research project on influenza in the city of Basel**, we are conducting **a survey in selected quarters of Basel**. Its aim is to gather information, if the people questioned had **influenza or the common cold** during the winter season 2015/16, if they were **vaccinated or not**, which **preventive health measures** are implemented in general, how **information on health** is procured, how the **accessibility of medical services** is assessed and which **aspects of city environment** play a role on influenza.

The questionnaire has been approved by the ethics committee of both Basel's. The participation in the survey (approx. 15 min) is voluntary and your anonymity will be ensured. We ask you to return this brochure with the completed questionnaire until 1st May 2016 with the postage-paid envelope. Please only fill in one questionnaire per household / flat share.

Participating persons can partake in a lottery, see end of questionnaire. There is no right of appeal. The signatories issue the information.

Thank you for your contribution.

Prof. Dr. Rita Schneider-Sliwa
Departement Umweltwissenschaften
Geographie/Stadt- und
Regionalforschung, Klingelbergstr. 27,
4056 Basel
E-Mail:rita.schneider-sliwa@unibas.ch

Prof. Dr. Tanja Stadler
Dept. Biosystems Sciences and
Engineering, ETH Zürich
Computational Evolution and Institute of
Integrative Biology
BSA M754, Mattenstrasse 26, 4058 Basel
E-Mail: tanja.stadler@bsse.ethz.ch

PD Dr. Dr. Adrian Egli
Universitätsspital Basel, Klinische
Mikrobiologie und
Dept. Biomedizin, Universität Basel
Petersgraben 4, 4031 Basel
E-Mail: adrian.egli@usb.ch

Prof. Dr. Manuel Battegay
Universitätsspital Basel,
Klinik für Infektiologie & Spitalhygiene,
Petersgraben 4, 4031 Basel
E-Mail: manuel.battegay@usb.ch

Universität Basel | Departement Umweltwissenschaften U|W Humangeographie Stadt- und Regionalforschung | Universitätsspital Basel | Departement Biomedizin Basel | ETH Zürich

Questionnaire on Influenza in the City of Basel

Within the scope of the **research project on influenza in the city of Basel**, we are conducting a **survey in selected quarters of Basel**.

The participation in the survey takes approximately 15 minutes and is voluntary. **Your anonymity will be ensured**. We ask you to return this brochure with the completed questionnaire until 1st May 2016 with the postage-paid envelope.

Participants can partake in a lottery (**Apple Laptop worth CHF 2500.- and two "Pro Innerstadt"-coupons each worth CHF 500.-**). See end of questionnaire. Many thanks for your participation.

A. Influenza and common cold

A.1. Did you suffer from a strong cold this winter?
☐1 no *(if no, please continue with question A6)* ☐2 yes, multiple times ☐3 yes, once
If **yes**, during which month(s): ________________
If **yes**, how many days did it considerably impact your day-to-day life? __________

A.2. Which grievances did you have? (*multiple answers possible*)
☐1 temperature (over 38 degrees) ☐3 muscle and rheumatic pains ☐5 cough ☐7 sore throat ☐9 runny nose
☐2 diarrhoea ☐4 strong fatigue ☐6 headache ☐8 strong sense of illness

A.3. Has anyone else in your proximity been suffering from the same grievances (influenza/cold) and fallen ill?
☐1 no ☐2 yes ☐3 don´t know
If **yes**, people (*multiple answers possible*):
☐1 in the family ☐2 at work ☐3 in the neighbourhood ☐4 in the circle of friends ☐5 in the "Verein" (club)

A.4. Did you contact an expert regarding the cold symptoms?
☐1 no ☐2 yes
If **yes**, where?
☐1 medical practice ☐2 hospital ☐3 pharmacy ☐4 other, namely: ________________

A.5. Did you take medication to cure of the cold?
☐1 no ☐2 yes
If **yes**, did you receive Tamiflu?
☐1 yes ☐2 no

A.6. Did you get vaccinated in autumn/winter 2015/16 against Influenza?
☐1 no ☐2 yes
If **yes**, where: ☐1 medical practice ☐2 pharmacy ☐3 hospital ☐4 other, namely: ______
If yes, during which month? ________________

If **no**: Why did you not get a vaccination? (please mark all relevant points)
☐1 I don´t know why I should get vaccinated.
☐2 I wanted to, but then I ended up not doing it.
☐3 I don´t believe in the effect of the vaccination.
☐4 A real flu strengthens my immune system and the protection lasts longer.
☐5 It´s too expensive for me.
☐6 I strengthen my immune system with other means.
☐7 Friends/family have had negative experiences with it.
☐8 I´m afraid of the side effects.
☐9 I find needles unpleasant.
☐10 The vaccination was not recommended to me by experts (doctor/pharmacist).
☐11 other reason, namely: ________________

If **yes**: Why did you get vaccinated? (please mark all relevant points)
☐1 I don´t want to get influenza.
☐2 I don´t want to be missing at work.
☐3 I have friends/family who I want to protect from influenza.
☐4 The vaccination was recommended to me by family/friends.
☐5 The vaccination was recommended to me at work.
☐6 The vaccination was recommended to me by experts (doctor/pharmacist) .
☐7 other reason, namely: ________________

MA

A.7. If you got vaccinated against influenza this year, state your experiences on a scale of 1 (very negative) to 10 (very positive):

☐1 1 ☐2 2 ☐3 3 ☐4 4 ☐5 5 ☐6 6 ☐7 7 ☐8 8 ☐9 9 ☐10 10

very negative very positive

If **positive** experiences, which: ______________________________

If **negative** experiences, which: ______________________________

A.8. Do you get vaccinated against influenza on a regular basis?

☐1 no ☐2 yes

If **yes**, since how many years: ________

A.9. In the past, have you refused other vaccinations which were recommended to you or your children by a doctor?

☐1 no, never ☐2 yes, but only certain vaccinations ☐3 yes, all vaccinations

A.10. How do you evaluate your general state of health on a scale from 1 (very negative) to 10 (very positive)?

☐1 1 ☐2 2 ☐3 3 ☐4 4 ☐5 5 ☐6 6 ☐7 7 ☐8 8 ☐9 9 ☐10 10

very negative very positive

A.11. Do you have a general practitioner?

☐1 no ☐2 yes

A.12. Do you have any chronic diseases due to which you have to take drugs on a daily basis (since at least 6 months)?

☐1 no ☐2 yes

If **yes**, which drugs: ______________________________

A.13. Do you smoke?

☐1 no ☐2 yes, sometimes ☐3 yes, daily (number of packets per day): ________ ☐4 not specified

A.14. Do you drink alcohol?

☐1 no ☐2 yes, sometimes ☐3 yes, daily ☐4 not specified

A.15. How important do you regard the following measures to prevent influenza?

	important	rather important	neutral	rather unimportant	unimportant	don´t know	no specification
Vaccinating	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Washing hands	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Health check-up at the doctor	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Healthy diet	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Regular physical activity	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Other	☐1	☐2	☐3	☐4	☐5	☐6	☐7

other, namely: ______________________________

A.16. How good do you implement the following measures into your day-to-day life?

	very good	good	average	bad	very bad	don´t know	no specification
Vaccinating	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Washing hands	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Health check-up at the doctor	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Healthy diet	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Regular physical activity	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Other	☐1	☐2	☐3	☐4	☐5	☐6	☐7

MA

B. Aspects of city environment

B.1. How often do you use the following means of transport?

	daily	several times per week	several times per month	rarely	never	don´t know	no specification
Car, motor cycle, motor scooter	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Public transport (bus, tram, train)	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Bike	☐1	☐2	☐3	☐4	☐5	☐6	☐7
On foot	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Other	☐1	☐2	☐3	☐4	☐5	☐6	☐7

other, namely: ____________________

B.2. How often do you undertake in the following activities?

	daily	several times per week	several times per month	rarely	never	don´t know	no specification
Shopping in supermarkets (Coop, Migros, etc.)	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Cinema	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Restaurant/ café/ bar	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Cultural events	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Sporting events / games	☐1	☐2	☐3	☐4	☐5	☐6	☐7

B.3. Approximately, with how many people do you have contact on a regular work day (work environment, family, friends, clubs)?
☐1 0-10 ☐2 10-50 ☐3 50-100 ☐4 more than 100

B.4. If you are working, do you have contact with other people?
☐1 no ☐2 yes ☐3 no specification

B.5. Do you work in the health sector with contact to patients (medical personnel or nurse)?
☐1 no ☐2 yes ☐3 no specification

B.6. Do you work with children (kindergarten, play group, day care, school etc.)?
☐1 no ☐2 yes ☐3 no specification

B.7. Is your workplace in an open-plan office or in a room with many people?
☐1 no ☐2 yes ☐3 no specification

B.8. Do you feel exposed to damaging environmental influences in your living environment? (e.g. emissions, fine dust, electric smog, noise etc.)
☐1 no ☐2 yes ☐3 no specification
If yes, which: ____________________

B.9. Have you visited people in hospital or an old people´s home this autumn/winter 2015/16?
☐1 no ☐2 yes
If yes, how often:
☐1 1-4 times ☐2 more than 5 times ☐3 I regularly visit people in healthcare facilities.

B.10. Do you regularly look after care-dependent family members at home?
☐1 no ☐2 yes

B.11. Do you live with people who suffer from a chronic disease?
☐1 no ☐2 yes

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C. Procurement of Information on Health Questions

C.1. From where do you procure your information on health questions? (*multiple answers possible*)

☐1 doctor
☐2 pharmacy
☐3 social circle (friends, acquaintances, family etc.)
☐4 religio-cultural context
☐5 other source of information,
namely:_______________________________

☐6 TV
☐7 radio
☐8 newspaper and magazines
☐9 social networks
☐10 internet, namely:
☐11 from experience reports of other people
☐12 from official websites (Federal Office of Public Health, hospital)
☐13 from other sites: _______________________________

☐14 I don´t inform myself.

C.2. How helpful do you find the information offered?

	very helpful	helpful	average	less helpful	not at all helpful	don´t know	no specification
Doctor	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Pharmacy	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Social circle (friends, acquaintances, family etc.)	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Religio-cultural context	☐1	☐2	☐3	☐4	☐5	☐6	☐7
TV	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Radio	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Newspaper and magazines	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Social networks	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Experience reports of other people on the internet	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Official websites on the internet	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Other websites on the internet	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Other sources of information	☐1	☐2	☐3	☐4	☐5	☐6	☐7

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D. Personal Data

D.1. Gender
☐1 male ☐2 female

D.2. Year of birth:
____

D.3. Nationality
☐1 Swiss ☐2 other nationality: _________________________ ☐3 no specification

D.4. How long have you been living at your current location?
☐1 up to 1 year ☐3 more than 2 to 5 years ☐5 more than 10 to 15 years ☐7 no specification
☐2 more than 1 to 2 years ☐4 more than 5 to 10 years ☐6 more than 15 years

D.5. Please look at the map of your quarter on the last page. In which segment do you live? Please state the coordinates (a combination of a letter and a number on the horizontal respectively vertical axis).
Segment:________________

D.6. Residential status of the household you are living in:
☐1 owner-occupied flat ☐3 rental apartment ☐5 co-operative flat ☐7 other:____________
☐2 owner-occupied house ☐4 rental house ☐6 old people´s home ☐8 no specification
Number of square metres of the apartment/house: ______________

D.7. How many people live in your household / flat share including yourself?
______ people

D.8. How many children live in your household?

	0	1	2	3	More than 3
Children under 7 years old	☐1	☐2	☐3	☐4	☐5
Children over 7 years old	☐1	☐2	☐3	☐4	☐5

D.9. If you have children under 7 years old, are they being looked after externally together with other children?
☐1 no ☐2 yes

D.10. What is the structure of your household?
☐1 one-person household ☐3 (married) couple with child ☐5 single parent with child ☐7 no specification
☐2 flat share ☐4 (married) couple without child ☐6 other:_________

D.11. Where have you attained your educational qualification?
☐1 compulsory school
☐2 vocational education / -training, trade school
☐3 gymnasium
☐4 higher vocational education (commercial college, higher professional school, foreman, technician)
☐5 institution of higher education (ETH, university, college, teacher training college)
☐6 other school qualification ___________
☐7 no specification

D.12. Are you currently employed? (*multiple answers possible*)
☐1 full-time (min. 90%) ☐3 pupil/apprentice/student ☐5 pensioner ☐7 voluntary work
☐2 part-time/side job (<90%) ☐4 housewife/househusband ☐6 currently not employed ☐8 no specification

D.13. If you are employed, what position do you hold?
☐1 employee with management function ☐2 employee without management function ☐3 self-employed

D.14. Category of income (monthly gross household income)
☐1 up to CHF 2000 ☐3 4001-6000 CHF ☐5 8001-10'000 CHF ☐7 > 15'000 CHF
☐2 2001-4000 CHF ☐4 6001-8000 CHF ☐6 10'001-15'000 CHF ☐8 no specification

D.15. Where do you work? (place and postcode): ____________________________________

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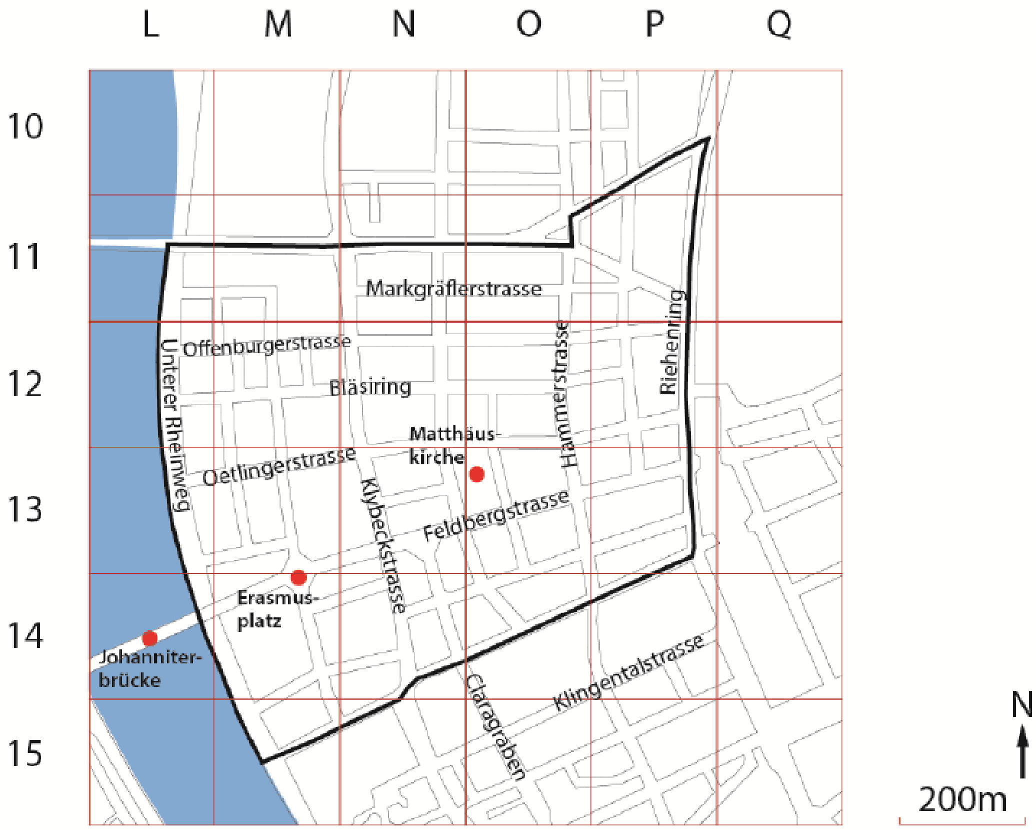
Map for question D5
Please look at the map of your quarter and mark the approximate location of your residence. Please state the coordinates (a combination of a letter and a number on the horizontal respectively vertical axis).

Example (right)
You live at the corner of Bläsiring / Müllheimerstrasse.
Answer: N12



Thank you for your participation.

If you would like to participate in the lottery for an Apple computer worth CHF 2500.- and two "Pro Innerstadt"-coupons each worth CHF 500.-, you can leave your name and address here: