

Coronavirus ping pong between pigs and humans: is an infection reverting back from infected pigs conceivable?

The Corona Triangle Part II: Technical Report

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Introduction

Within the last three months, the international press has reported several cases of slaughterhouse workers infected with COVID-19. According to the news, many of these slaughterhouses seem to be some sort of super-spreading hot spot.

Three countries - the United States, Germany and Brazil - drew the attention of the authors, because of their own nationalities and/or because of the representation that these countries have in the world's production and export of pork. These countries will therefore be the focus of this report.

In terms of the ranking in world pig production¹, China ranks first, followed by the United States and the European Union with Brazil coming fourth. Amongst EU countries, Germany ranks first and slaughters 23% of the EU total of pigs². In these three countries of focus, there has been a considerable amount of complaint involving cases of slaughterhouse workers in precarious working conditions who have contracted the disease.

In Germany, for example, the case of the Tönnies slaughterhouse near Gütersloh in North Rhine Westphalia, became well known. With more than 650 persons diagnosed with COVID-19 by 17 June 2020, a new outbreak hotspot was reported, and caused protests amongst employees³. By 22 June 2020, more than 1,500 cases were confirmed positive out of 6,650 persons tested⁴.

In Brazil, the Public Ministry of Labor investigated 206 complaints involving contamination by COVID-19 of slaughterhouse workers up to 1 July 2020^{5/6}. This type of

¹ <https://www.statista.com/statistics/263964/number-of-pigs-in-selected-countries/>

² <https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20170919-1>

³ https://www.spiegel.de/wirtschaft/unternehmen/coronavirus-bei-fleischfabrik-toennies-nicht-fuer-die-pandemie-gebaut-a-be17ffc1-b4e3-4c16-aaa6-65d03344c475?sara_acid=soci_upd_KsBF0AFjflf0DZCxpPYDCQgO1dEMph

⁴ <https://www.zeit.de/wirtschaft/unternehmen/2020-06/toennies-corona-ausbruch-guetersloh-lockdown-armin-laschet>

⁵ <https://g1.globo.com/economia/agronegocios/noticia/2020/07/06/mpt-apura-206-denuncias-e-tem-114-inqueritos-abertos-por-casos-de-covid-19-entre-funcionarios-de-frigorificos.ghtml>

⁶ https://content.govdelivery.com/attachments/MIEOG/2020/07/09/file_attachments/1492329/EO%2020-145%20Emerg%20order%20-%20Workplace%20safeguards%20-%20re-issue.pdf

contamination of workers and, obviously, of their family members too, has even been interpreted as one of the vectors of the pandemic's interiorisation in the country⁷.

In the United States, the Michigan state governor issued a security order requiring slaughterhouses to adopt a protection protocol for their employees⁸. The governor, in issuing the document, stated that slaughterhouses had proved to be an entry point for COVID-19 infections in other states⁹.

In our previous discussion article¹⁰, we elaborated the hypothesis - not yet proven - that COVID-19 infections may occur not only through transmission from person to person, or by viruses dispersed by human saliva particles and/or present in faeces, but also through infected pigs. At the end, we posed the questions: "Would pigs contract COVID-19, carry the virus and in turn infect us?" and, "Could we, if infected with SARS-CoV-2, pass on the virus to pigs?"

There is, as yet, no conclusive answer to these questions - it would require extensive animal testing and interdisciplinary studies on the ground. However, in the previous discussion article, we could show a spatial correlation between areas of intensive pig farming on the one hand and on the other hand, overlapping areas with a high population rate infected with COVID-19 in spite of low human population density. We found this salient spatial correlation using the example of the state of Santa Catarina, in southern Brazil, which is responsible for more than 60% of pork production in the country. In this current report, we have expanded our analysis of spatial correlation to the United States, Germany and the entire southern region of Brazil.

Meat industry: What is involved in mass pig husbandry and slaughtering?

Meat industries worldwide, and particularly those in the three countries analysed here, have been denounced as amplifying hotspots of COVID-19 infections. Before we get to COVID-19 infections however, we would like to discuss three basic questions of current mass animal husbandry, particularly in pork meat production.

1. How are these animals fed? Feed is basically produced from grains such as soybeans and corn. For every kilogram of pork produced, three kilograms of cereals are needed¹¹; these cereals are mostly transgenic, produced largely in Latin America. The resulting

⁷ <https://g1.globo.com/bemestar/coronavirus/noticia/2020/07/02/coronavirus-cresce-mais-rapido-no-centro-oeste-que-na-media-do-pais.ghtml>

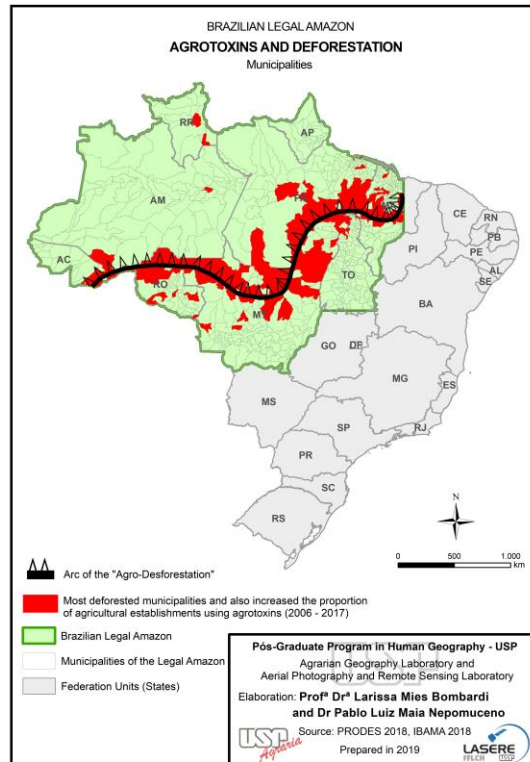
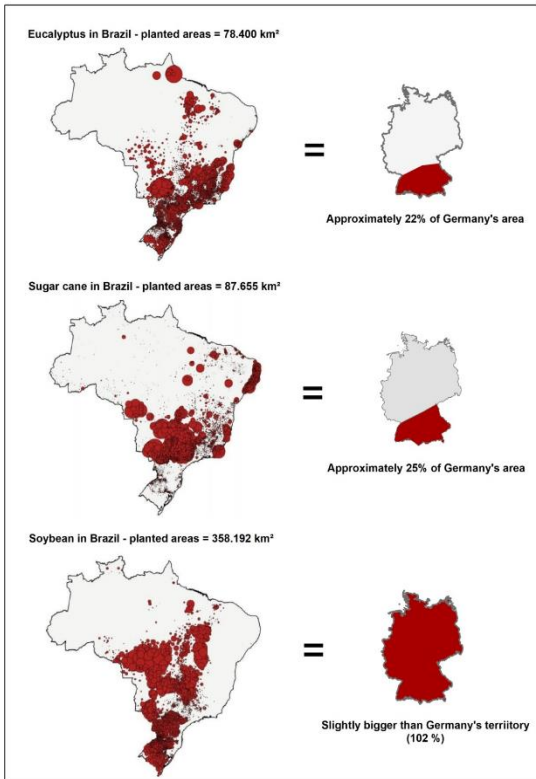
⁸ https://content.govdelivery.com/attachments/MIEOG/2020/07/09/file_attachments/1492329/EO%202020-145%20Emerg%20order%20-%20Workplace%20safeguards%20-%20re-issue.pdf

⁹ <https://www.msn.com/en-us/finance/companies/whitmer-signs-order-outlining-safety-guidelines-for-meat-processing-plants/ar-BB16y1XU>

¹⁰ https://www.researchgate.net/publication/341525356_Hypothesising_on_the_emergence_of_SARS-CoV-2_through_bats_Its_relation_to_intensive_pig-factory_farming_and_the_agro-industrial_complex

¹¹ NEGRÃO, S. L. *Uma análise do ciclo de produção agroindustrial de suínos e aves, à luz da ética global*. Tese. Programa Interdisciplinar de Ciências Humanas. UFSC. Florianópolis, Brasil, 2008.

intensive grain production in Brazil involves serious environmental and social problems: (1) deforestation of the Amazon rainforest, (2) the intensive use of pesticides in feed production, and (3) an impact on the country's food security due to the reduction of areas destined to direct crop production for humans. To give the reader an idea of the extent of soybean production in Brazil today, the area occupied with soybean cultivation is equivalent to the entire territory of Germany (Map 1) accompanied by a devastating effect on deforestation (Map 2).



Map 1: Comparison of the eucalyptus, sugar cane and soybean areas in Brazil with the territory of Germany

Map 2: Advance of deforestation and pesticide use in the Amazon rainforest

2. How are these animals raised? The conditions of husbandry, particularly for chickens and pigs, are rather inappropriate to the species: there is no space for them to move, they do not have access to the soil nor to any sunlight. As such, animals feed, defecate and sleep practically in the same place. To avoid the spread of disease and the exacerbation of disease symptoms, it is quite common to include antibiotics and other drugs into their diets¹².

¹² https://www.researchgate.net/publication/341525356_Hypothesising_on_the_emergence_of_SARS-CoV-2_through_bats_Its_relation_to_intensive_pig-factory_farming_and_the_agro-industrial_complex

3. How are these animals slaughtered? The slaughtering of these animals and the work in the slaughterhouses causes both animals and humans a lot of distress. In all three of the countries under discussion here, complaints from workers subjected to poor working conditions grow daily¹³: such complaints include the agglomeration of workers in their work environment, degrading housing conditions, long working hours, very low wages and lack of overtime pay. In addition, the majority of workers are migrant labourers: in the case of the US, these are mostly Latin American migrants¹⁴ and, in the case of Germany, migrants from Eastern Europe, especially from Romania¹⁵.

These precarious working conditions, combined with despicable animal husbandry, is most probably a root cause of the spread of infection in these regions and, often, of new outbreaks, as was the case in Germany.

In the previous article, we already discussed the hypothesis that such animals – pigs – may themselves be vectors of this infection. Pigs have numerous similarities with humans, ranging from the gastro-intestinal system to genetic ones. The immunodepressed condition in which these animals live, makes them a great vessel for the development of infections (swine fever, African fever, etc.) thus also potentially becoming a ‘focus’ for viral adaptation and mutation.

Spatial correlation between COVID-19 and pork production

For the three countries in question, the USA, Germany and Brazil, the maps that we present below indicate a salient spatial correlation between the areas with a large presence of mass pig husbandry and/or slaughterhouses and those in which there is a high rate of population infected by COVID-19.

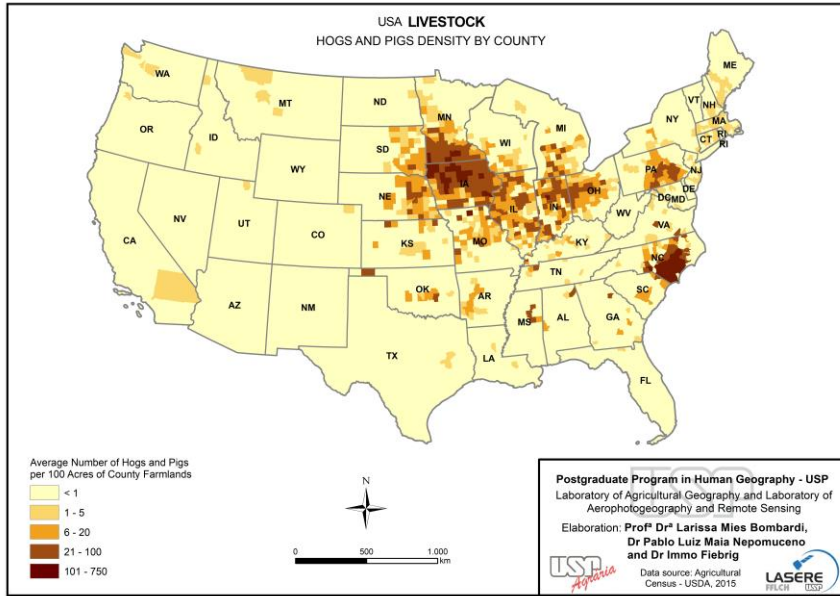
USA

It can be noted in Map 3 that the highest density of pigs in the United States has a fairly clear core in the midwest region, encompassing the states of Minnesota, Iowa (centre of this pig-producing region), Nebraska, Illinois, Missouri, Indiana and Ohio. There is also an important concentration of pig farming in the states of Pennsylvania and North Carolina.

¹³ <https://g1.globo.com/economia/agronegocios/noticia/2020/07/06/mpt-apura-206-denuncias-e-tem-114-inqueritos-abertos-por-casos-de-covid-19-entre-funcionarios-de-frigorificos.ghtml>

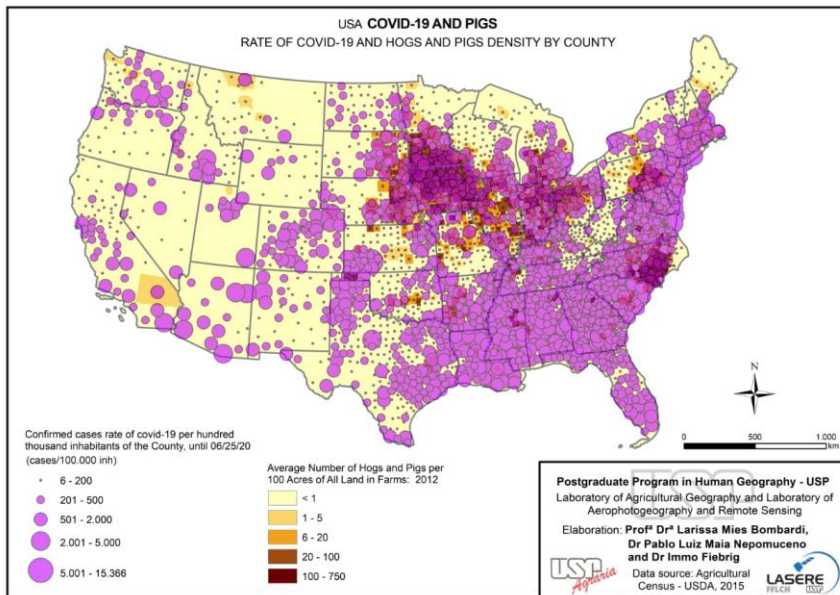
¹⁴ <https://www.reuters.com/article/us-health-coronavirus-usa-meat/confirmed-coronavirus-cases-surge-in-reopened-jbs-colorado-beef-plant-worker-dies-union-idUSKBN22C3VR>

¹⁵ https://www.spiegel.de/wirtschaft/unternehmen/deutsche-fleischfabriken-in-der-corona-krise-schlachtbank-europas-a-bc67c942-27ce-4668-8908-ecde4af86619?sara_ecid=soci_upd_KsBF0AFjflf0DZCxpPYDCQgO1dEMph



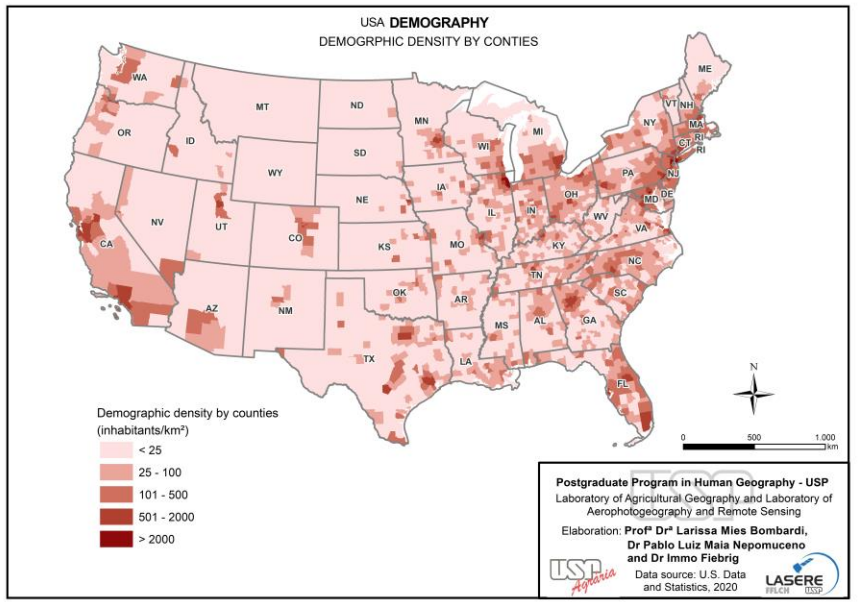
Map 3: USA and pig farming - average number of hogs and pigs per 100 acres of county farmlands

On Map 4 presented below, we have used the previous map as a basis and overlaid the data of the COVID-19-infected population rate up to 26 June 2020.



Map 4: USA - overlay of total of COVID-19 infections until 26/06/2020 on pig farming densities

One can also appreciate that the states located in the east and southeast regions are the ones that also stand out most in relation to high rates of infected population, which, in a way, is obvious and to be expected due to the high demographic density in these areas, since the infection is known to spread through interpersonal contact.

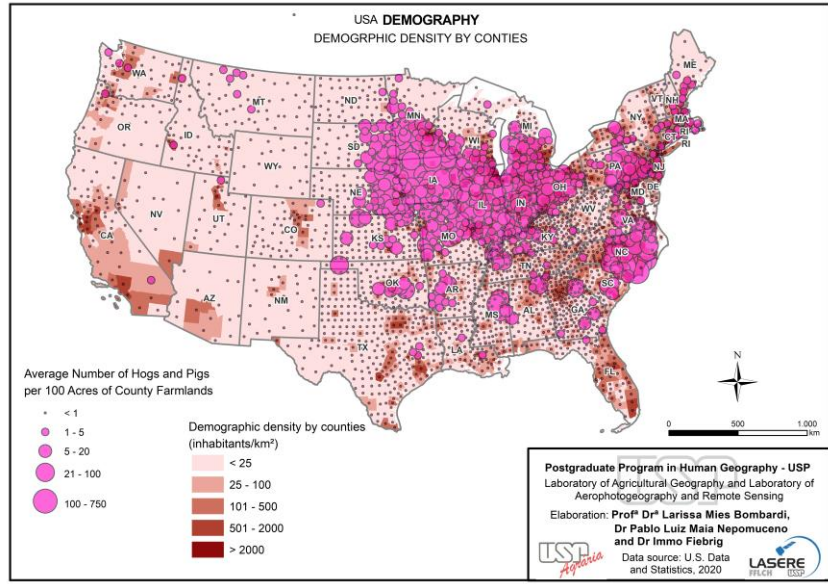


Map 5: USA - demographic density

It can be noted by comparing maps 4 and 5 that most areas with high population rates of COVID-19 correspond to those with high demographic density and/or are contiguous to them, notably, in the northeast and southeast portions of the country. Interestingly, however, there is another hotspot with high rates of COVID-19 which corresponds exactly to areas with intensive pig rearing.

We point out that the states of the midwest region, and more importantly, the areas (municipalities) of these states with intense pig production are also the areas in which there are high rates of confirmed COVID-19 cases.

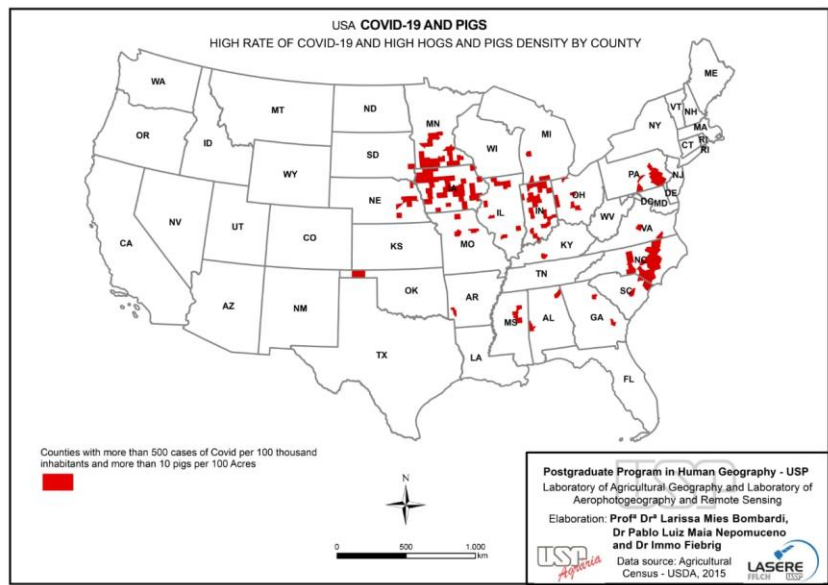
Besides that, as we can conversely appreciate on Map 6 below, those areas in the US with the highest demographic density are not the same areas with the highest number of pigs.



Map 6: USA - demographic density and pig density

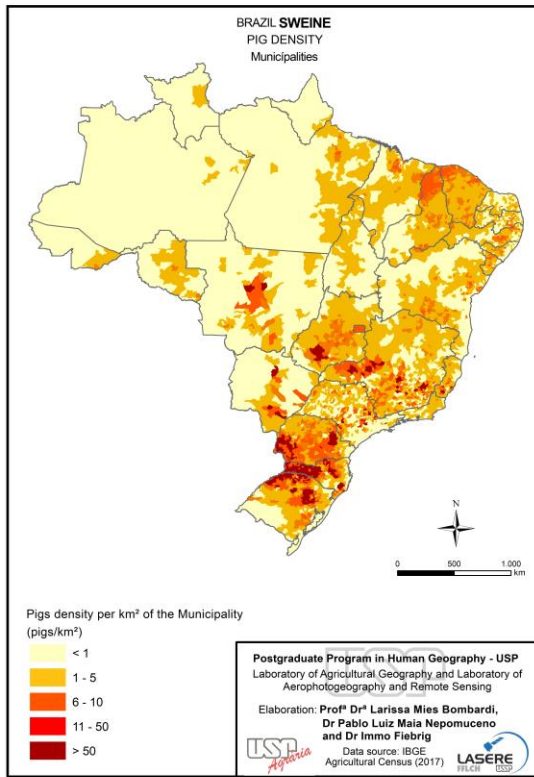
Note that in the midwest region, which concentrates intensive pig production, the population density is not high. And yet, there is a high rate of population infected by COVID-19, as shown in Map 4.

After selecting the municipalities with more than 500 cases of people infected with COVID-19 per 100,000 inhabitants and also those counties with more than 10 pigs per 100 agricultural acres, the corresponding synthesis mapping (Map 7) shows a notable convergence.

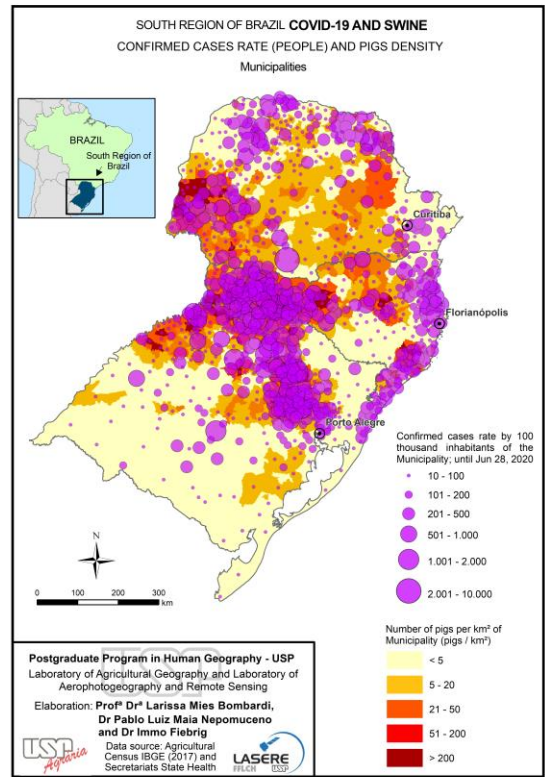


Map 7: USA - the synthesis mapping joins areas with high infection rates and high pig density, highlighting the affected municipalities in red

Brazil



Map 8: Brazil - pig farming

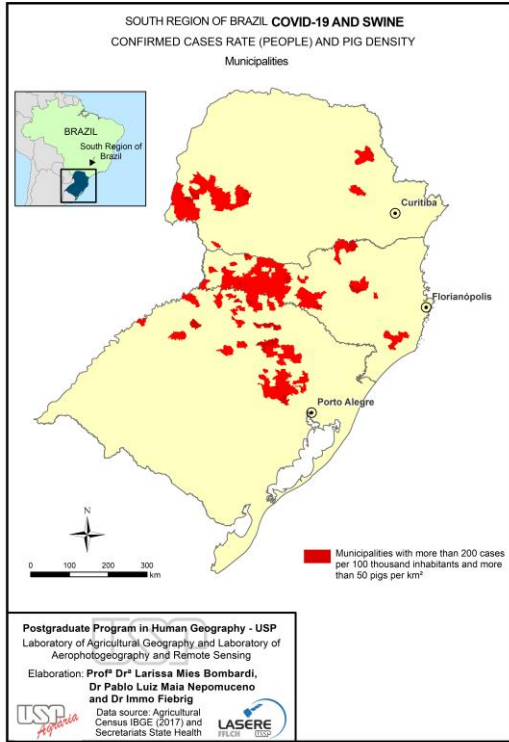


Map 9: Brazil - southern region, pig farming and COVID-19 infections

With regard to Brazil, we observe an analogous situation. More than 70% of its pig production is located in the southern states. We chose to zoom in on this region and focus our analysis directly on it.

As in the United States, in Brazil, the spatial correlation can be noted between areas with pig farming and those with high rates of population infected by COVID-19. And as in the United States, the coastal region of the country has higher population density, thus the highest rates of infected population were to be expected. However, in the western portion of the Brazilian states that make up the southern region - notably northwest of Rio Grande do Sul, west of Santa Catarina and west of Paraná - this spatial convergence between a large density of pigs and a high rate of infected population is salient.

By synthesising these two pieces of information (municipalities with the highest rates of population infected by COVID-19 and those with the highest densities of pigs per hectare), we obtain Map 10 below.



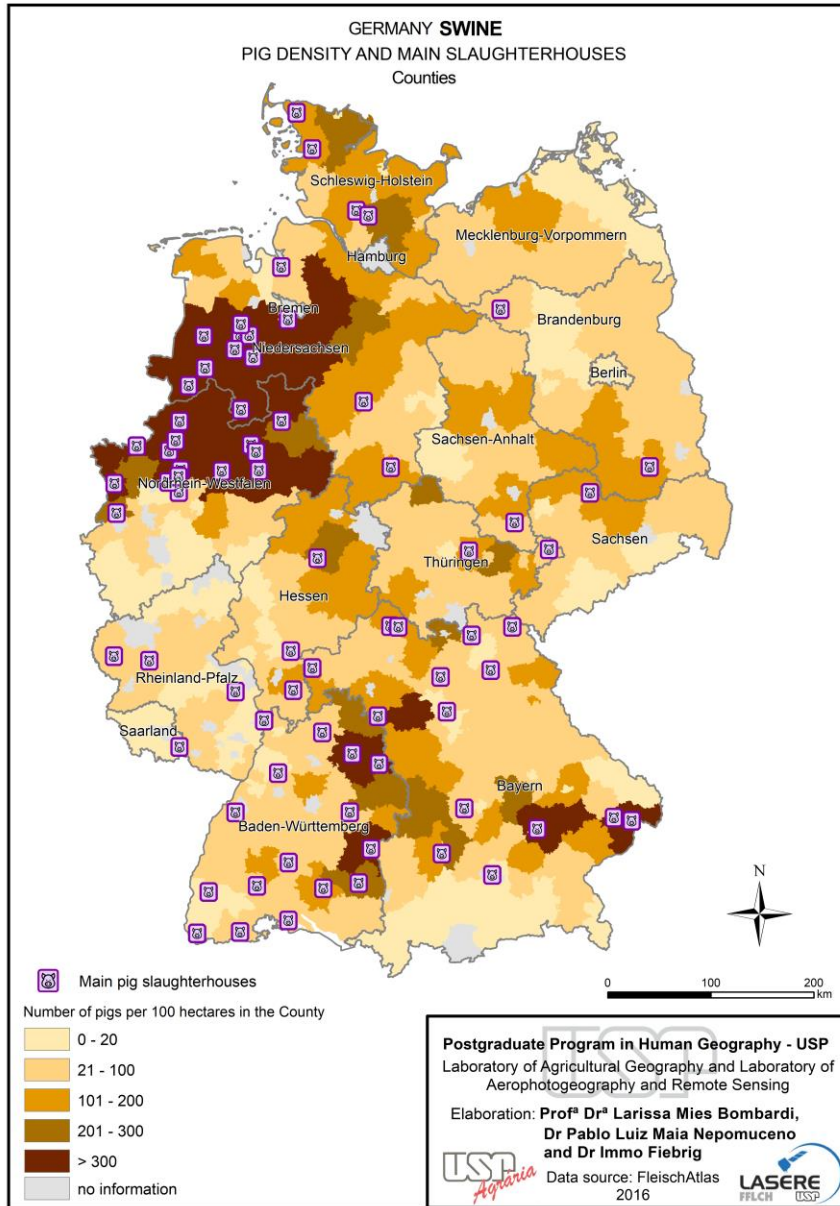
Map 10: Southern region - synthesis map with relevant municipalities highlighted in red

Map 10 summarises the information displayed on the previous Map 9 with noticeable spatial correlation between pig breeding and the dissemination of COVID-19.

Germany

The concentration of pig farming and slaughterhouses in Germany takes place in the northwest portion of the country (Nordrhein-Westfalen, Niedersachsen), as can be appreciated on Map 11.

For Germany, we obtained data on the location of the slaughterhouses, which allowed us to add this fundamental element to Map 11 and therefore we can conduct a more qualified analysis. Essentially, we selected from around 3,800 enterprises with a slaughtering authorisation and removed all those that were assumed to be too small to be relevant, that is family farms, local butchers, non-chain hotels and any enterprise that was not a limited company (GmbH) but a sole trader enterprise. In case of doubt, the website of each enterprise was consulted to judge whether or not it was a small family firm, with the result that fewer than 100 companies were left (16 for Nordrhein-Westfalen alone and 66 for the rest of Germany).

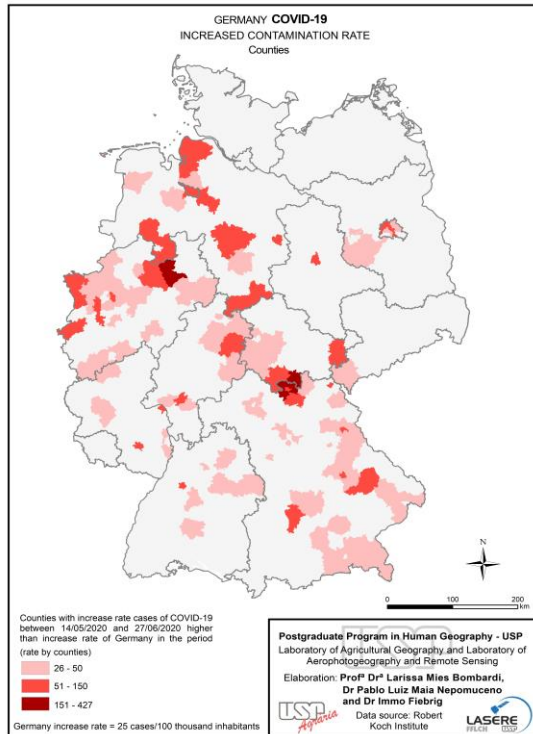


Map 11: Germany - pig farming and slaughterhouses

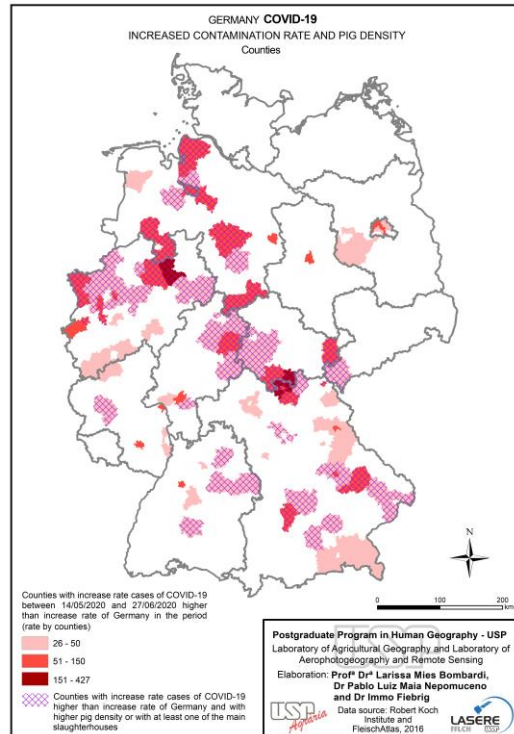
Unlike in the US and Brazil where the municipalities with the highest pig production are not those with high population density, in Germany, there is a convergence between the areas with high concentration of pork husbandry and/or slaughterhouses and areas with higher population density.

Thus, in order to verify whether or not there is also a correlation between the spread of COVID-19 amongst humans and pig farming activities, we chose to set a time frame, mapping the data of the infected population rate only in the period between 14 May 2020 and 17 June 2020, that corresponds to the emergence of a second focal outbreak within a general decrease of COVID-19 infections.

In addition, in this case we chose to carry out a statistical exercise that would give us the certainty that we were dealing indeed with a second focal outbreak: we identified the rate of increase in the number of cases in this period for the whole of Germany and from there, we defined the average of this rate within the 14 May to 17 June timeframe. We then selected to represent spatially only those municipalities that presented a value higher than the calculated average rate of increase. The results are shown in Maps 12 and 13.



Map 12: Municipalities (Landkreise) that have presented a value of COVID-19 higher than the calculated average rate of increase



Map 13: Municipalities (Landkreise) that have presented a value of COVID-19 higher than the calculated average rate of increase and where the main slaughterhouses and/or the higher pig density (checkered areas) are located

On these maps, it can be noted that there is a salient overlap between the increase in cases of COVID-19 infection and the presence of pig and/or slaughterhouses. We also chose to highlight the municipalities that, in addition to having high rates of infection, are adjacent to those in which there are slaughterhouses and/or intensive pig rearing, because we take into account the factor of displacement of workers human between the municipality of residence and the municipality of work.

Discussion

For the three countries, the population rate infected by COVID-19 was used, that is the percentage of the infected population. This means that regardless of whether a municipality has 100,000 or one million inhabitants, it is possible to establish a comparison between them regarding infections. We are showing through mapping of the three countries that the regions with high densities of pig husbandry and/or slaughterhouses overlap with high rates of people infected with COVID-19.

Although the major axes of contamination in the USA and Brazil are those in which there is greater population density (east coast of these two countries), it is notable that the second major focus is on the areas in which there is a prevalence of intensive pig farming and the so-called meat industry.

The methodology used for the case of Germany allowed us to sharpen the mapping correlation between these elements, since only the areas where there was an increase in the number of cases of infected people were focused on and it is important to note that the increase of COVID-19 occurred after the pandemic situation was apparently 'controlled'. However, the maps cannot prove causality - they only indicate a problem as a result of the apparent spatial correlation.

In Brazil, factors such as lack of sewage collection and treatment explain why there are high rates of infection in the northern regions, especially in the northeast region, yet in the southern region of Brazil, the one with the highest HDI (Human Development Index) rates, this large number of infected people is not to be expected. However, the total spatial overlap between these COVID-19 foci and pork production in the country is quite striking. The same phenomenon is observed in the United States.

Scandals involving the working conditions in slaughterhouses in the three countries mapped in this report have filled the pages of newspapers around the world in recent weeks. Slaughterhouse employees have become vectors of pandemic expansion whether in Germany, the USA or Brazil. The meat industry may have become an important vector of COVID-19 infections, whether by the inhumane way in which the production process is carried out for workers in this sector or by way of adverse animal husbandry standards.

It is noted, therefore, that precariousness and socio-environmental impacts prevail throughout this production chain: from the production of the grains that feed these animals (transgenic and with a high load of pesticides), through the industrialised and technologised form of this animal husbandry model and finally to the degradation of human labour.

Conclusions

To us, these mappings seem sufficient to raise concern about the meat manufacture chain from feed production, the conditions of rearing animals and the working conditions in the slaughterhouses. Further studies and monitoring of the possible risk of transmission of SARS-CoV-2 to pigs under intensive animal husbandry and back to humans, possibly from pig faeces, should be undertaken in order to safeguard human health globally.

In summary, by means of human geography mappings as the method chosen here, we are observing a salient overlap between COVID-19 in humans and the pork industry in three major corona-affected countries. It is a 'view through our *macroscope*' that indicates a correlation - but is unable to prove causality. Instead, it would in any case be the duty and responsibility of virologists, epidemiologists or veterinarians to investigate causality by 'taking a look through their *microscope*' - to assess possible risks from industrial meat production. •

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