CHAPTER 4.
HEALTH-IMPACTING BEHAVIORS AT THE HOUSEHOLD LEVEL, AND THE INTERSECTION OF HOUSING AND HEALTH AND WELLBEING.

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Introduction

Previous chapters of this Report have analyzed household morbidity patterns and relative access to medical treatment across the four communities, with a particular focus rural pueblos and comparisons to a *colonia popular* in Atlixco. In addition, and all too rare in health studies in Mexico, we have sought to better understand issues of mental health and perceptions of community wellbeing among residents. In this section we turn to a more detailed analysis of how the physical structure of the dwelling environment intersects with health outcomes, wellbeing and, sometimes, presents particular risks. We examine the use of the lot as part of the agricultural production process; household cooking and food preparation practices; adequacy of water and electricity provision; and household organization and the use of rooms and patio spaces. In the first chapter Table 1, we showed that it is common for lots to have two or more families sharing the lot and living space either as "compound" arrangements (in which two or more close kin related households live in separate dwelling/spaces).[1] More common are extended household arrangements (parents, adult children, and grandparents), parents, adult children, etc.).[2] Nuclear families are also common especially in the more established communities such as Santa Ana and Flores Magón, but even here compound and extended arrangements are commonplace. Singleton households are very rare, although as we discuss later in this chapter we selected one such case for intensive case study, in large part because the owner was severely disabled.[3]

Our discussion below examines responses to the survey,[4] complemented by data from focus groups that broke out from concerns expressed by members of the community themselves, or were health related issues that the team identified as worthy of further study.[5] In a similar vein we used an intensive case study methodology that had been developed earlier as part of the Latin American Housing Network (www.lahn.utexas.org) and which had been applied in Mexico as well as in Texas low income *colonias (*Ward et al. 2015). These intensive case studies involved the team working on site for several hours measuring rooms, taking photographs and recording videos, conversations with household individual members, with the goal of examining the links between the physical structure and specific health and mobility challenges faced by households in these agricultural pueblos. Five intensive cases were purposively selected to

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[1] An example is provided in Appendix 4: Case Studies #1 & 2 San Fco. Xochiteopan where households share the lot in separate dwellings: 1) Nuclear family of parents and children and 2) the nuclear family of the eldest son. But both households share the "kitchen" and often eat together.

[2] Appendix 4: Case # 2

[3] Appendix 4: Case # 4

[4] See Appendix # Sections, **

[5] These explored nutrition and food security; cooking practices and the use of starter fuels (plastic bottles); and concerns about dogs running loose in one particular community (Santa Ana Coatepec).

explore health challenges presented by: 1) hazardous air quality in homes and kitchens; 2) mobility impediments and risks of accidents associated with self-help building structures and lot organization; 3) health risks associated with living in very close proximity to farm animals (goats; chickens, cows, etc.; 4) disease and poor health linked to dirt floors, flimsy housing structures, pests, etc.; and 5), the utilization of new dwelling units that had been provided to households who lost their homes in the 2017 earthquakes.[6]

Behavioral Household Practices

We begin by first exploring household behaviors within the dwelling environment which may shape health and wellbeing: nutrition and food security; cooking practices; access to potable and other sources of water for drinking and other household uses.

Nutritional Intake and Relative Food Security

A significant minority (17% - Table 4.1) had experienced food insecurity in the past year and reported to having had to skip meals or tighten their belts. Our focus group discussion (https://lahn.utexas.org/Puebla/App5.html) underscored the basic diet: "beans and tortillas". What else Dr. Ward asked? "More beans and tortillas" (laughter...). In the poorer pueblos (Agrarista and Xochiteopan) meat or fish figured in meals once or twice a week at best, and invariably would be chicken. Consumption of fruit and vegetables were also somewhat irregular, but in the two pueblos for which we have data, around 28% did report eating both vegetables and fruit either daily or 4-5 times a week. That said, the focus group suggested that it was usually not quite that frequent – at least once a week – and that access to fruit and vegetables was better in the rainy seasons (July – October) when squash, *alaches/queletes*[7] etc. are most plentiful. Those with greenhouses are able to grow year-round and irrigate (see Intensive Case # 2 Figure 4.4 below – Francisca's greenhouse https://lahn.utexas.org/Puebla/Appendix4/Case2a.pdf). There have been attempts through school to teach healthy eating, participants in the focus group mentioned that kids get slapped down if they remonstrate with their parents (focus group- https://lahn.utexas.org/Puebla/App5.html). Agricultural workers are paid on Saturdays so the following day they go to the market and buy cheese, milk, fruit etc. Sundays is also the day when they will buy tortillas rather than make them at home, and also prepare foodstuffs – *pico de gallo* etc. However, in the planting season even Sundays are considered a workday.

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6 All (and each) of the detailed plans and lot hazards documentation referred to in this chapter are included in https://lahn.utexas.org/Puebla/App4.html

[7] These are high protein plants which grow wild and are gathered and added to the diet when available. We observed *alaches* when we returned in October

Table 4.1. Household Cooking and Nutritional Behaviors, Perceptions and Measures of Water and Air Quality

Pueblos and Sites	San Fco. Xochiteopan	Colonia Agrarista	Santa Ana Coatepec	Colonia Flores Magón
Family Nutrition Behaviors				
Have rationed food in last 12 months	17.3% (14)	19% (10)	15% (9)	8.7% (4)
Drink sodas (sugary drinks): daily or 4-5 * a wk.	13.6% (11)	22.6% (13)	30% (30)	30.4% (14)
Rarely eat cookies and chips	58% (47)	67% (37)	54% (34)	37% (17)
Eat meat once or twice a week at the most	ND	38% (21)	66% (40)	43.5% (20)
Sources of Cooking Fuel (may use				
Leña % who use	97.5% (79) *	87.3% (48) *	78.35 (47)	19.6% (9)
Carbon % who use	76.5% (62)	78.2% (43)	73.3% (44)	26.1% (12)
Gas tanks propane % who use	34.6% (28)	43.6% (24)	76.7% (46) *	98% (45) *
* = principal				
Drinking water - household usage always or very frequently				
Tap (llave) maybe via tank	82.7% (67)	60% (33)	60% (36)	98% (45)
Pozo (well)			49% (29)	9% (4)
Tap & Bottled (purified)		3.6% (2)	43% (26)	76% (35)
Don't know or don't believe that tap water is chlorinated	17.5% (14)	47% (37)	1.6% (1)	4% (2)
Regularly boil water before drinking	14.81 (12)	30.91 (17)	40 (24)	50 (23)
Strongly agree that water needs to be improved (Q142-1)	43.21 (35)	54.55 (30)	58.33 (35)	69.57 (32)
Mean chlorine concentration (ppm)	0.0307	0.0393	0.1151	0.1461
Air Quality in the Home and Community				
Very satisfied air quality in home (145-1)	79.01 (64)	74.55 (41)	73.33 (44)	76.09 (35)
Yet also believe that are significant problems of air quality in the home 145-3	49.38 (40)	36.36 (20)	30 (18)	45.65 (21)
Very satisfied air quality in the community	64.2 (52)	72.73 (40)	56.67 (34)	30.43 (14)
Air Quality in Kitchen				
Mean CO2 concentration (ppm)	792.48 (Moderate)	760.71 (Moderate)	812.44 (Moderate)	987.91 (Moderate)
Mean PM2.5 concentration (ppm)	44.58 (Unhealthy for SensitiveGroups)	70.91 (Unhealthy)	38.14 (Unhealthy for Sensitive Groups)	12.68 (Moderate)
Mean PM10 concentration (ppm)	58.75 (Moderate)	87.97 (Moderate)	48.36 (Good)	16.5 (Good)
Measures of Air Quality PM 2.5; Pm10; and CO2				
Poor levels of PM2.5 (N)	66.7% (9)	57.14% (42)	71.3% (42)	54.55% (33)
Unhealthy levels of PM 2.5 (N)	33.30%	2.38%	2.38%	3.03%
Hazardous Levels of PM2.5 (n)	0%	7.14%	2.38%	0%
Poor levels of PM10 (N)	33.30%	5% (40)	2.38%	3.03%
Unhealthy levels of PM 10 (N)	0%	0%	0%	0%
Hazardous Levels of PM10 (n)	0%	7.50%	2.38%	3.03%
Poor levels of CO2 (N)	33.3% (33)	50% (42)	40.48% (42)	54.55% (33)
Unhealthy levels of CO2 (N)	7.69%	0%	14.29%	15.50%
Hazardous levels of CO2 (N)	0%	0%	2.38%	0%

Source: Household Survey

In the focus groups it was argued that the use of fats and cooking oils for soups, potatoes, refried beans etc., were limited because of cost, but Paty mentioned afterwards that in her view they are not as costly as *refrescos*, and that people overused fats and oil in food preparation. However, we were not able to measure this in the survey. Given the high rates of chronic illnesses such as diabetes and obesity we were especially interested in exploring the consumption of sugary drinks and high calorie snacks such as cookies, potato chips etc. Table 4.1 shows that a significant minority of the population drink sodas (mostly coca cola) daily or several days a week, and while many participants in the focus groups professed to like sodas, they were largely constrained by cost (especially in Agrarista and San Fco. Xochiteopan).

Significantly, people are well aware of the links between sodas and diabetes but they said they liked it so much. It is something of a status symbol, and one focus group member said that if her husband did not provide coca cola his *peon*, then the latter would refuse to work for him. Another woman whom we interviewed in Flores Magón had diabetes (as did several of her adult siblings), but they all blithely drink coke regularly – much, she said, to the dismay of her doctor! The cost and lower availability appears to constrain households in the pueblos especially from eating unhealthy store snacks with between half and 67% rarely buying such "treats". In both pueblos cost remains the major constraint, but as pressures or the capacity to purchase sugary sodas (especially) rises (as it might), campaigns to reduce intake or go with sugar free sodas will be important. But our data show that lack of awareness is not the issue. Upon our return to the communities in October we described the health problems related to sugary drinks and described anti-soda campaigns in Chile and Mexico.[8] The reaction was one of interest and some shock/surprise, but our sense was that little behavioral changes should be anticipated.

In sum, baseline poverty is closely related to relative nutritional poverty (especially in the two more rural communities) and this clearly relates to poor health (diabetes and hypertension, etc., although the lower intake of sugary drinks and the physical exercise of agricultural activities (especially for men) almost certainly mitigates obesity levels in those two communities. Poor nutritional practices (sugar drinks and snacks) in better-off communities such as Santa Ana and Flores Magón almost certainly exacerbates the primary diseases that we found.

[8] Specifically, the poster: "Would you give 12 cuchardas of sugar to your kids?" www.actuaporsalud.org

Table 4.2. Dwelling Structures and Problems

Pueblos and Sites	San Fco. Xochiteopan	Colonia Agrarista	Santa Ana Coatepec	Colonia Flores Magón
Lot size Trimmed mean (5%)	1015m2 (37)	2377m2 (26)	917m2	566m2 (22)
Dwelling Number of Rooms Excluding Kitchen and Bathroom				
One or two	53% (43)	46% (25)	35% (21)	33% (15)
Four or more	16% (13)	27% (15)	30% (18)	28% (13)
Most Cited Problems in Specific Rooms and Spaces (Top 3)				
Kitchen Response Rate	1. humidity/ goteras 16.05% (13) 2. smoke 14% (11) 3. plague/pests 7.41% (6)	1. humidity/ goteras 20% (11) 2. smoke 9.09% (5) 3. plague/pests 3.64% (2)	1. humidity/ goteras 11.66% (7) 2. plague/pests 6.67% (4)	1.plague/pests 21.74 (10) 2. humidity/ goteras 15.22 (7) 3. smoke 4.35 (2)
Bathroom	1. humidity/ goteras 8.64% (7) 2. smoke 1.23 (1)	1. humidity/goteras 3.64% (2) 2. NA	1. humidity/goteras 8.33% (5) 2. plague/pests 1.67% (1)	1. humidity/ goteras 4.35% (2) 2. plague/pests 4.35 (2)
Bedrooms Principal Problems	1. humidity/ goteras 38.25% (31) 2. plague/ pests 6.17% (5) 3. smoke 1.23% (1)	1. humidity/goteras 47.28% (29) 2. plague/pests 25.45% (14) 3. smoke 9.09% (5)	1. humidity/ goteras 33.34% (20) 2. plague/pests 8.33% (5) 3. NA	1. humidity/ goteras 34.79 (16) 2. plague/pests 19.57 (9) 3. NA
Living Area	1. humidity/ goteras 7.41% (6) 2. plague/pests 2.47% (2)	1. humidity/ goteras 20 (11) 2. plague/pests 3.64 (2)	1. humidity/ goteras 10 (6) 2. plague/pests 1.67 (1)	1. humidity/ goteras 17.39 (8) 2. plague/pests 10.87 (5)
Households that store fertilizers or fungicides in the home.	40.3% (25)	43% (23)	37% (22)	NA
Stored in almacen / dedicated space	48% (12)	61% (14)	64% (14)	NA
Stored in patio area	16% (4)	4.3% (1)	27% (6)	NA
Stored in one of the dwelling rooms/corridor	20% (5)	30% (7)	9% (2)	NA
Stored in kitchen	8% (2)	4.3% (1)	--	NA
Do use fosfuro de aluminio on maize storage	65% (53)	80% (44)	50% (30)	NA
Of those storing -- recognize dangers of storage agrochemicals in the home	58% (24)	44% (23)	71% (21)	NA

Source: Household Surveys

Water Sources and Patterns of Consumption

All three of the communities have access to a piped water supply (*de la llave*) and which is widely understood to be clorinated (although many in Agrarista said they were unsure). In the two most rural pueblos (Xochiteopan and Agrarista) all households pay a month fee assessed upon the number of members in the family (at 20 pesos per person in Xochiteopan, where the high cost is largely to cover the costs of pumping from the aquifer). Largely for the reasons of cost, in both communities supply was provided only twice a week (Sundays and Wednesdays), and sometimes only once (as occurred in the week that we were doing fieldwork. Supply in Flores Magón comes via the city.

Photograph 4.1: Typical Well in Santa Ana Coatepec (Image taken by Dr. Peter Ward)

Photograph 4.2 (left): Roof-fed Rainwater to Storage Tank SFX. Photograph 4.3 (right): Water storage tank in San Fco. Xochiteopan. Note the feeder in-pipe, as well as buckets to scoop water for washing etc. (Images taken by Dr. Peter Ward).

However, in our survey we found that while tap water supply is widely used both for drinking and for daily household uses, several other sources are also locally important: wells in Santa Ana (Photograph 4.1); storage tanks and cisterns across all three pueblos (see Photographs 4.2 & 4.3 above for a storage tank in Xochiteopan which was used to provide water for the household as well as for the animals. It was fed from the piped supply (*llave*), and while these

tanks may also be sourced from rainwater most are also supplied by network (*llave*). Often, therefore, we were unable to distinguish between the true original water source. Our attempts to measure the water quality (presence & level of chlorine) were made problematic therefore, since water from the tap via a storage tank would inviably register much lower levels of chlorine than that directly off the network (see below for data).[9] Despite being potable, a proprtion of households (25% in the three pueblos) boiled their water before drinking it. With the exception of Flores Magón and Santa Ana, few families regularly purchased bottled (purified) drinking water (Table 4.1), largely because of cost: in Flores Magón respondents reported paying an average of 60 pesos a week for bottled water.

Internationally adding chlorine is used as disinfectant in water treatment processes to eliminate pathogens and reduce contaminants and other harmful organisms present in water. However, the amount of chlorine introduced to the distribution system must remain within certain levels to ensure its efficiency. According to the EPA, the maximum amount of chlorine in a public water system is 4 mg/L. The smell or taste of chlorine can be detected when the levels are around 1 mg/L, so poor smell reports are not an uncommon occurrence. However, the optimal chlorine levels range from 0.3 to 0.5 mg/L (EPA). If water is stored for any length of time, chlorine tends to dissipate and eventually stops disinfecting the water – certainly it becomes difficult to measure with any exactitude, as we found in practice.

In the two most rural pueblos (Xochiteopan and Agrarista), the concentration of chlorine in households was significantly low, with an average of about one tenth of the prescribed minimum level (i.e. 0.03 ppm). In large part this could be due to our often having to test on stored water since daily tap water flow is not continuous, as mentioned earlier. However, even in the instances when tap water was available for measurement , the samples collected displayed low levels of chlorine. This suggests that not enough chlorine is being introduced into the distribution system, and as we observe in Table 4.1, some families regularly boil water that they drink.

In the case of Santa Ana Coatepec and Flores Magón, chlorine levels in the water appeared to be the highest with averages of 0.12 and 0.15 mg/L, respectively. This was substantiated by the perceptions of the communities with 98% and 96% of households responding to being aware of their tap water receiving treatment (Table 4.1). However, these more urbanized communities opted to purchasing bottled water due to concerns with the water supply. In Santa Ana Coatepec many expressed dissatisfaction with the taste and smell, perceived their water as being overchlorinated, and believed that the quality needed improvement. In Flores Magón, the dissatisfaction with the water supply came from distrust in the treatment process. The

[9] For the water quality data collection, we used the eXact I-Dip© smart photometer system with Bluetooth, see sensafe.com/idip-compatible-devices. After letting the water run for two minutes and flushing the instrument with sterile water, the IDIP receptacle cell is filled, the test selected, the cell closed and meter primed and then a dip strip is introduced to the cell water receptacle and the results read after which the results are sent and saved via Bluetooth. In addition, we measured for solids and water temperature using a simple TDS meter.

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belief of the water needing improvement was slightly greater in these communities than in the rural ones.

Safe Water Practices

As mentioned earlier, water availability is limited to once or twice a week in the rural communities which obliges them to regularly store their water in large containers and to use these as their source of drinking water. The issue with this practice is that if the water is stored for longer than 24 hours, or the containers themselves are not adequately equipped to prevent contamination, then there is the potential for hazard to health. Some recommended practices for safe water storage include regularly sanitizing the storage containers, ensuring that "old" water is fully replaced by fresh water, and using containers that have a small cover or lid that discourages the insertion of hands or objects into the tank to draw water (Photograph 4.3). Because chlorine will dissipate over time, and the storage of water is the only viable option for some of these communities, it is crucial to introduce and encourage safe water storage practices to reduce potential risks to waterborne diseases.

In addition to safely storing water, other steps can be taken to reduce health-related risks associated with poorly treated water such as boiling and filtering water before consumption. Boiling the water will eliminate pathogens and other contaminants while filtering will separate and remove particles and sediments from the water. These two forms of treatment can also be beneficial for rainwater collected for drinking or cooking purposes as was observed in the communities, particularly in Colonia Agrarista. Rainwater is generally safe for consumption and is evidently an important source of drinking water for rural communities, so ensuring the education over safe water practices can have positive health outcomes.

Dwelling Environments & Post Earthquake Reconstruction.

Traditional building and lot arrangements in these pueblos requires a sizable lot for dwellings, animals, and storage of wood, fertilizers and grain, etc. As our intensive case study diagrams illustrate (below and in Appendix 4), lot-sizes of around 1000m2 or more is normal, and is almost double that in Agrarista (Table 4.2). Most are *ejidatarios* who, as part of the original creation of the *ejido*, received both a lot for residence in the “urban” *ejidal* zone, and larger parcels of land for cultivation outside of the pueblo. Many will walk for an hour or more to reach their parcels.

Dwellings traditionally were made of adobe which rarely allow for a second story, and rooms often lack natural lighting or, have small window openings. More recent building is of concrete block (*tabique*) which does allow for a second story provided that steel reinforcement is used and that the first-floor roof is made of concrete. Otherwise roofs are of laminated iron or bituminized cardboard (*lámina de cartón*).

The 2017 September earthquake hit both communities very hard especially Xochiteopan where the Church was destroyed, as were many homes. There were few casualties since most people were out in the fields when it struck at 1:00pm, but such was the damage especially to the adobe structures that a major rebuilding effort was put in place. The first phase was an

emergency campaign to provide basic materials (tarps, wood, plastic etc.) for temporary shelter, followed by funding support for rebuilding and a number of new homes were built by FONDEM (3 bedrooms) and by the FCP (2 bedrooms -- See Appendix 4 Case 1a & Case 1c for prototype examples of FONDEM dwellings, and Case # 2 [Appendix 4 Case 2b) for FCP L-Shaped buildings with an open patio https://lahn.utexas.org/Puebla/App4.html.) [10]


Photograph 4.4 (left): Earthquake damage to consolidated adobe walled house (Image taken by Alejandro Luna López). Photograph 4.5 (right), Members of the FCP on site to discuss plans for new homes with Doña Francisca's family (see also Appendix. 4 Case 2a https://lahn.utexas.org/Puebla/App4.html) (Image taken by Alejandro Luna López)


Photograph 4.6 (left): Lidia's house in March 2018. Photograph 4.7: in July 2019 showing enclosure of the patio (now a dining/living area). (Both images taken by Dr. Peter Ward.)

The self-help modifications to the FCP dwelling suggests that the FCP's premise of an open patio in which to cook was misconstrued since families continue to cook outside using wood, and until they choose or can afford propane gas (tanks) they are unlikely to move to an inside kitchen. Thus, the FONDEM designs seem better designed. In a later section we will examine the health challenges presented by both the new and the older traditional housing structures.

[10] Note: All names have been changed in order to offer of confidentiality relating to the cases and their households. However, we understand that local identification from the photographs may be possible and we have redacted any sensitive information (location of kin in the USA, particular health problems of indoviduals, etc.) that may cause embarrassment to the families.

In reconstruction some families preferred financial support to design and construct new homes for themselves, although this can lead to a stall in the building process when money runs out (or is diverted for other uses) -- as we found in one of the case studies (Appendix 4 Case 2a). Thus, core housing with the opportunity for extension, or completed new house design can have a dynamic effect, albeit in often unpredictable ways. The structure as planned and installed is not always congruent with the family's needs, and will be adapted accordingly. Also, it appears that post-earthquake reconstruction support can generate and raise expectations such that building activity stalls when no additional (or external) resources are available.

We were also struck that in these poorest agricultural communities much of the interior space of dwellings (new or old) is largely for sleeping and/or storage, and that little effort appears to be made to furnish rooms: most of the daily activities are in the patio/yard and/or the external kitchen area. An action item here might be to create a micro loans program that would allow families to finish-out the interior of buildings.

Table 4.3. Characteristics of Dwelling Structures, Building Materials etc.

Pueblos and Sites	San Fco. Xochiteopan	Colonia Agrarista	Santa Ana Coatepec	Colonia Flores Magón
Lot size Trimmed mean (5%)	**1015m2 (37)**	**2377m2 (26)**	**917m2**	**566m2 (22)**
Dwelling Number of Rooms Excluding Kitchen and Bathroom				
One or two	53% (43)	46% (25)	35% (21)	33% (15)
Four or more	16% (13)	27% (15)	30% (18)	28% (13)
Construction Materials Used in the Various Rooms*				
Tierra/earth	41.5% (16)	21.82% (12)	1.67% (1)	6.5% (3)
Concrete	86.3% (70)	90.91% (50)	83.3% (50)	71% (33)
Tile/mosaic/Loseta	5% (4)	10.8% (6)	20.1% (13)	34.77% (16)
Other				
Walls*				
Adobe	24.7% (20)	41.82% (23)	5% (3)	--
Block/tabique/concrete	96.2 (79)	87.27% (48)	112.7% (87)	113.1% (52)
Wood/lamina/plastic etc. throwaways	8.62% (7)	9.1% (5)	--	2.2% (1)
Roof*				
Concrete	78.96% (64)	67.3% (37)	88.3% (53)	91.3% (42)
Zinc corrugated etc.	33.4% (27)	50.1% (28)	25% (15)	26.9% (12)
Lamina de carton/asbestos	13.61% (11)	21.8% (12)	10% (6)	10.9% (5)
Other				
Type of wc/toilet/connection				
Latrina/fosa septica	40.73% (33)	43.64% (24)	5% (3)	2.1% (1)
WC connected to drainage system	56.78% (46)	50.9% (28)	94.7% (12)	97.80%
Type of Bathing				
Ducha/Shower	25.9% (21)	21.8% (12)	61.6% (37)	60.9% (28)
Tina/bathtub	13.6% (111)	--	--	--
Tazón (bowl)	40.74% (33)	70.9% (39)	36.7% (22)	40% (28)
Jicarazos (bowl)	17.2% (14)	3.6% (2)	1.7% (1)	--

% households reporting rooms without natural lighting	28% (12)	14.4% (7)	9.3% (2)	8% (2)
Primary room where no natural lighting	Bedrooms	Bedrooms	Kitchen & bedroom	Bedrooms

Source: Household Surveys

*Floors might be mixed materials and thus percentages may add up to more than 100%

Contemporary Dwelling Characteristics:

As one can observe in Table 4.3, dwellings in Xochiteopan and Colonia Agrarista are somewhat smaller (excluding the kitchen and bathroom spaces), with around 50 percent of the dwellings comprising one or two rooms (Table 4.3). This leads to higher rates of overcrowding -- a fact that can have important negative health implications especially when several members are sleeping in the same room (e.g. TB, respiratory illnesses, skin infections, etc., see Pemberton *et al*. 2007). Many homes comprise rooms made of more than one material, and while walls and floors are made of permanent materials such as concrete and bricks, Xochiteopan and Agrarista have a significant proportion of dirt floors in one or more rooms (42% and 22% respectively);[11] walls made of traditional adobe (25% and 42%), and occasionally more temporary materials such as lamina, wood and plastic (see examples in Figure 4.1).

[11] Important since several important diseases and parasitic infections are often related to dirt floors.

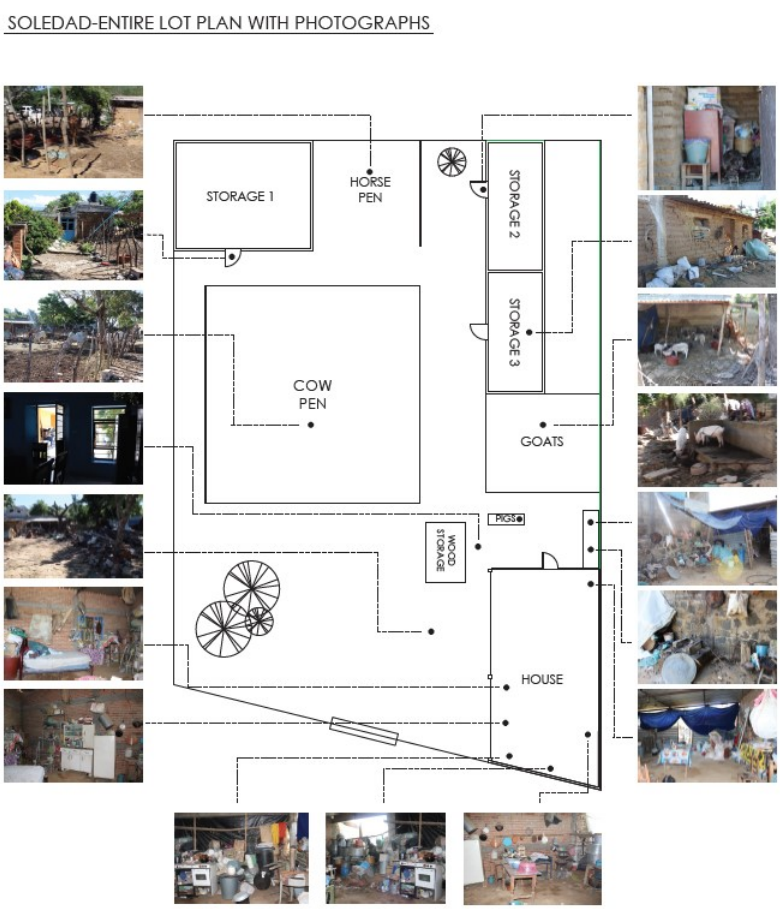

Figure 4.1: Example of Lot and Photos Plans in Appendix 4 Case 3a & 3c. María Carmen's house. Note dirt floors, and flimsy building materials.

As mentioned above the earthquake impacted Xochiteopan especially hard and destroyed many of the housing units made of adobe; it was less severe in Agrarista which still has many homes built of adobe (42%). In the construction of the one observes greater variation of materials with a large minority of homes having one or more rooms roofed in zinc or other laminated materials. Concrete roofs are important not only because they provide better conditions for heating and cooling, but are also easier to keep clean and reduce infestations from pests, etc. As we expected, the somewhat better-off communiies of Santa Ana Coatepec and urban Flores Magón have more consolidated and larger dwellings (Table 4.3).

Toilet and bathing facilities vary, the former especially being predicated upon the household connection to a formal drainage network – as exists in Santa Ana and Flores Magón. Both Xochiteopan and Colonia Agrarista rely upon pit latrines of one sort or another (above 40% of cases); and only 22-26% of dwellings have a formal shower/bathroom facility; the majority making do with a *ta*zón (bowl) to bath themselves. One focus group mentioned that lice infestations (*piojos*) were a serious problem among children and, to the extent that hair washing is less frequent among those families without showers, then these less effective forms

of personal hygiene may exacerbate the problem (although it invariably also requires medication treatments as well, and these are relatively expensive).

Natural lighting is important -- both for its own sake as well as to enhance ventilation -- and while relatively few homes have no rooms without natural light/windows, a modest number do – in Xochiteopan especially (28%, double that of Agrarista, and three times as high as Santa Ana and Flores Magón).

As we were preparing the survey, we were alerted by our collaborators at the Fondo Mónica that it would be good to include some questions about the use and storage of agrochemicals and fertilizers in the three agricultural pueblos. The majority of farmers use aluminum phosphide to fumigate their maize crop, and we were interested to know how household members viewed the relative risk of storing such chemicals in and around their home, and where these were stored on site. As shown in Table 4.2, the majority of households were aware of some of the dangers of storing chemicals (although it was significantly lower in Agrarista (44%). Moreover most households had a dedicated space (*almacén*) in which to keep them (lower in Xochiteopan [48%]), but a minority also kept them in living spaces around the home, sometimes even in bedrooms or cooking areas (See Table 4.2 & Figure 4:4 Case 2 below [Appendx. 4 Case 2a & 2c).

Air quality and Perceptions

Because the majority of households in rural pueblos cook with wood (*leña*) especially and *carbon* for tortilla stoves (see Figures 4.8 & 4.9 below), kitchens and cooking spaces are often outside or adjacent to main dwelling and living spaces, and are especially likely to be made of lámina, sometimes open on one side and giving out onto the patio (see photos in Appendix 4. Case 5a). Even if partially open on one side, if good ventilation is not assured, then very poor or even hazardous air quality may ensure (see below and Appendix. 4 Case 1a & 1cd).

Photograph 4.8 (top): Typical wood fire in outdoor kitchen. Photograph 4.9 (below): Large bowl set above a wood fire (for *mole*) and small stoves for carbon and heating *tortilla* (Images by Dr. Peter Ward).

Photograph 4.10: Wood fire *comal* and chimney. Photograph 4.11: Wood fire oven with small stove and coal (Images by Dr. Peter Ward).

Health Parameter Guide							
PM2.5	PM10	AQI	CO2(ppm)	Status	HCHO(mg/m³)	TVOC (mg/m³)	Displayed Contents
0.0-12.0	0-54	0-50	0-700	Good	0-0.1	0-0.5	Safe
12.1-35.4	55-154	51-100	701-1000	Moderate			
35.5-55.4	155-254	101-150	1001-1500	Unhealthy for Sensitive Groups			
55.5-150.4	255-354	151-200	1501-2500	Unhealthy	> 0.1	> 0.5	Unsafe
150.5-250.4	355-424	201-300	2501-5000	Very Unhealthy			
≥250.5	≥425	≥301	≥5001	Hazardous			

Figure 4.2: Air Quality Thresholds for PM2.5, PM10, and CO2.

During the survey we gathered household perceptions of air quality within the home and in the wider community locality, and then followed up with measurements of actual air quality in several rooms (particularly the kitchen), in order to assess the possible impact of poor indoor air quality on health (for details on each of the measures and instruments used see https://lahn.utexas.org/Puebla/App3.html). Measurements were taken using a handheld instrument which provided detailed readings of particulate matter in the air PM2.5 and PM10), (largely smoke and ash particles, etc.), as well as of carbon dioxide, humidity, and temperature.[12] Most households gave us permission to take air quality samples in at least two areas of the dwelling, and we focused mostly on the kitchen and the patio space which is where most people spend much of their time. But we often also obtained readings for bedrooms and occasionally for bathrooms.

We focus primarily on CO2 and on particulate matter, specifically PM2.5 as it consists of finer particles that are widely known to be detrimental to health. Short-term exposures to particulate matter can aggravate asthma, heart, and lung disease, leading to respiratory problems. Long- term exposure can lead to the development of heart and lung disease and premature mortality. This can be especially harmful to young children who we observed spend a lot of their time close to their mothers, and some women reported having to carry their toddlers while they cooked – a practice that occupy them for three hours at a time. Children are more prone to developing acute or chronic respiratory diseases when exposed to CO2 and particulate matter in poorly ventilated dwellings. Health effects of poor indoor air quality include low birth weight, tuberculosis, asthma, and the development or worsening of other respiratory illnesses. In San Fco. Xochiteopan, for example, asthma was the third highest chronic illness and can be linked to the poor levels of PM2.5 and CO2 in this rural community. Poor respiratory health outcomes among children in low-income residential settings can be

[12] Temtop Model M2000C https://www.temtopus.com/

stimulated by a combination of inadequate ventilation, crowded, unsanitary conditions, and the lack of resources to use safer fuel alternatives (WHO, 2005).

Fuel combustion, agricultural activity, and emissions from unpaved roads are all sources of particulate matter. In the case of the three rural pueblos, agriculture is the primary source of economic activity and the majority of the households utilize wood as cooking fuels over natural gas or electricity (Table 4.1 and Photos 4.8-4.11). In Flores Magón, 98% use natural gas, although they, too, often use *carbon* and *leña* for occasional cooking.

The limited or poor ventilation observed in many kitchens and homes can increase the exposure to toxic pollutants emitted by solid fuels (Maldonado et al. 2011). We also observed plastic (usually bottles or cups) being used as an accelerant to start the wood fire, and even when fires were outside the house smoke often drifted back into ones' eyes and face. Where cooking was done in a single room (see Fig. 4.3 Intensive Case # 1 below, [also Appendix. 4 Case 1a & 1c), with limited ventilation, the readings were often hazardous and toxic. This inspired us to run a focus group strictly over air quality and cooking practices in San Fco. Xochiteopan. Through that exercise we learned that community members seem to be more concerned about the volcanic ash periodically emitted by the volcano than by the smoke from their own kitchens. This suggests that cooking with wood, and the discomforts that arise (eye and skin irritation, cough, etc.), have become the "normal" in rural communities that lack education and, most importantly, do not have the resources to use safer fuel alternatives. It was through this focus group(https://lahn.utexas.org/Puebla/App5.html) that we learned of people burning plastic to intensify and speed the lighting of fires. Awareness of the hazards of such practices was widely voiced; however people reiterated that wood was simply more affordable and accessible, and gave their meals a better taste.

Particulate matter (smoke and ash):

In the three rural pueblos, concentrations of PM2.5 had means ranging from 38 to 71 ug/m3 (ppm see Table 4.1). By comparison, EPA's annual air pollution standard for PM2.5 is 12 ug/m3. The levels in the rural communities were considered unhealthy as Table 4.1 shows. These are average levels, but we have also disaggregated the "tail" of the distribution in order to highlight the proportion of households exposed to unhealthy and very unhealthy particulate and CO2 readings across each of the three communities (Table 4.1).

Carbon Dioxide (CO2):

In all four communities the mean CO2 concentrations ranged from 760 to almost 1,000 ppm and fell under the "moderate" health category. Although CO2 did not vary and show such high levels as particulate matter, there were still some alarming observations within the homes, particularly in the kitchen spaces. It is important to note that most households had their cooking space set up outside, but the existence of adequate ventilation varied greatly from home to home. See Appendix 4. Case 1b & 1c for further discussion on indoor air quality and its impact on family health.

Additional possible sources of poor indoor air quality can be attributed to the a number of practices: storage of agrochemicals inside the home, sometimes in the spaces used for sleeping (See Case Study #2), proximity between humans and farm animals in or around the living space, and, lastly, from the building materials themselves. Fertilizers, pesticides, and other agrochemicals are widely used in the three rural communities, however, if not properly stored, they can have adverse effects on human health. Acute illnesses such as skin rashes, headaches, dizziness, nausea, among others have been linked to contact with pesticides. In more serious cases, chronic illnesses such as prostate, lung, and breast cancer have been correlated to the use of agrochemicals. Although the majority of households in the communities under study reported storing such chemicals in a designated space away from the living space, a large proportion do store them inside the home, including in the kitchen (Table 4.2).

Overcrowding of sleeping space, unclean bedding and poor ventilation can also comprise health and wellbeing (infestations) and poor air quality (high CO2). In these agricultural communities most yards had a range of farm animals which can also impact the quality of air in a home and in all four communities a large percentage of household's own livestock (cows, chickens, horses, etc.). In some cases chickens were loose and climbed onto beds and other furniture. Building materials and household furnishing can also be a source of indoor air pollution. Domestic or non-domestic animals can shed or spread allergens, biological particles, and some gases. This close interaction between humans and animals was commonplace. Formaldehyde and volatile organic compounds (VOCs) can be emitted from wood products and paints, and earthen floors can emit radon as well as generate higher levels of suspended particulate matter.

Perceptions of Air Quality:

More than 50% of households in the three rural pueblos reported being very satisfied with the air quality within their homes, while often also believing that there are significant health problems related to indoor air quality (over 30% of reports). As for the quality of air outdoors, a lower percentage of people reported being satisfied, and blamed most of this discomfort on the Popocatepétl's frequent discharge of ash. It was surprising to hear that most people believe the random volcanic eruptions that send ash in their direction when the wind comes from the volcano posed a much greater risk on their health and on pollution than the smoke and pollutants generated by the daily wood-and-plastic-burning inside their homes. Additionally, most individuals who reported smoke being a problem in their kitchen, also denied experiencing any form of discomfort including eye and skin irritation, cough, etc. However, we did witness several families coughing or rubbing their eyes while cooking (including ourselves). Cooking with charcoal, without a ventilation fan, was associated with an even higher increased risk for asthma.[13]

[13] *From <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2760246/>)*

Housing & Poor Health & Exposure to Hazards.

We conducted five intensive case studies purposively selected in order to explore some of the micro aspects of the dwelling environment that could impact upon health and (im)mobility of household members around the lot. These case studies were identified after we had concluded the survey phase in each community, and it followed an intensive case study methodology used elswehere (Ward, 2015). Comprising several team members simultaneously on site to undertake a number of data gathering activities: 1) detailed measurements of the dwelling structures to prepare lot and building plans; 2) photographs and video records of all buildings and features; 3) air quality readings in all of most of the rooms, as well as water quality readings; and 4) one-on-one interviews with family members and with the original interviewee(s).

In order to conduct these intensive case studies, we first visited with the family in order to explain the objectives and to request their permission for five or six team members to come on site, not least since there would be considerable intrusion both in their dwelling space and demands upon their time. While families had not received any remuneration for the original interview which took around 30 minutes, given the intrusion and the time we expected to spend on site (3-4 hours) we offered a modest payment (500 *pesos*). We also informed the case study families that we would return in the Fall and provide each with copies of the detailed lot and dwelling plans.[14] Of the six households whom we approached, only one family declined. A mutually convenient time and date was arranged for the second visit. In each case our architecture student, Melannie Ruiz, base in Austin drew up the specific house plans with lot and photos (see Appendix 4, Case Studies 1a-5a https://www.lahn.utexas.org/PueblaNeeds.html), as well as detailed dwelling construction plans and 3-D sketch-ups, which, as we had agreed at the outset, we delivered to each of the five households when we returned in October 2019. (These internal house building plans are not included in Appendix 4.) We also created a second set of lot and dwelling diagrams in which we sought to pinpoint locations that presented possible health risks to household members. These risks included poor or dangerous air quality; poor building materials; proximity to animals (turkeys, goats, cows, etc.); uneven or dangerous surfaces, hose pipes, high entry lintels on doors all of which would impede mobility especially for the elderly; rooms with high humidity; and garbage or dump areas on the lot which attracted flies, and offered breeding sites for mosquitos etc.

In the following section we offer a discussion of each intensive case study and use the second set of lot and photo diagrams (below and Appendix 4 Cases 1b-5b), in order to explore how the micro lot environment and three dimensional structures, air quality readings for different

[14] We are indebted to UT School of Architecture undergraduate student Ms. Melannie Ruiz who turned our sketches and measurements into the final plans as well as creating 3D sketch ups of each building. We returned in October 2019 and delivered the plans to each of the five families, usually at the open community meeting called at which we presented our broad-brush findings.

structures/rooms, behaviors and room arrangements may present health risks and hazards to household members.

Intensive Case Study # 1. San Fco. Xochiteopan. Rationale for Case Study

As we document in the Appendix this case was selected for three reasons (https://lahn.utexas.org/Puebla/Appendix4/Case1c.pdf). First, the survey had identified extremely poor air quality and the burning of plastic in the kitchen area (as an accelerant), such that smoke problem in the "*cocina*" was off the charts on p.10 = 928.05 (Hazardous) and p2.5 = 230.1. Second, it was a clear case of two dwellings, so we wished to explore lot sharing arrangements and organization of space: namely two families and proximity to a range of farm animals. Third, this family had been badly affected by the earthquake on September 19th 2017, and they were the recipient of targeted support from FCP and FUNDEN – and had received two prototype dwellings (houses). See Appendix 4: Case 1a for the initial detailed lot map with photos (https://lahn.utexas.org/Puebla/Appendix4/Case1a.pdf). (The diagram below is the health hazards plan derived from the initial photos and plans.)

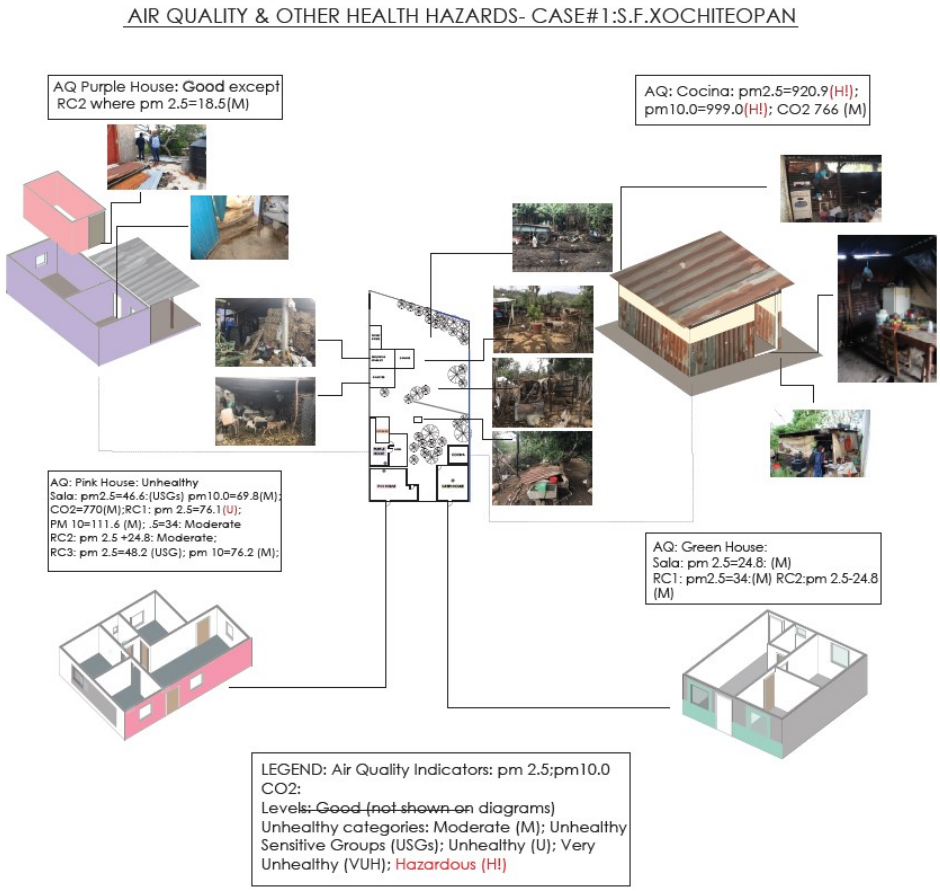

Figure 4.3: Lot plan with Health Hazards. Intensive Case Study # 1 Xochiteopan: Home of Doña Victoria and family (see also Appendix 4 Case 1a-1c).

Synthesis of the Case from the Original Survey

Victoria ** and husband Vicente are owners. She is 46 (he 48), and there are two dwellings on lot; theirs and that of her son Felipe and his family. This is a "nuclear compound" arrangement (even though the two families often cook and eat together). Three people sleep in her house (she, husband Vicente and their daughter ** 10 years old). This is the green house marked on the plans with three rooms (apart from the *cocina* and *baño*).

Their home was one of many that were badly hit or destroyed by the earthquake and was the subsequent target of housing replacement intervention. Fortunately, no-one was hurt: it hit at 1:00 pm when most were in fields. But they returned to find houses destroyed. Doña Victoria & Don Vicente and daughter slept in their *camioneta* for three weeks until donors delivered some materials and they were able to construct a wooden room which they used for sleeping. Not until August 2018 (almost a year later) were the two houses were built and ready for occupancy. Meanwhile their son (Felipe) and his family slept in a shelter in the school. Don Vicente was part of the Committee Emergency kitchen – cooking -- and would arrive home at midnight.

In the upper sections of lot. The original house was built of adobe with space for the *camioneta*. The other "blue" house (on the plans) is partly made of adobe and block [see Figure 4.3 above, and Appendix 4 Case 1a), and this became the temporary housing for the two families. Today each room in the blue house is used for storage: Victoria has one side and son Felipe the other. The wooden structure (now above the blue house) was where Victoria's family lived once they received the temporary building materials, and while they were strongly advised not to use temporary wooden structure or the original rooms (the adobe structure blue house) after receiving their new homes, they nevertheless kept them and today use all three rooms for storage. The upper wooden structure is very awkward (and somewhat dangerous) to get to.

In the lower section is a brown shed (also built from materials donated after the quake), and is used as a breeding area for chickens and turkeys). It comprises a penned area for smaller ones, while the larger ones roam free in the daytime. The lower section also has a small *huerta* area. In their field plots they also grow some *hortalizas* (vegetables) in rainy season and do so off site because here the chickens etc. would otherwise eat them. They also showed us two pomegranate trees - Red and Grenada Amarillo -- and banana trees.

Middle Section of lot has a tractor "port" (they have 2 tractors which makes them better off than most), and this is also the area where the larger animals are penned (see photos): specifically several cows, horses and a donkey which they take to the fields each day so that they can forage, but it takes an hour to get there. They also have: 30 *borregos*; many *guajolotes*; 3 *caballos*; 1 *burro*; 5 *vacas* and one calf. They are *ejidatarios,* and have two tractors which they also rent out to other farmers.

Health Commentary:

Upon our return to undertake the intensive case study the hazardous air quality was confirmed in the kitchen (where the families also eat). We asked Victoria if this was common practice and,

a tad embarrassed, she nodded and said “most”. This suggest that there is some awareness, but they do it anyway – i.e. it is not a lack of awareness. Somewhat unexpectedly given that these were newly constructed, rooms in both the pink and green houses also recorded poor air quality – either moderate of unhealthy for sensitive groups -- due in part we believe to poor ventilation (the windows were kept closed). Clearly there is little apparent cultural interest in cooking indoors since most people prefer wood and can’t afford gas and gas cookers etc., https://lahn.utexas.org/Puebla/Appendix4/Case1b.pdf).

This is a serious working agriculture unit, and fertilizers were stored in the blue house, so they did not present a health risk. Although the cows and horses were close to the house the other animals (goats) were corralled away from the dwelling space; as were the chickens and turkeys.

The water cistern (see Photograph 4.2 earlier), is fed from the tap supply and is used both for drinking and for watering the animals. While not fetid, the water clearly was not fit for human consumption (insects etc.): if used as a drinking source it would be a health hazard.

The pipes and hoses leading to and from the cistern impede mobility and present a danger to mobility and may cause falls. Although no-one in the family is yet elderly, the high lintel to the blue house; multiple hose pipes, and an uneven climb to the kitchen and dwellings impeded mobility. And climbing up to the temporary storage room above the blue house was dangerous (climbing up of a chair).

The multiple stacks of wood, while set aside, are always a possible fire risk and likely harborage of pests such as snakes and scorpions etc.

Intensive Case Study # 2. San Fco. Xochiteopan. Rationale for Case Study

This case was selected primarily because it appeared on the survey as comprising three households living on the lot (https://lahn.utexas.org/Puebla/Appendix4/Case2c.pdf). Also of interest was that it included one of the post-earthquake FCP core houses which we first saw in a preliminary visit to the site in March 2018, and which by the time we conducted fieldwork a year later it was apparent that there had been considerable building activity. This included the enclosure of the open patio area on the FCP dwelling, and two new but as yet unfinished dwelling structures (see Appendix 4. Case 2a https://lahn.utexas.org/Puebla/Appendix4/Case2a.pdf).

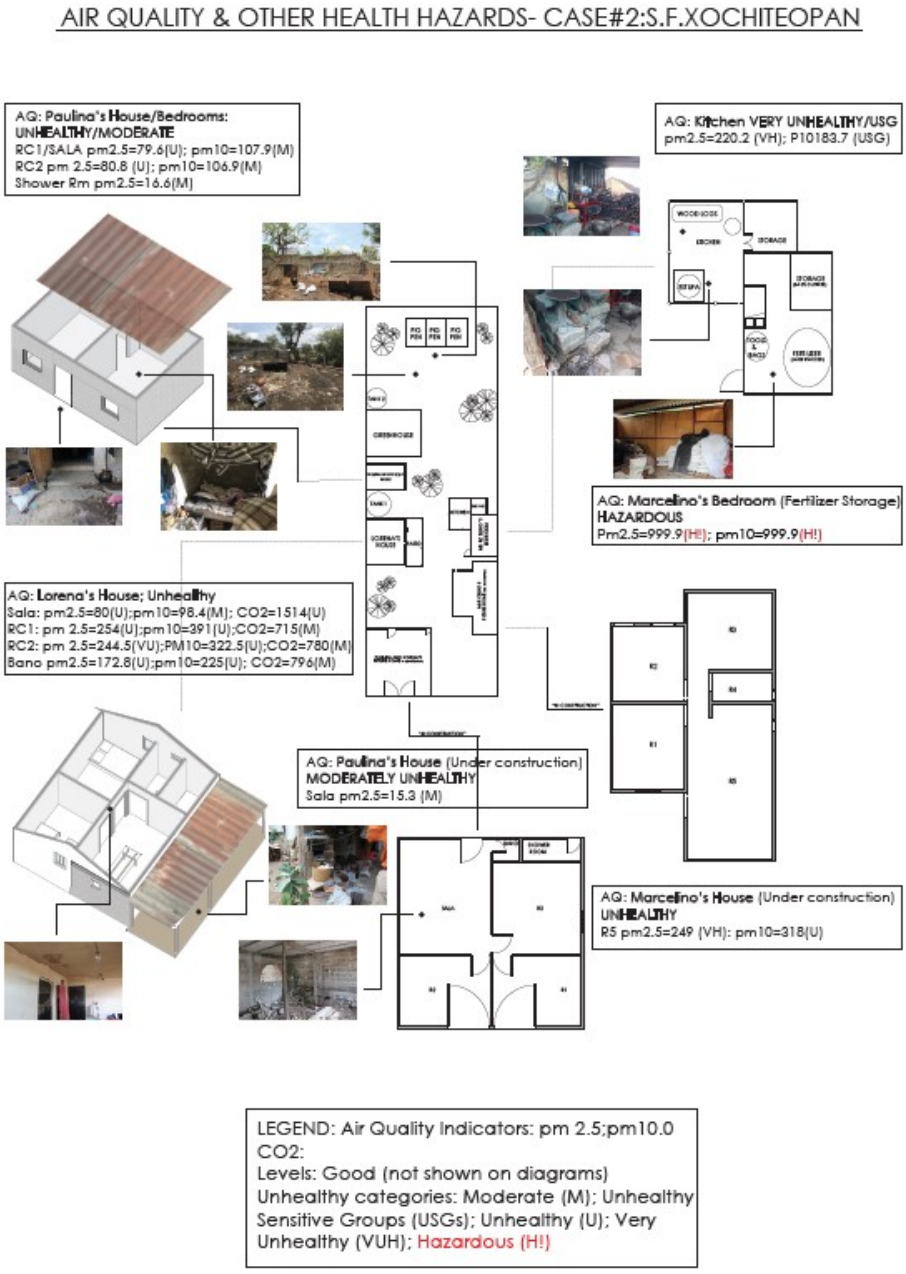

Figure 4.4: Lot plan with Health Hazards. Case # 2. Xochiteopan: Home of Lidia and Francisca, Extended Family (see also Appendix 4 Case 2b & 2c)

Synthesis

The original survey was conducted with Lidia, a 30-year-old mother who has lived on the lot all of her life and today lives in the FCP built dwelling with her son (aged 9) and daughter (aged 4). As we gathered the data it became apparent that this was actually

a mixed compound/extended household structure, headed by the matriarch Lidia's mother (Francisca), whose son Marcelino and daughter (Noemí) also live on the lot. Marco has **redacted health problems, is ** and sleeps in the blue wooden house (with the Guadalupe Image [now hidden on the site photos]), while Noemí is studying *preparatoria* and sleeps with her mother (Francisca) in the small two-roomed building (house # 2 Appendix 4 Case 2a). Francisca has two other adult children who live elsewhere, one of whom Erendino is building on site.

The incomplete new constructions are destined to be for Francisca and Noemí,[15] while the redbrick dwelling will be for Erendino.[16] The lot is large with two pig pens at the rear, and a plastic greenhouse (provided by the Fondo Mónica Gendreau) that Francisca attends to year-round – watering from the two large tanks (see plans at Appendix 4 Case 2a). These tanks were originally designed to store rainwater, but now are filled from the tap.[17] She grows a variety of vegetables largely for home consumption. There is also a dilapidated storage shed and kitchen area adjacent to Marcelino's room, as well as a small corral for goats not marked on the plot map. Most of the cooking is done with wood in this kitchen, and there is also a baking oven on the corner of Lidia's house (see photos). In the entrance to the newly enclosed area of Lidia's house they have a small stove on which they cook tortillas (using *carbón*), and on the sink area they have an electric blender.

<u>Health Commentary:</u>

As one can observe on the plans (Figure 4.4 above, "Health Hazards" [see also Appendix 4 2b]), many of the rooms have poor air quality. Lidia's house is classified as "Unhealthy" in all rooms with particulate and CO2 readings at "unhealthy" or "moderately unhealthy" levels. We also noticed some damp in the former patio area at the entrance to one of the bedrooms. The poor air quality in the two bedrooms and bathroom are almost certainly the result of some dampness and inadequate ventilation. The "sala" which is the now enclosed patio space, even with an open doorway and gap above the new *tabique* block walls also has unhealthy levels, resulting from the heavy use as a dining area, and the small cooking stove located at the entrance.

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[15] It seems that Francisca's house is also being built – at least in part -- using earthquake reconstruction funding from FONDEN, but which are insufficient to complete the job (she said that in part because Marcelino demands money for drink).

[16] Some confusion here since the notes also refer to an Erendino (son) who is building the brown house and that Marco will move into Francisca's two room dwelling when she and Noelmí move into the spacious new house. In fact, when we checked the red house in construction is for Erendino, and Marco will eventually take over Francisca and Noella's rooms. There are also plans to build two more homes at the back of the site for her other children. Upon our return in October we also met with Francisca's father and mother who have a house nearby in Xochiteopan.

[17] In October when we returned, she showed me that she was prepping the greenhouse for new planting. October was harvesting seasons in the campo and there was also a lot of other food that could be gathered so fresh vegetables etc., were hardly necessary at this time of the year.

Marco sleeps in the wooden box room which has fertilizer bags stacked up at one end (removed by October when we returned), and this, too, has very poor air quality – actually "hazardous" on both particulate counts, almost certainly due to the poor ventilation and to the smoke from the kitchen area next door. The latter was also very unhealthy on the 2.5 particulate matter measures. Francisca's house is actually just bedrooms (for she and Noemí), and again the poor air quality is due to a lack of adequate ventilation (there is no cooking area – it is all done in the kitchen and in Lidia's house). Photos reveal that they also share a bed in one of the rooms. Improving air quality is a relatively easy fix through better ventilation, namely by opening the windows for air circulation.

Somewhat to our surprise, the two buildings in construction also showed poor air quality measures in one or more of the room spaces, which we interpret as a result of construction dust and also maybe proximity to the road and vehicle fumes, etc. The rubble and building materials lying around could cause problems for the youngest daughter (** or "chatterbox" as Dr. Ward called her).

Photographs 4.12a-d: Images from Case 2 showing garbage and hazards to mobility (Images taken by Dr. Peter Ward). See also Appendix 4. Case 2b.

In addition to the air quality problems that this case presents we can point to several other health issues in this micro-environment. Uneven surfaces and the hose pipes and building materials lying around the front half of the lot impedes mobility, and are especially hazardous for young children as well as the elderly (see photos in Photographs 4:12a-b). Uneven ground and entrance (to Francisca's house) would also likely to cause trips and impede mobility. Lidia is heavily overweight and appears to be in very poor health (diabetes?). The kitchen area is bare earth and combined with the dirty lot areas could be a source of infectious diseases.

Their drinking water comes from the piped supply. Hoses are used to move water around the lot and to fill the two cisterns (for the greenhouse). Although chlorinated, these on-site usage practices may lead to poor or contaminated water.

The rear part of the lot is strewn with garbage (plastic etc. – see photos 4.12 a-d above), and also smells foul -- in part due to the pig pens at the back. There is OK separation from the residential areas, but the area is a locus of flies, mosquitos (breeding grounds) etc., and other pests and disease carriers. Better yard care and cleanup would undoubtedly help reduce health risks here,[18] as would removal of the junked vehicle.

Intensive Case Study # 3. San Fco. Xochiteopan. Rationale for Case Study

The rationale for selection was threefold: 1) the house comprised a single large room made of rudimentary and mixed materials for the walls, including plastic tarps, galvanized metal, and brick. The floor was also one of the few case study main rooms that had a dirt floor (which has major health implications); 2) Animals, including chickens and pigs and the chickens were free to roam inside the house, walking on the table and the beds. Thus, we were interested to explore how animals in close proximity to living space can impact health and quality of life. 3) The interviewee's six-year old (Christian) has mental and physical disabilities and for some years went to physical therapy to help him walk, so we were interested in observing his movement around the house and if he is frequently exposed to possible health risks presented by the animals on the property (https://lahn.utexas.org/Puebla/Appendix4/Case3c.pdf).

Synthesis of Case from Survey.
María Carmen Pérez is a 33-year-old single mother of a child with disabilities who no longer has any relationship with her partner. She lives with her elderly father (** 77), mother (** 75), and her young son (**). A brother also lived with them, but he died ** redacted. Until that time both her brother and father worked the fields, and the father continues to do so and hires a *peon*. Thus, this is a mix between an extended and nuclear family (extended since we focus on

[18] We discussed this mess with Francisca upon returning in October, and she said that she was planning on clearing it up in the dry season -- now everything was too wet. She is also planning on building two more homes at the rear of the lot for her other two children, at which time she will get rid of the pig pen and the tree.

María Carmen). (See Figure 4.5 below, and Appendix 4. Case 3a Lot Plan and Photos for a detailed lot description.

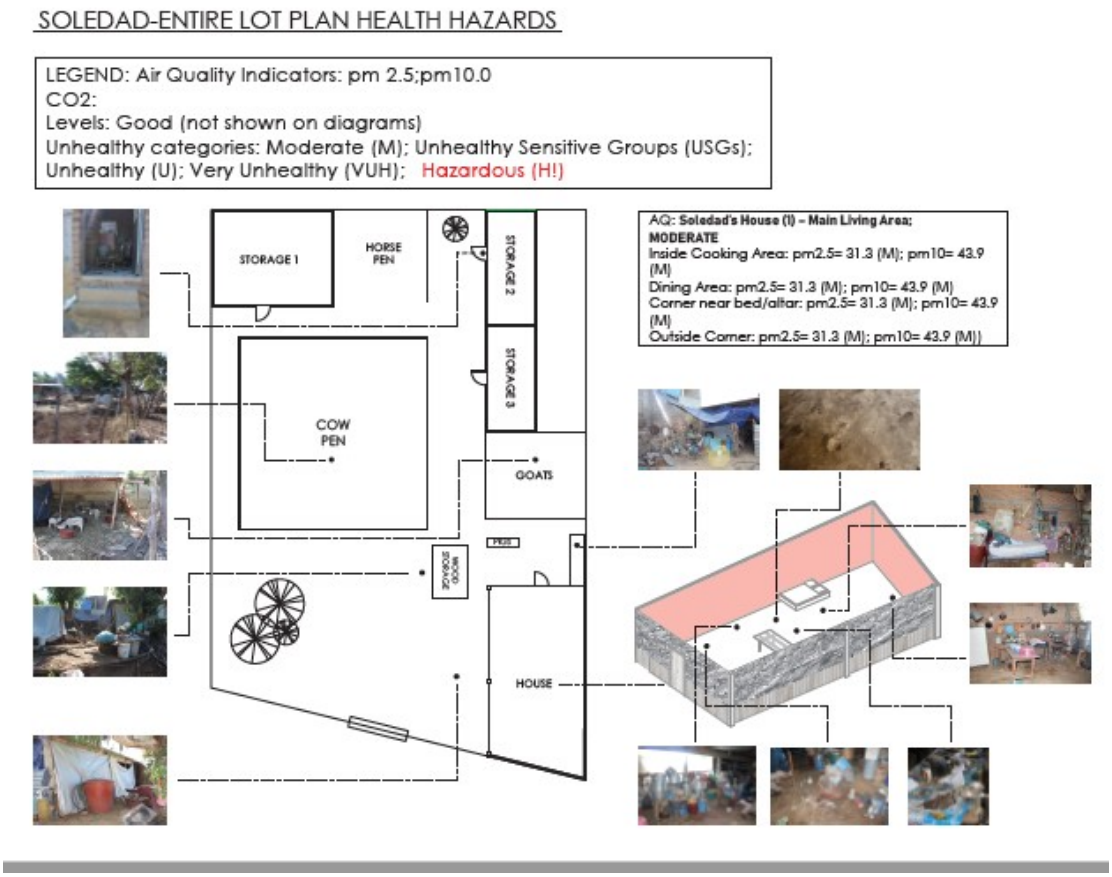

Figure 4.5: Health Hazards' Case # 3. Xochiteopan: Home of María Carmen & Family

Our discussion here focuses on the lot plan above (Figure 4.5), but of importance in this case is that there is another house 15 mins walk away that belongs to a brother who lives in Puebla. Before the 2017 earthquake María Carmen and her family used to live in her brother's house down the street, but it collapsed. They received aid from the government and her brother, who is an architect, oversaw the reconstruction of the house. While they waited for the construction on the brother's house to be finished, María Carmen, her parents, and her son moved into the house they currently live in. It was originally built by her father around 10 years earlier to store the truck and tractor, but after the earthquake it became a place of daily residence. At the beginning it was only the brick wall and a rudimentary roof. The ceiling's galvanized laminated roof and tarps were added immediately after the earthquake to serve as walls and make it livable. The house consists of one single room that serves as a dining room, bedroom, and storage space. The floors are made of dirt and there is only one bed. Only María Carmen, her mom, and ** (son) sleep there since her father decided to sleep and guard the brother's house for fears of someone breaking in.

They walk back and forth between the two dwellings, and while the brother's house is much nicer and safer, her parents prefer to stay on the lot with María Carmen because they have more space, and there is room for the animals. They view the other house as too small, but prefer not to keep coming back and forth (difficult when it is raining and when she [María Carmen] is cooking). So she would rather stay here and do everything (feed everyone and the animals). María Carmen does use the brother's house as the hairdressing salon where she works Saturdays.

María Carmen's son ** has epilepsy since birth and received physical therapy to learn how to walk (achieved when he was 2.5 years old). He has still not learned to speak fully, saying a few words in broken-Spanish (e.g. "ia" instead of "mira"). María Carmen says he has the mind of a 2-3-year old. He used to go to speech therapy twice a week in Atlixco, now he goes only once a week. María Carmen said that he (son) doesn't have mobility problems in the house.

Animals in Proximity to Living Space.

They have chickens, turkeys, goats, sheep, and pigs. She says they used to take the sheep and goats to the *cerro*, but now there isn't anyone that can take them, so they are always locked up. Some chickens are kept in an enclosed area, but others are always loose. These walk into the house and climb onto things, including the only bed shared by 3 people. The animals always sleep outside, so at night they do not have access to the house. The pigs are located between her house and the goat pen (see Figure 4.5). She cleans their area every 8 days. The son ** plays in the goat corral and plays with the sheep and goats. Indeed, he plays with everything: the tree, with the pigs and with the chickens.

Like most families she cooks with wood and charcoal (carbón). The dwelling is one large room where they cook, eat, and sleep. There is humidity present in the room. They use a *jícara* to wash, not having a formal shower (although there is a shower in their brother's home).

Health issues Presented by the Case:

This case study presents several major health concerns. The quality of the primary dwelling is problematic, comprising a single room made of provisional building materials and tarps, with a dirt floor. All of the family eat and sleep in this single room, and different sections of the space are dedicated to different functions (sleeping, cooking, eating), and show moderately unhealthy air quality readings. A second hazard is the close proximity of the animals and particularly the fact that chickens freely roam all parts of the dwelling. Third, are the mobility risks that the uneven surfaces pose to María Carmen's son and to her elderly parents (see Appendix 4 Case 3b, 3c).

Intensive Case Study # 4. Colonia Agrarista. Rationale for Case Study

It is relatively rare to find single person households and even more unusual to find a disabled person who lives alone. He is paralyzed from the waist down, is unable to walk, and doesn't use a wheelchair to move within house. He moves around by himself (crawling) and does all

the house duties, including taking care of his yard and his *burro*. Therefore, the case of Manuel was of particular interest and we hoped it would provide insights about how the physical dwelling structure and the lot environment would be adapted to allow for mobility, as well as allow us to explore and identify the particular health challenges or hazards he faced. Specifically: how does he move around his house; how are his daily needs met? And how is his house modified to fit his disability (https://lahn.utexas.org/Puebla/Appendix4/Case4c.pdf). We had also identified some poor air quality in one area of the patio.

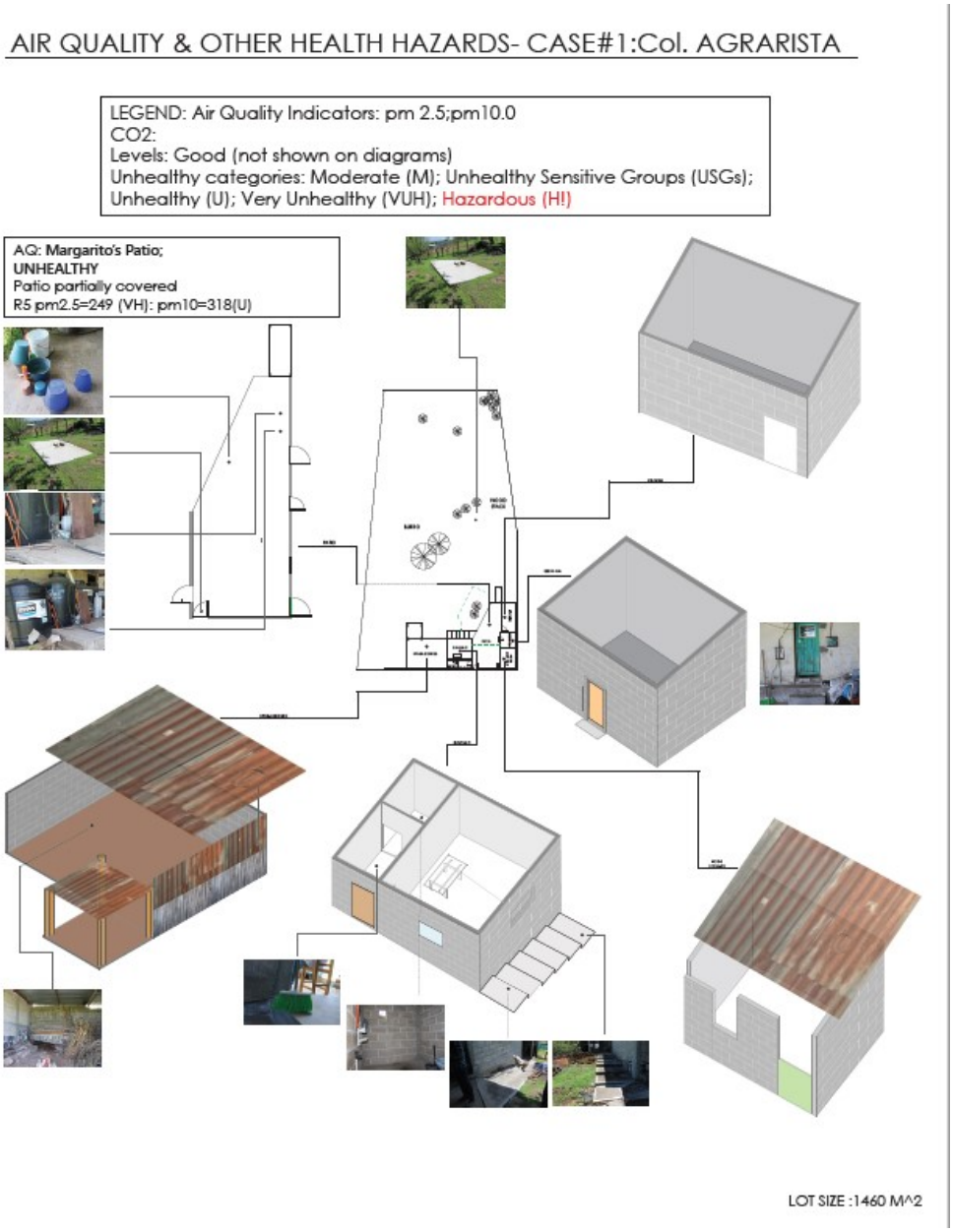

Figure 4.6: Case # 4. Colonia Agrarista Emiliano Zapata

Synthesis of Case from Survey

Manuel Flores (51) owns his house and has lived there for 40 years. His house has been added onto during these 40 years. He is originally from San Francisco Xochiteopan and is one of the original founders of the Colonia Agrarista.

He was three years in the military and served as a lieutenant in Mexico City which is where he had his shooting accident that left him paralyzed from the waist down (the bullet hit him in the spinal column). He was 22 and married with a one-year old daughter at the time. Four years later his wife left him, leaving him to raise their five-year old daughter as best he could. Much later his daughter migrated to the USA and now lives in Brooklyn. Each month she sends him money – a lifeline for him -- and they talk often via the internet (there is a dish on the top of the house). He has had an internet connection for several months (since April), and it works very well so that he spends time on social media, and on other internet outlets to distract himself. But mostly, he uses it to talk to his daughter through videocalls. His father (83), and *sobrina* (niece) live in the community (actually next door), and everyday family members come and visit him, which he says, makes his life a lot easier because they increase his accessibility. He relies on his family to bring him groceries and take him into town.

Health issues Presented by the Case:

Mobility challenges are the first and foremost issue. His paralysis greatly affects his mobility and how he interacts with his house, and he utilizes great ingenuity to modify the dwelling to fit his needs and mobility issues. While these methods do substantially improve his mobility and independence, they are also a potential cause of injury. For example his house has a lot of steps because of the slope of the lot (See Appendix 4: Case 4a), and despite the fact that most of the house was built after Manuel's accident, it is not wheelchair accessible. To deal with the steps he has a lot of sticks and brooms around the house, which allows him to pull himself up into the rooms. (Ramps within the house, even used when he is on his hands, would improve safety and mobility.) As Manuel ages, he is at a higher risk for injuring himself again. As is well known, injuries from falls are commonplace in the USA and pose a hazard in all of the cases that we explored using case studies, especially as household members age (Under and Riley, 2016: 41; see also https://stacks.cdc.gov/view/cdc/79969).

Because he owns the house, he has been able to make modifications and accommodate to his unique needs, including setting light switches, shower fixtures, latrine, and kitchen appliances at an accessible height. While he mostly uses cups for showering, his shampoos and soaps are at a low level to allow him to independently take a shower. In fact, in the months since we conducted the survey, he has added a well-equipped bathroom, a "sala", and installed a solar panel water heater (see below).

Photographs 4.13a-c: Additions to Manuel's home July-October 2019: Solar panel water heater; new bathroom and "sala/bedroom"

The latrine is located far from the house, making it less easy to access, but is a good option to improve sanitation. This latrine is a concrete hole in the ground without an above ground seat, which is very comfortable and accessible for Manuel (see Appendix 4: Case 4a).

The kitchen appliances are also low to the ground and accessible to Manuel, allowing him to enjoy one of his favorite tasks – cooking -- while also helping him maintain his independence and cook for himself. Unlike most of the community he cooks using propane – which is probably for the best since the kitchen has no windows (see Appendix 4 Case 4a & 4c) so the air quality is not affected. He believes that the water is very poor quality and does not think that it is chlorinated. There was no evidence of humidity or pests, and fertilizers are stored in the patio which he thinks is safe. In fact, this is the one area where there is poor air quality ("Very unhealthy" and "unhealthy" readings – see Figure 4:6 above for levels).

The house has concrete floors. While this is practical and health wise is the best option, he moves using his hands and protects his arms using an old feed-bag. Again, this method seemingly works for him but could cause injury and pain in his arms and legs. A wheelchair can ease mobility burdens and improve quality of life.[19] The storage shed has dirt floors which could present a disease problem given that he uses his bare hands to move around.

As a step to increase his independence, Manuel is able to mount his donkey by himself using a house modification that he created. In his storage shed he has a space to mount his donkey using rope and a pole that runs across the entire building. To get on his donkey he wraps a rope around himself and pulls himself up. While he pulls himself up, he calls the donkey over and when the donkey comes he drops himself down onto the animal. This gives him independence and allows him to visit the fields and talk to people. But it is also risky – should he fall (although he says he has no falls in two years). As Manuel gets older, there is a higher propensity for a dangerous fall while using these informal methods.

[19] https://www.youtube.com/watch?v=qCHVuMgz18c

The road that leads to the house is very rocky and is one of a number of streets in the pueblo that has yet to paved. This limits his mobility within the community as he is unable to use the wheelchair. In order to leave the property he must rely on the help of others, specifically his niece and father who live nearby. They bring him into town in a car for doctor's appointments and usually bring his groceries to the house.

This is a remarkable and unique case from which it is difficult to generalize. Even more remarkable is his optimism. With great individual ingenuity and perseverance, he has modified his dwelling environment to enable him to largely overcome his disability and enjoy a degree of mobility. His donkey is his lifeline to the outside; as are his *sobrina*, friends, and the financial and moral support that he receives from his daughter in the USA. While by no means well off economically, his fields and the remittances from the USA allow him to survive. One wonders how he would manage without. The principal health challenges are hazards associated with his disability. At first glance one would assume that modification of steps to ramps would improve his use of a wheelchair, but at the same time, *he needs and uses the steps to exercise that mobility*, and a wheelchair and ramps might present even great hazards in the event of loss of control. Laying a concrete floor in the storage shed would both improve access and reduce the disease risk associated with the dirt floor. Unless and until the road infrastructure is improved, a (the) wheelchair is not an obvious solution: he will continue to rely on his donkey.

Intensive Case Study # 5. Santa Ana Coatepec. Rationale for Case Study

The case was selected for several reasons that broke-out of the survey. The house structure is the most consolidated of the five cases; there is good lot space organization within the house at the front; and with the location of the *huerta* and animals at the rear (good separation of the animals [*borregos]*). Ana lives with her elderly mother who has mobility problems, and they have a small store at the front of the house, and we wondered how tempting it might be to regularly graze on snacks and sodas. Finally, remittances have greatly impacted family finances, substantially improving living conditions (https://lahn.utexas.org/Puebla/Appendix4/Case5c.pdf).

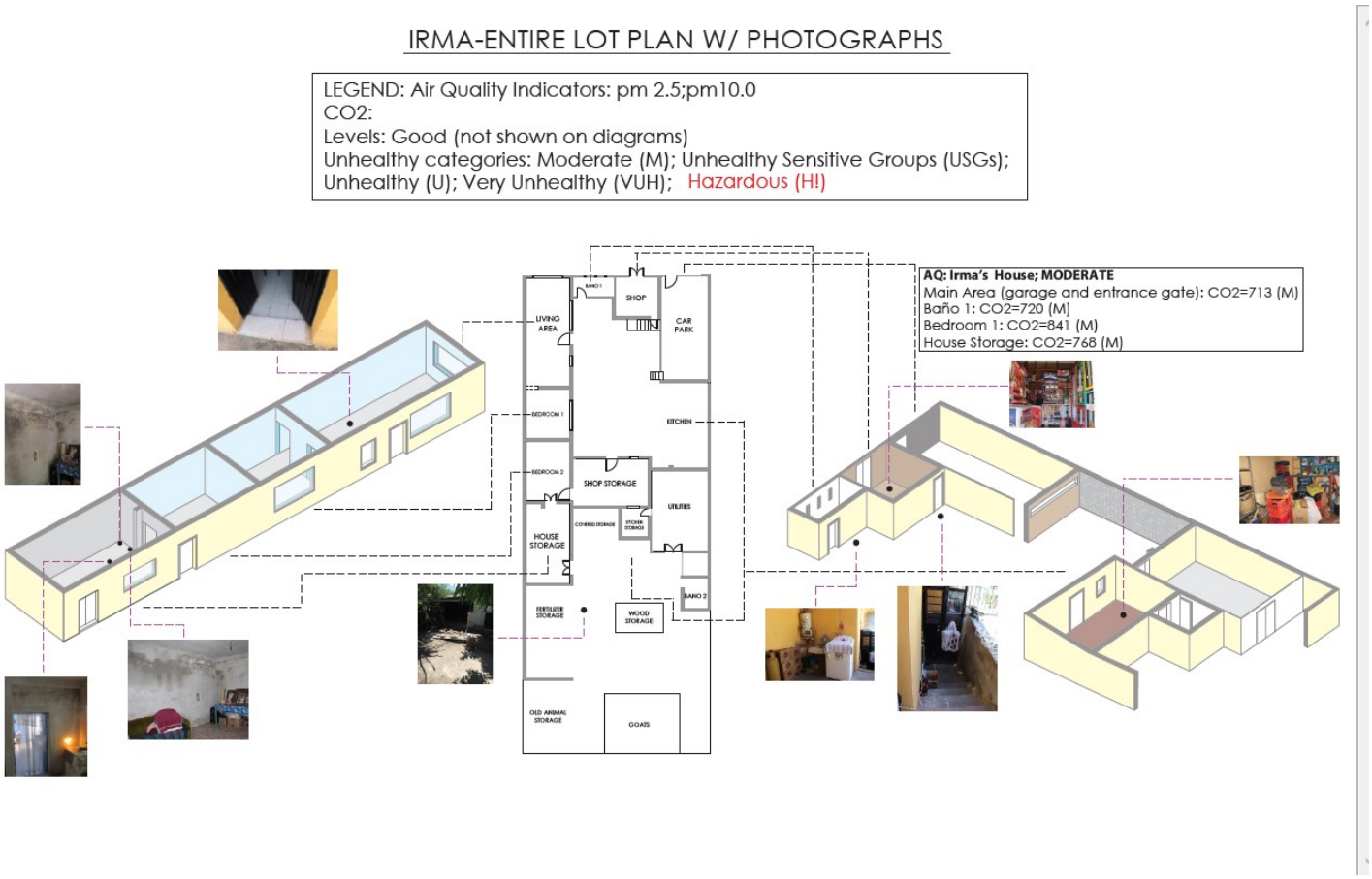

Figure 4.7 Case # 5. Santa Ana Coatepec

Santa Ana Coatepec while being a pueblo is located close to Atlixco which we classified as "peri-urban". The proximity to Atlixco means that the employment structure is more diverse, and that consequently it is somewhat better off than San Francisco Xochiteopan and Colonia Agrarista. Being much closer to Atlixco it also has better access to medical attention (see Chapter 2).

Synthesis of Case from Survey

Doña Ana is aged 52 and lives with her mother Xochitl (aged 84)and her son Simón (23) who is currently away at university. They have a single (but sizeable) home that was previously owned by her grandmother who was one of the original *ejidatarios,* going back 100 years or so. Her grandmother split the lot in two, and her cousin is her neighbor.

They frequently go to Ana's niece, (** a nurse) to get medical check-ups. Ana has lived in the U.S for a year, but returned a long time ago, and has another son who was born and lives in McAllen, Texas. She also has a brother that lives in the U.S and has arthritis. She uses both gas and carbón to cook, but primarily uses gas. Her family eats fruit regularly, and in the backyard she has dragon fruit, pomegranates, and calabazas. The family uses well water and bottled water, the latter since she is worried about the chlorine levels in tap water. Her mom pays for the aqua potable (tap), but they use mainly water from the well and drink bottled water.

Her Mom (Xochitl) is the formal owners (although there are no deeds), but she pays the *predial* (property tax) and the utilities and has all the records. Xochitl has a Will, and the beneficiary is Ana's brother. She, Ana, has extensive contacts and family in the United States, including her son in New York, and her brother in McAllen with whom she is quite close. She has four brothers and a sister, and her mother receives remittances from all of her siblings. The money her mother receives is mostly for health issues, as well as for the maintenance of the various properties and fields. Her mother has had knee surgery most recently through Seguro Popular, as well as cataract surgery on one eye.

The house is structurally sound with an open sided cooking area with a wood fired oven and chimney. The floors (in her Mom's rooms) are made of a material that makes it easier for her mom to walk around. But in her room it can also be slippery, so they put a special floor for her to walk about (see Appendix 4 Case 5a-c).

Relative to the other cases there was a large amount of space in the house, and each member has their own part and seemingly has to share very little with other family members. They even had multiple storage spaces for different things. It was also interesting to see how the lot was separated and had been split in two, but the cousins (next door) still keep in close touch and mutual visiting is via a chain link door connecting the backyard, and a small chain link "window"/door at eye level through which to share food and stuff without having to go out the front.

Health issues Presented by the Case:

In general Ana's house presents relatively few negative health issues. The husbandry of the animals is well organized and removed to the back of the lot. The cooking area is well ventilated, and her wood fire has a chimney to extract the smoke, but she generally uses gas (propane). The well is covered and well maintained, although we did not measure its quality, and the water is mostly for household use (Ana uses bottled water). Care has been taken to minimize the dangers of her mother falling by laying down a non-slippery surface, and the front patio area is made of concrete and is reasonable flat. There are stairs down into the small shop, and while steep her mother seems to be capable of getting up and down.

The only real health issues are the "Moderate" levels of CO2 in several rooms and in the car port area at the front of the house. When we pointed this out to her, and expressed our surprise, she suggested that it was probably due to cars on the road. The moderate levels in her bathroom, bedroom and storage area (see Figure 4.7 left hand side of the diagram [Appendix 4 Case 5a) are probably the result of poor ventilation, and the windows being closed. We observed some dampness in her mother's bedroom which she also later explained (in October when we delivered the plans), was due to water coming in off her neighbor's roof.

In short, this case presents a good example of a well-maintained home and lot: good site organization; well-constructed physically (for the most part); clean and offering reasonable mobility around the lot especially in the front half. Group reflections as we exited and

discussed the case, were that unlike other cases this home was clean and "modern", with much more interior furniture. The dwelling appears to transition through the lot to more provisional structures (around the patio and "kitchen"), through to the rear section which comprise sheds and storage and provisional outbuildings, the *huerta,* and pens for the goats, etc. It was as if there were two adjacent cultures all integrated into a single case. In many respects this is exactly what it is: a peri-urban pueblo in which agricultural activities sit alongside more service and other activities. Both traditional and modern, but in ways that are a positive hybrid (not a dichotomy).

Ana clearly takes considerable pride in what she has achieved (with her brother's help), and from her own hard-won earnings as a seamstress (*costurera*) and later through the shop.

Overall Summary of our Principal Conclusions on Chapter 4: Housing and Health.

The wider survey, our interviews, focus group discussions, taken together with the insights formed by these intensive case studies provide further evidence of how important and helpful it can be to examine the micro (dwelling and lot) environment and multiplex interaction between the physical fabric and how these shape people's health and wellbeing. Household and individual behavior mitigates or accentuates risks. Moreover, this dynamic changes over the life course: what affects young children and adolescents is likely to be significantly different to the middle aged and elderly, and vice versa.

Previous sections of this report have highlighted that the principal health (often chronic) challenges are diabetes, hypertension and muscular skeletal pain (arthritis etc.), all of which are known to present at increasing levels over the life course. We have also noted the widespread nature of "lighter" (non-chronic) illnesses such as diarrhea and gastroenteric diseases, as well as respiratory illness such as asthma, etc. In ways that are often well known, the dwelling environment can exacerbate such adverse outcomes (Unger and Riley, 2016; Tartof et al., 2016). We have documented many similar outcomes, but our research has also complemented the literature by providing a much more nuanced understanding of the physical and behavioral interactions in poor rural pueblos in Mexico.

Infrastructure Water and Drainage

Access to potable water is essential and our study highlights the following:

- Ensuring that potable water supplies are appropriately chlorinated is essential, and that adequate levels appear not to be met in the study communities.
- Increase the number of days water supply each week (to reduce the need for storage and possible chlorine dissipation).
- Where other (non-chlorinated) water is captured (rainwater collection; wells, etc.), and where tap water is not effectively chlorinated, then water should be systematically boiled and/or filtered, and wherever possible refrigerated, before drinking.
- Enhance cleanliness practices when scooping or drawing water from storage tanks.

- Bottled drinking water is rarely consumed in the poor pueblos, although it is more widely used in the better off peri-urban pueblo of Santa Ana and in urban *colonias* and neighborhoods. Cost is the primary mitigating factor, but we also found is also widespread suspicion about the purity of bottle water. Such suspicion and lack of confidence should be addressed.

Sanitation is generally through pit latrines and septic tanks.

- We have little information about whether or not this contaminates water sources (wells especially). However, it seems likely that close proximity to farm animals and animal feces are a likely contaminant (directly or indirectly) of water tanks and present hazards to household water usage such as washing, bathing cleaning etc. (Tapeworm and other infections can be absorbed from well and other water sources without actually being drunk.)

Many streets lack formal paving and this inhibits access and mobility especially for the elderly and infirm. That said, the recent street expansion in the newer section of San Fco. Xochiteopan will greatly assist access and mobility to that half of the community.

Household Behaviors with the Home:

Our primary findings are those that will improve nutrition to mitigate poor health outcomes:

- Reduce the consumption of sugary drinks in all communities, but especially those where rising incomes are likely to make consumption more available. Sugary drinks are related to obesity and diabetes especially. Greater awareness and production of natural & consumption of fruit drinks (with potable water) is encouraged, especially building upon existing producers (as in nearby *pueblo* San Fco. Huilango for example where Alejandro has promoted this).
- Reduce intake of unhealthy "snack-type" foodstuffs (this is largely in the better off communities where people can better afford it).
- While poverty is the principal constraint to regular consumption of meat, encouraging greater access and consumption of vegetables, fruit and wild plants should be a priority (*hortalizas* – as it already is through Fondo Mónica).

<u>Improved air quality.</u>

Behaviors to improve air quality and reduce negative health outcomes:

- Ensure greater (or more adequate ventilation) around wood burning stoves and ovens. This might include openings that would encourage breezeway flows; and removal via extractors or other fans, etc.
- Promote the adoption of safer fire lighting procedures (not using plastic as an accelerant).
- Develop workshops to promote the adoption (&/or retro installation) of chimneys and other more efficient wood burning systems.

- Maintain separation between cooking and family eating areas.
- Keep children away from the smoke and cooking area since their lungs are less capable of resistance to damage and it can exacerbate asthma, and other respiratory diseases in younger children.
- Increase awareness about CO2 (how it is produced through exhaling, car exhaust etc.), and the widespread existence of poor air quality due to (unseen) CO2 levels. Ventilation is key here, especially in bedrooms and enclosed spaces.
- Windows should be opened, and bedding aired daily.
- Avoid storage of chemicals and fertilizers close to, or in spaces that are used for sleeping or dining. They make for poor or even hazardous air quality.

On the dwelling structures and lot management

Poverty, by its very nature means that many on site dwelling constructions are of poor quality and offer inadequate protection from the elements, and in some instances harbor threats to poor health and wellbeing. Unlike in the USA and in most urban areas where people spend a large part of their daily lives indoors, rural populations such as those we observed in Puebla, spend most of their time outside – either in the fields, in the outside patio – working, cooking, playing, relaxing, and eating. They use the indoors far less, and rarely do so for cooking unless they have electric and gas stoves. Even the modern prototype homes built after the earthquake were "urban design", and our observation (and video coverage) revealed that they were primarily used for sleeping, as a place to mount their religious altar and candles, and for storage, rather than as safe areas for play or entertaining. Indeed, the relative lack of furnishings demonstrated the clear differences with what would be consider "normal" households' use of room spaces in urban society.

Our surveys were largely conducted in people's homes and patios, so we experienced a wide range of housing conditions (as Table 4.3 shows), ranging from well-built homes, new earthquake replacement dwellings, to one and two-room hovels. Our five intensive case studies broadly cover that span and offer many insights:

- While earth floors are no longer as common as in the past, they are difficult to keep clean, and present a risk to disease and infection especially to children (Chargas disease, malaria, etc.). Small scale loans (or grants) to provide a concrete floor in living spaces would help. (Also important in non-living spaces, to which children have access.)
- Attention to minimize damp and high humidity especially in sleeping spaces.
- Improve ventilation and air circulation by ensuring that windows and openings provide for a throughflow of fresh air.
- Increase availability of natural lighting in all rooms, and especially where none currently exists Ensure safe storage of foodstuffs and maintain a level of surface hygiene that will minimize pests and the disease dangers and bites that they can pose.

- Minimize uneven floors and walking areas that impede mobility and pose a threat to falls.
- Similarly, keep yard space clear of items that impede mobility and cause tripping and falls (hoses, pipes, etc.)
- Keep yards clear of garbage and other items (tires for example) that provide harborage for pests and disease
- Maintain a healthy level of separation between farm animals and household sleeping and eating and food preparation spaces.
- To the extent possible, maintain tree and shrub foliage close to the dwellings to provide shade and to improve air quality (plant absorption of CO2).

In short, our detailed discussion in this chapter, and the summary overview provided above, emphasizes the need not only to better understand the epidemiology of these communities and the ways in which health care is sought and received, but also the ways in which the micro level environment of housing and home are inextricably bound-up with behaviors and practices that impact upon health and wellbeing. In fact, we venture to suggest that such interactions between housing, home, and good health outcomes, are more dynamic and more volatile than they are in urban and more "safe" housing environments.

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