Pathways, practices and architectures

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Pathways, Practices and Architectures: Containing Anti-Microbial Resistance (AMR) in the Cystic Fibrosis Clinic

Abstract

Antimicrobial resistance (AMR) and the adaptation of microbial life to antibiotics is recognised as a major healthcare challenge. Whereas most social science engagement with AMR has focussed on aspects of 'behaviour' (prescribing, antibiotic usage, patient 'compliance', etc), this article instead explores AMR in the context of building design and healthcare architecture, focussing on the layout, design and ritual practices of three cystic fibrosis (CF) outpatient clinics. CF is a life-threatening multi-system genetic condition, often characterised by frequent respiratory infections and antibiotic treatment. Preventing AMR and cross-infection in CF increasingly depends on the spatiotemporal isolation of both people and pathogens. Our research aims to bring to the fore the role of the built environment exploring how containment and segregation are varyingly performed in interaction with material design, focussing on three core themes. These include, first, aspects of flow, movement and the spatiotemporal choreography of CF care. Second, the management of waiting and the materiality of the waiting room is a recurrent concern in our fieldwork. Finally, we take up the question of air, the intangibility of air-borne risks and their material mitigation in the CF clinic.

Keywords: Cystic fibrosis; Infection risk; Antimicrobial Resistance (AMR); built environment; architectures

Pathways, Practices and Architectures: Containing Anti-Microbial Resistance (AMR) in the Cystic Fibrosis Clinic

Introduction

The capacity of microbial life to adapt to and overcome antibiotics has been recognised as a major global healthcare challenge. Efforts to mitigate antimicrobial resistance (AMR) are likely to involve a profound realignment of our relationship to bacterial ecology, hygiene, sanitation and infections. Although AMR is necessarily deeply socio-political, the humanities and social sciences have only recently become more intensively engaged in understanding and shaping the AMR debate (Chandler et al. 2016; Smith 2015). This article contributes to these efforts by exploring the socio-material implications of building design and healthcare architecture for AMR.[1] Our research focusses on the layout, design and ritual practices of three cystic fibrosis (CF) outpatient clinics. CF is one of many life-threatening multi-system condition characterised by frequent respiratory infections and antibiotic treatment. Antibiotics may suppress infections without eliminating them, giving rise to highly resistant pathogens and the potentially fatal cross-infection of those pathogens between people with CF.

Over the course of several decades, the prevention of AMR and cross-infection in CF has increasingly come to depend on the containment, segregation and spatiotemporal isolation of both people and pathogens. This raises critical questions for clinical care in terms of the spatiotemporal flow of people and objects through clinical spaces, the way waiting and waiting rooms are arranged and navigated, and a heightened attention to airborne transmission and the role of ventilation design in limiting cross-infection. Our research aims to bring to the fore the role of the built environment exploring how these aspects of containment and segregation are varyingly performed in interaction with the material design of the CF world. This, we argue, necessitates a focussed attention on the entanglements of spaces, practices, humans and pathogens (see also MacDonald 2018; Fox 1997; Braun 2013) including attending to the layered histories of such spaces and how they have co-evolved over time with the bodies that inhabit and reconfigure them. Segregation, isolation and containment stretch back and forward through time. Hospitals are the products of multiple historical forces materialising competing medical discourses and contrasting theories of disease (Prior 1988). They embody the legacy of distinct architectural influences and are also, we suggest, shaped by the very availability of antimicrobial agents becoming infrastructurally enmeshed in the fabric of the built environment.

Our research sets out to comparatively map the differing real-world pathways, journeys and flows through clinical space, attending to discrepancies between material practice and design intentions. We explore the way physical interactions are configured by the temporal and spatial layout of clinics and how pathways are materially controlled or resisted and subverted. Understanding the complex entanglements of infection risk asks that we enquire into the way the built environment is differently travelled and spatiotemporally performed. Ultimately, to what extent is it possible to both re-imagine and reshape the built environment with reference

[1] *Pathways, Practices and Architectures: Containing Antimicrobial Resistance in the Cystic Fibrosis Clinic,* 2018-2020, funded by the UK Arts and Humanities Research Council, AH/R002037/1 and *Architectures for a post-antibiotic age: the co-design of an exhibition,* 2018-19, funded by the Wellcome Trust/University of York Centre for Future Health.

to a 'post-antibiotic' imaginary (Brown and Nettleton 2017a, 2017b, 2018)? Our intention here therefore is to move away from a conception of 'the building' as a 'built environment' in which life and living takes place, and instead recognise architectural designs as themselves forms of biotic life and liveliness.

This paper explicitly focusses on how clinical staff attempt to orchestrate the movements and flows of patients through clinical space. We show how the attempted segregation of CF patients (from each other) comes into tension with healthcare buildings designed during, and indeed for, the antibiotic era. Our study demonstrates the deeply 'interpretive flexibility' of buildings (Gieryn 2002) and the complex strategies used to reconcile conflicts between practices, priorities and the built environment. By concentrating on both clinical labour and building design, this paper distinctively complements previous research on the implications of segregation for patient experience (e.g. Duff 2002; Griffiths et al. 2004; Lowton and Gabe 2006; Russo et al. 2006; Russo 2007; Waine et al. 2007). At the same time, research on experiences of the built environment in healthcare contexts has tended to focus on service users rather than staff (Buse and Twigg 2018). In what follows, we first layout the background and history whereby AMR interacts with questions of building design more broadly, and in the context of CF more specifically. We then outline our methodology before turning to three core recurrent analytical themes in our data. These include, first, the managed flow of patients, their movement within clinical space and the spatiotemporal choreography of CF care. Second, the orchestration of waiting and the materiality of the waiting room in terms of layout, design and furnishing is an enduring concern for clinical respondents in our fieldwork. Our third and final theme is concerned with the clinical management of air-borne pathogen risks and the material mitigation of cross-infection through various approaches to airflow, ventilation and access to 'fresh air'. However, approaches to what we might call 'air care' are deeply contingent upon material aspects of modern healthcare building design.

Cystic Fibrosis, AMR and the built environment

Our approach to questions of design and architecture in respiratory care is informed by a growing humanities and social science literature on healthcare and the built environment (Martin et al. 2015, Bell et al. 2018). This includes research exploring how the design intentions of architects relate to the lived experience of the building for healthcare professionals and patients (e.g. Adams et al 2010, Bromley 2012, Curtis 2007). Martin's (2016) research on Maggie's cancer care centres, for instance, applies Kraftl's (2010a: 409) concept of 'choreography', conceptualising architecture as 'a kind of 'choreographing' endeavour, combining the design *and* use of built spaces'. He examines how philosophies of 'care' and 'hospitality' are enacted through the everyday routines and time-space practices of clinicians and patients, in dialogue with the material environment. Similarly, we explore the interconnection of the situated impact of healthcare architectural design for AMR and cross-infection with the lived experiences, routines and practices of clinical settings. The CF clinics at the centre of our study, are highly dynamic and in constant states of change as they are made and re-made by the practices of building users, illustrating 'architecture in the making' (Yaneva 2008, 12).

Cystic fibrosis and respiratory infections prompt us to think carefully about shifting understandings of biotic life and parallel changes in architectural and material forms. How is it, for example, that we have historically come to envisage restructuring space for a 'post-antibiotic age' (Brown 2019; Holmdahl and Lanbeck 2013)? Design, materials and spatial layout necessarily give expression to successive discursive shifts in healthcare (Verderber & Fine 2000). Prior (1992; 1988) genealogically traces the history of hospital architectural plans,

revealing fundamental changes in competing medical discourses. He reflects on a late-nineteenth century children's ward, a hexagonal pavilion shape with beds dotted around the edge, each bed having a window opening onto a surrounding veranda. Patients would be wheeled outside during the daytime, a classic feature of 'fresh air wards', a material discourse influenced by a miasmic theories of contagion. Anticipating our discussion below on 'air care', illness is here conceived as a question of atmosphere, chemical processes, fermentation or putrefaction, resulting in airs, vapours and stagnating fumes. Torpid air must move if it is not to fester.

As miasma gives way to germ theory, air and atmosphere give way to a focus on touch, contact, interaction and surfaces. But much of that emphasis on air and light was not necessarily lost. Blundell Jones (2016) reflects on two well-known early modernist hospital designs pre-dating the antibiotic age, Jan Duiker's Zonnestraal (1926) and Aalto's Paimio (1928), both tuberculosis sanatoria. Like their fresh air ward precursors both are intended to take advantage of the vulnerability of TB to ultraviolet light: '… benefits of sunlight and air... [are] oriented to make best use of the sunlight that provided a valuable weapon against... [TB] before the age of antibiotics for the *tubercule bacillus* is killed by ultraviolet light' (267).

According to Bud (2006, 2007) antibiotics have played a key role in reshaping clinical space, enabling new efficiencies, concentrations of scale, compressions and densities of clinical activity. In some ways infection becomes a matter of pharmacological rather than spatial and environmental control. In this way Chandler (2016) writes of antibiotics as 'infrastructure', constituting healthcare spaces in deeply socio-material ways. Healthcare architectural literature also highlights fundamental conflicts between the competing spatial priorities of hygienism in tension with 'patient experience' (Bromley 2012). The 'antiseptic architecture' of the modernist era, its industrial scale and density, is thought to conflict with 'patient comfort' and wellbeing (Jencks and Heathcote 2010, 6-7). But segregation may also be seen to architecturally align with more individualised aspects of personalised care and privacy.

It is against the backcloth of this multi-layered history that we situate more specific challenges in the context of CF and antimicrobial resistance. The material practices associated with cross-infection control in CF are far from stable and have altered radically over the course of recent decades, evolving in direct tension with the buildings in which healthcare is delivered. Until the late 1980s most people with CF would have been accustomed to spending time together in the same buildings and spaces. Care would have been organised to facilitate interaction, sociability and mutual support through games rooms, social events, summer camps, holidays and clubs. Having CF would have been organised around an embodied sense of mutual identification with others sharing the same condition and physical spaces.

But by the early 1990s, clinical studies had established causal relationships between social contact and the circulation of cross-infectious bacterial 'epidemic' strains. Holidays camps for children had resulted in the person-to-person transmission of resistant *Pseudomonas aeruginosa* (Tummler et al. 1991; Ojeniyi et al. 2000). Cross-infection was found to be virtually inevitable during prolonged periods of contact. The 1990s emergence of the 'Liverpool Epidemic Strain' (LES) was understood to provide the first 'unequivocal evidence' of resistant *P. aeruginosa* cross-infection amongst unrelated patients (Al-Aloul et al. 2004; Panagea et al. 2005; Conway 2008). As a consequence, the whole world of CF has lurched from one characterised by interaction and sociability, to one characterised by segregation and thresholds of confinement. Cross-infection results in bacteria evolutionarily selecting for resistance and consequently more frequent high-dose antibiotic treatment, poorer post-transplantation

prognosis and shorter life expectancy. Essentially, if people with CF meet, they can kill each other.

Reducing resistant cross-infection in CF and other contexts has therefore increasingly come to depend on rituals and architectures of physical isolation. This includes sophisticated choreographies of social distancing, restrictions on physical interaction and the avoidance of public spaces (waiting rooms, public transportation, lobbies, entrances, elevators and corridors, etc.). Preventing resistant cross-infection has gradually become a question of spatial layout, architectural design, signage, pathways and physical flow. Movement through space (of patients, visitors, clinicians, support workers, devices, etc.) therefore necessitates careful choreography to reduce AMR.

And yet, restricting social contact is acutely contentious, both materially and socially (Duff 2002; Griffiths et al. 2004) particularly in the context of a condition which disproportionately affects younger people (Russo 2007). Parents understandably recount the challenges of 'containing' their children (Russo et al. 2006) and imposing restrictive codes of hygienic conduct on their playful youngsters. Spatial segregation also has adverse implications for recreational social contact and sexual intimacy (Jamieson et al. 2014). The romantic tragedy is a recurrent narrative trope in the stories told of, and by, people with CF. These, and other aspects of 'segregation' highlight the many tensions between competing mandates of living with CF. There are also, predictably, wide variations in the socio-material techniques employed to minimise resistant cross-infection. Clinics are differently configured within highly varied architectural constraints with implications for the choreography of segregation. Localised differences in the real world of segregation have been endemic: '…some CF centres have a strict patient segregation policy, some centres have no policy at all, and many centres follow management protocols that fall at varied points between these two extremes' (Conway 2008, 31).

Research into the different design priorities within the built environment of respiratory clinics remains sparse. There are several classic ethnographic studies focussing on spatiotemporal flows (Roth 1963; Zerubavel 1979; Fox 1997), but very little in the more recent context of CF and AMR specifically. Lowton (2009) shows how the physical environment and symbolic meanings of place shape experiences of end-of-life care in CF. However, less account has been taken of the role of the built environment in literature on CF and experiences of segregation. Some studies highlight CF patient concerns about hospitals as 'dirty' or 'risky' spaces (e.g. Russo 2007; Russo et al. 2006). Lowton and Gabe (2006) describe how some patients self-manage and maintain physical distance from others with CF when visiting hospitals. However, there is less previous research on clinical staff experiences of attempting to manage segregation, and how this takes place through material and spatiotemporal strategies. This paper therefore explores the way AMR mitigation is differently performed by clinicians in respiratory clinics in dialogue with the built environment. For the clinics in our study, segregation to prevent cross-infection is essentially a question of design within what Fox (1997) has called 'circuits of hygiene'.

Methodology

This paper draws on data from an ongoing study [anonymised] (2018-2020), exploring the management of cross-infection in CF clinics working with patients, clinicians, architects and designers. The study includes qualitative and creative methods comprising documentary analysis (including analysis of plans, segregation policies, and newsletters), graphic interviews, walking interviews, ethnographic observations, and co-design workshops. Here we use the term 'creative methods' to refer to participatory approaches using visual and arts based

practices (Kara 2015). Data collection is being conducted at sites over a period of around 10 months and is ongoing. The sample so far includes 52 respondents based at 3 cystic fibrosis clinics (34 hospital staff, 13 patients, 2 family members, and 3 architectural designers). The three clinics selected for our comparative case study were chosen to reflect differences in their architectural history, their layout, the scale of their delivery, the implementation of their segregation policies, and their differing material approaches to resistant cross-infection. Site 1 has around 35 adult CF patients, and is based within a 1970s built hospital. Site 2 accommodates 400 CF patients, with outpatient CF services based in the 1990's wing of an outpatient hospital built to treat infectious diseases during the 1890s. Site 3 has over 300 CF patients, with outpatient services based within a specialist respiratory department built during the early 1990s, situated within a larger hospital estate. None of the clinics are purpose-built CF units.

Here we focus on staff experiences of managing cross-infection, drawing on initial study data from 28 graphic interviews with 33 hospital staff (5 physiotherapists, 4 CF nurses, 7 consultants, 2 healthcare assistants, 2 infection prevention staff, 3 estates personnel, 8 domestic services staff (managers and cleaners), 1 portering manager, 1 ward clerk) and 18 walking interviews. Our graphic interviews involve the use of drawings (sketches, maps, plans) to elicit discussion (Bagnoli 2009). In this case, architectural plans of the clinics were used to prompt discussion about spatial practice, encouraging participants to annotate plans, using different colour markers indicating routes, cross-infection 'hot spots', design features and potential improvements. Respondents were then invited to participate in a walking interview, guiding the researcher along their route(s) through the building, and using the built environment as a prompt for discussion. During walking interviews the researcher took photographs to document spaces, objects, signage that the respondent identified as significant.

Ethical approval for the research was granted by the UK NHS Research Ethics Committee (REC). The names of participants and clinics have been changed to protect anonymity. Scheduling graphic and walking interviews at hospital sites helped to minimise disruption to routines. During walking interviews, the researchers avoided taking photographs that could identify people or clinic sites. The potential implications of anonymity during walking interviews were carefully discussed with staff and patients, as were preferences for how the interview was recorded (e.g. audio-recording with lapel microphone, note-taking and photography).

The researchers recorded detailed fieldnotes after each interview or observation, identifying emerging themes and issues. Transcripts and fieldnotes were analysed thematically using NVivo qualitative software. The different types of data are being analysed in dialogue with one another using NVivo to create links between written and visual data. This triangulation of sources can add 'depth and detail' across different types of data bringing (Woolner et. al. 2010, 20). For instance, comparison of participants' graphic maps highlights similarities and differences in perceptions and use of space between participants. Data from the walking interviews brings to light tacit practices, embodied routines and knowledges which are often hard to recall in 'sit down' interviews, as well as the sensory experience of place. Much of what follows draws directly on interview transcripts, nevertheless the visual and graphic data has been integral to our analytical approach and the contextualisation of interview data.

Flow, movement and spatial segregation

Within the constraints of available physical space, segregation within CF clinics involves scheduling clinical appointments at different times, on different days and sometimes in

different spaces, thereby preventing different bacterial strains coming into contact with each other (resistant and non-resistant, transmissible and non-transmissible, etc.). Segregation, and therefore the whole patient experience, commences with bacterial diagnosis, and the classification of patients according to the bugs they 'grow':

> *... I classify patients according to their bacteria... I would have overall say of who would come to which clinic […] we would aim to take a sputum sample [...] on a regular basis [...] if they are not able to produce sputum we will try and get a cough swab… we get those sputum samples and then the laboratory process them and inform us what bacteria they have growing, and then we classify people…* (consultant, site 1)

Classification underpins the construction of spatial divisions in hospital environments, facilitating practices of segregation and control (Prior 1992) and therefore shaping the construction of temporal and spatial boundaries between CF patients. Patients are 'cohorted' (Russo 2007) according to the bacteria that they have in common and scheduled to attend the clinic. In this sense, the bodies of patients and bugs become intricately entangled with one another. Everything depends on what it is that patients 'are growing' or what 'they grow' (CF clinicians). Bacteria becomes a significant referent for the patient, shaping their 'journey' through the hospital (Mol 2002), who it is that they meet, when and where they can attend the clinic, and whether or not they are safe or unsafe. Nevertheless, this careful choreography of the patient through clinical space tends to break down as patients with co-morbidities enter in and out of other aspects of care beyond the CF clinic itself (blood-taking, x-ray, transplantation, diabetes, etc.). The bacterial classification of patients also exhibits ambiguities and variations. While all three clinics segregate patients with *cepacia* or *pseudomonas*, clinics vary in whether and how they segregate for different strains of these bacteria, or other types of bacterial infections including *nontuberculous mycobacteria* (NTM). At an individual level, classification is fluid and shifting as patients develop new bacterial infections. 'You are only as good as your last sputum sample' is a constant and recurrent refrain in the clinical world of CF.

Although different bacterial cohorts are scheduled to attend the clinical space at different times, the potential for cross-infection within cohorts remains. To mitigate this, staff carefully choreograph the movement of bodies through the clinic to keep patients separated, creating what Seamon and Nordin have called 'place ballet' (1980). One such technique used in two clinics (site 1 and 2) is referred to as the 'carousel'. During graphic interviews, staff (in particular healthcare assistants and nurses) mapped out how they guide patients directly into consultation rooms, while the patient remains stationary for the duration of their appointment. While the patient remains spatially static, the multidisciplinary staff team 'moves around them' reducing the risk of patients meeting in corridors, hallways and waiting areas. In the smallest clinic (site 1) running outpatient surgeries of around six patients, this process was regarded by staff as relatively unproblematic. However, in site 2 with clinics of up to nineteen patients per clinic, staff described the challenges of 'keeping things moving' so patients are seen on time and not 'hanging around'. As one consultant said you are 'constantly trying to keep up'.

The choreography of bodies in this way depends on the affordances of the built environment, its dimensions and geometry. Despite high numbers of patients in site 2, the clinic benefits from its own dedicated CF outpatient clinic area with seven specialist rooms servicing its weekly clinics. During walking interviews, the quietness of this space was in stark contrast with the clinic area at site 3, which is based in a busy outpatient area, where staff struggle to 'keep hold' of rooms in competition with other outpatient clinics. Staff here describe how the 'carousel' approach is unworkable due to the constraints of the building, room availability, and high patient numbers:

> *… space has always been a premium… because in an ideal world… you would have a patient in a room and they wouldn't move…everyone would go in to them and then they would leave. But our patients arrive, wait in the waiting area, go through and have pulmonary function, then come through to the doctor. And you could have three or four patients with CF sat in the waiting area… We don't have the facilities to have a patient in a room and we all move around* (CF nurse, site 3).

A physiotherapist at the same site expressed similar views: '... we'd need potentially 21 rooms' and 'a purpose-built facility', and sufficient numbers of staff working across rooms. As patients go back and forth to appointments, there is the risk of crossing pathways. Staff at each of the clinics seek to manage this through the 'staggering' of appointment times, with specific intervals (often fifteen minutes) between patient appointments. However, if a patient turns up late, or just as likely, too early, they still risk 'bumping into' another CF patient. The meticulous sequencing of patients and their bugs holds together only to the extent that patients arrive and depart on time, as one consultant at site 3 puts it:

> Consultant: *So if they all turn up in their allocated time the dance works beautifully. They know they should come at their clinic time. They decide they do not want to come at their clinic time. […] We negotiate with them when we are booking an appointment, when's best for you, what time are you going to be.*
>
> Interviewer: *But they don't come [on time]?*
>
> Consultant: *Of course they don't.*

This 'place ballet' (Seamon and Nordin 1980) depends on the regularity and predictability of a ritual practice, a choreographed 'dance', that is easily disrupted by unscheduled arrivals. Respondents at all of the clinics highlight problems with punctuality and time keeping. On the one hand, this reflects the precarious instability of the choreographed synchronisation of bugs and bodies to prevent cross-infection. Inevitably, timing comes to depend on a whole range of wider contingencies connected to the patient journey. But on the other hand, deviations from the appointment schedule are also inseparable from a moral discourse of 'patient compliance' and even 'disobedience'. However, clinicians also discuss the tensions between making sure patients adhere to appointment times, and make sure that they receive 'care'. This reflects debates in CF care and more widely around the tensions between maintaining segregation and sterility, and providing personalised care (Russo 2007). As one clinician put it:

> *Of course we're going to see them. That's what we're there for…And ultimately what's our issue here? Is our issue to care and treat patients, or is our issue to be so safe that nobody ever gets looked at?* (consultant, site 3)

Despite efforts to temporally separate patient pathways, the risk of patients passing in corridors, entrances or waiting areas remains, often exacerbated by the building design. Corridors in some areas are described as 'tight' or 'congested' and conducting walking interviews in these spaces involved squeezing past staff, patients and trolleys. According to Gieryn (2002, 61) 'buildings insist on particular pathways that our bodies move along everyday' and 'install routines in the movement of bodies' that 'quickly become implicit'. However, the collision between CF segregation, and buildings designed in the antibiotic era, renders the implicit explicit, bringing these pathways to the fore. Respondents talk of the desirability of a 'one-way system' or 'one-way flow' preventing patients entering and leaving using the same route, something observed in some purpose-built CF units.

Building design often imposes inescapable constraints. At site 1 ad-hoc outpatient appointments take place on an inpatient ward with one central corridor having 'only one way in and one way out', a cross-infection 'crunch point' according to one physiotherapist. However, while the outpatient department has an alternative exit, patients still tend to exit through the entrance. The use of signage directing patients would be difficult because the space is shared with other services: 'I think if we had our own space it would be very different…we would have set entrances and exits, highlight that importance of how they navigate the area' (nurse). This is in contrast to Fox's (1997) discussion of operating theatres, with 'sterile corridors' and clear signage directing 'circuits of hygiene'.

A further challenge for clinical staff is that the careful segregation of bacterial 'cohorts' is insufficient to spatiotemporally accommodate the sheer ecological diversity of the bacterial resistiome in CF. As one clinician puts it, 'there are far more bugs than there are days in the week... with every new strain, we need to come up with another separate day [and] ignore a lot of bugs' (Consultant, site 3). The classification of different bacterial strains is constantly evolving. Patients 'growing something new' may be seen in isolation at separate times and spaces until they can be appropriately reclassified. But the logistical life of the CF clinic must continually respond dynamically to the emergence of new strains of pathogen. Nevertheless, there are limits to the subdivision of clinical time by pathogen, and the adaptability of the built environment in creating sufficient space to accommodate an ever-diversifying bacterial ecology.

Waiting

The hospital waiting room is a classically liminal space riven with ambivalence, anxiety, hope, and frustration (Akerstrom 1997, Cohn 2001). In the context of CF, episodes of waiting or having to linger in spaces shared or occupied by others can be an acute source of concern. In graphic interviews using layout plans clinical staff routinely identify waiting rooms as high-risk cross-infection 'hot spots'. People with CF are advised to sit at least six feet (or two metres) apart from the next person with CF (CF Foundation 2014). There must always be a space in which to breathe, a bubble of air around one's chair. And yet there are important differences in how 'waiting' is spatially choreographed within contrasting architectural arrangements. Outpatient visits often involve the input of numerous specialists, sometimes involving multiple episodes of waiting thus increasing chance encounters. It is important therefore to ask how 'waiting' in hospital (Strathmann & Hay 2009; Arneill & Devlin 2002; Malatino 2013) is performed and features in the design of AMR mitigation.

Staff actively manage patient pathways to discourage or minimise waiting, physically guiding patients through the building to their appointment, preventing them 'hovering' or 'congregating'. The layout plans annotated by nurses and healthcare assistants showed movements back and forth, 'looking out' for patients in the corridors to 'guide them' quickly into their clinic room, discouraging them from sitting down. Technologies can facilitate, or disrupt, the management of waiting times. The clinical team at site 1 use text messaging to communicate directions and room information to patients. At site 3 patients use a touch screen to confirm their arrival. Visual displays in the waiting area then call them through to the treatment room. Nevertheless, staff still prefer to greet patients in person to guide them through the building 'safely' and directly, as one consultant says: 'I go and get the patient, so I can guide them from their chair into my room' (consultant, site 3).

Where waiting is necessary, staff closely monitor waiting areas, and using mundane material strategies to maintain distance between patients. The material arrangements of waiting areas

can be used to engender either sociability or segregation (Bell 2018). In site 2, based at an outpatients hospital, there are three separate waiting spaces, and staff showed us during walking interviews where they would direct CF patients to sit so that they are spread out, one patient per waiting area. If these areas are occupied, they encourage patients to wait outside in their vehicle. However, this is only possible because of the availability of multiple waiting areas and nearby parking at this particular site. Elsewhere, at the Tuesday clinic in site 3 they have only one waiting area, which is a small alcove in the corridor, adjacent to the clinic rooms. Instead of permanent seating there is a stack of plastic chairs. Before the start of each clinic, staff carefully set chairs out two metres apart, creating some degree of physical distance between patients. The materiality of the chairs is important. One nurse suggested the choice of 'little plastic chairs' is deliberate 'because we don't want to encourage people to be sitting there'. Comfortable seating encourages bodies to be at rest (Bissell 2008), while CF clinic staff are keen to keep patients 'moving on'. The use of 'hard and cold' materials incites the 'body-in-waiting' to be 'alert and attentive', ready to move (ibid, 1705).

However, complex intersections of the biographies of buildings, bugs, and patients can thwart attempts to maintain segregation in waiting spaces. The Tuesday clinic at site 3 is for patients with an epidemic strain of *pseudomonas* who are seen in the morning, and patients with *Cepacia* who are seen three hours later in the afternoon. Many of these patients are from older cohorts who have grown up prior to segregation and have long-term friendships.

> *... these older ones ... just, don't care. When I first started... there used to be a social club just down there... and the cepacia patients and the pseudomonas patients used to come over and play pool together. […] And then we discovered [epidemic strain], and we separated the [epidemic strain] and the non-[epidemic] out. So you've still got some of those patients that remember the pool playing days and you just think, that ain't going to work, they're not interested* (nurse, site 3).

This illustrates how tensions between segregation and sociability are played out in the microcosm of this space (Russo 2007). The social rules around waiting are deeply localised and entangled with the specific biographies of bodies and place. As one consultant puts it: 'they grew up with a culture of you must mix and... support each other… and they have known each other for 30 odd years [they] remember the pool playing days'. Furthermore, for those with *Cepacia* or other 'nasty bugs', it was understandable that patients would reject socially limiting segregation: 'I think partly they accept they've got the worst bug they can get, so why segregate?' (consultant, site 3). This group of patients therefore represent something of a 'dissenting enclave' where isolation and the authority of clinic staff are resisted (Lowton and Gabe 2006). In contrast, other research suggests that adherence to segregation strengthens with maturity and the exacerbation of symptoms over time (Russo et al. 2006).

Despite these challenges, clinical staff feel they have 'more control' over the Tuesday waiting area and are able to 'monitor' patients given its close proximity to the clinic rooms. In contrast, the Monday (non-*pseudomonas*) clinic had become too large to be accommodated by this waiting area, so patients now use a large, general waiting area for the outpatient clinic. Here staff have less 'control' over the management of this space, which is more distant from clinic rooms, limiting opportunities for staff surveillance. They also have less control over the layout of the space which recently underwent a refurbishment with unintended consequences for AMR. Architects were commissioned to make waiting more 'comfortable' giving it the atmosphere of leisure and retail hospitality. The design brief specified an area that 'functions like a hospital' but 'looks like a hotel' (estates manager). A Costa café was incorporated into the space, and new couch style benches were introduced alongside stand-alone chairs and tables.

Although this waiting area is more spacious, the couches (introduced for 'bariatric' patients) make social distancing for CF patients more difficult. The result is a shared open-plan space where different patient groups can move more freely amongst each other. That is often what the design of public space is supposed achieve, to optimise interaction (Jull 2011), yet for some members of staff this raises concerns about cross-infection.

This illustrates wider tensions between discourses of hospitality and comfort in healthcare design (Bromley 2012) and increasing emphasis on sterility. It also raises questions concerning the agency of staff to shape the spaces they work in. One of the clinics (site 2) had spent several years lobbying to have the carpets in the entrance, corridors and waiting area replaced with hard surface flooring. This has now been achieved, but with the input of additional funding raised by the CF unit itself. Many healthcare settings, including our CF clinics, have seen soft-fabric chairs replaced with wipeable plastics. In the new outpatient waiting area discussed above, fabric seating was replaced with material that is easy to clean, and compliant with infection control requirements. Yet estates and domestic services staff at the different clinics described the challenges of creating a homely or hotel like environment, while using more 'institutional' materials that meet with infection control requirements. As one respondent from a hospital estates team (site 1) put it: 'in my personal opinion you shouldn't go down [the hotel] route, because then we are using materials and carpets that don't fit with a sterile environment.' Here again, aspects of comfort and hygiene can be seen to be in tension with one another highlighting conflicts between competing registers of wellbeing, comfort and security.

Airs and atmospheres

AMR mitigation strategies largely focus on materially tangible objects, surfaces and interactions. However, CF clinics have become increasingly concerned with airborne cross-infection and the design of airflow (ducting, ventilators, windows, airtight doors, etc.). By the mid 2000s, airborne circulation of the 'Liverpool Epidemic Strain' (LES), a significant factor in CF morbidity, had been detected in rooms and flowing into adjacent areas several hours after being vacated (Panagea et. al. 2005). This focus on the air raises important questions in 'making the invisible visible' (Macduff et. al. 2014) and how air is made material and tangible in CF clinics through the everyday 'air practices' of staff (Hauge 2013).

Part of choreographing 'flows' through the clinic, involves managing flows of air between patient appointments, in order to minimise the risk of airborne transmission. This forms part of the 'boundary work' of preventing infection (Mesman 2009). Many clinical staff are concerned, but also unsure, how long 'bugs' remain 'lingering in the air' (CF nurse). In newly designed buildings for people living with CF or other infectious diseases, negative air pressure systems can be used to manage the threat of airborne bacteria (Holmdahl and Landbeck 2013). However, in our partner clinics which are part of older NHS hospital buildings, these facilities are unavailable in outpatient clinic rooms. Hospital estates personnel at site 1 describe a lack of air conditioning in the hospital which had been 'built on the cheap'. During walking interviews they showed us the extensive space on the hospital roof taken up by air purification systems for surgical theatres, explaining that these systems are impossibly expensive to retrofit because the 'structure of the building is not designed for it'. This reflects limitations concerning the adaptability of hospital buildings (Weeks 1965) to changing standards of hygiene and management of AMR.

Yet despite constraints on the availability and control of systems for mechanised air, examining everyday 'air practices' reveals how staff attempt to regain control (Hauge 2013), developing

'work-around' solutions with existing buildings. This includes, where possible, opening windows in treatment rooms to 'change the air' and let in 'fresh air'. As one CF nurse describes: 'ideally we would need the negative pressure rooms… all we can do is open the windows to get some fresh air' (CF nurse, site 1). Window opening is seen as particularly important if a patient has been 'coughing up' in order to provide a sputum sample:

> *... the environment .. it's hard to say sort of how clean [it is]. When you've been in the room and someone's been coughing... . You've cleaned your hands, you've tidied the [sputum] pot away, you've cleaned the surfaces ... but how long it stays ... sort of airborne, you don't really know…I always have the window open in the room. But there's a lot of rooms that don't have windows that open… when there's not a patient I have the door open. But then I don't know whether that's a good or a bad ... you're potentially spreading whatever has been in your room back out into the area...* (physiotherapist, site 3).

Most contemporary clinical buildings are hybrid environments with a mixture of sealed and openable window designs. As one consultant describes when complaining about the un-openable windows: 'I do worry that affects the airflow…someone coughs in the room, is that sticking around longer…?'. If he requires a patient to produce a sputum sample, he will sometimes send them to 'cough up' in the 'physio room' instead which has an openable window. Opening a door to let bad air out is enmeshed in uncertainty, potentially allowing bad bugs out into the rest of the clinic. Site 1 encourages staff to keep doors closed, to avoid the spread of airborne bacteria.

Respondents are also concerned about whether airborne bacteria 'sticks' to them, and whether it 'clings' to their bodily surfaces and clothing, to be passed on to other patients: 'if someone coughs during your physio session… at what point are you not covered in *pseudomonas*? (physiotherapist, site 3). They try to manage this through the sequencing of patients, but also through the management of clothing. This includes hospital-wide 'bare below the elbow' policies, changing clothes before leaving the clinic, and wearing protective clothing like gloves and disposable aprons when seeing patients with 'bad bugs' (e.g. NTM, MRSA). However, staff expressed concern that the wearing of protective clothing like gloves and aprons could make care feel quite cold and 'clinical', again raising tensions between the sterility of treatment and more qualitative and interpersonal aspects of care, not least the stigmatisation of patients with particular bacterial infections (see also Duff 1992).

Managing the risk of airborne transmission is entangled with the choreography of appointment timings. Where possible rooms are 'rested' between appointments to ensure 'there was no contamination in the air' (nurse, site 1). Staff at site 3 operate a 'forty-five-minute rule', leaving longer (several hours) between patients with certain bacterial strains. This 'rule' also has to be flagged up if patients go to appointments in other departments. The X-Ray department would be instructed to leave two hours between patients. The ordering of patients with different bacterial infections is also used to address concerns about airborne bacteria, seeing patients with 'nasty bugs' last:

> *... the way we always see our patients... is the least infectious bugs first with the more nasty bugs last… so that if for whatever reason cleaning hasn't happened or whatever, and any bugs do happen to be lingering in the air, they're not going to be an issue. Because the bugs that they grow are worse than the ones that could possibly be lingering in the room…* (nurse, site 3).

Yet the ability to be able to 'rest' rooms between patient appointments is again limited where staff have to see high numbers of patients within a half-day clinic, and also need to avoid patients sitting in waiting areas. One suggestion for addressing this is having smaller clinics running throughout the day, but this is described as 'resource intensive', deploying a multi-disciplinary team of staff for a full day's work with a small number of patients. The other option is 'more rooms', yet this again comes back to the constraints of available space in hospital buildings. Examining air practices therefore reveals tensions between the agency of staff as they seek to adapt hospital buildings to mitigate cross-infection, and the constraints of the built environment (Lewis 2015).

C**onclusion/s**

Our concern in this paper is to join others in re-adjusting the way we understand the 'problem' of AMR to take account of the otherwise understated role of the built environment. To date, most attention in policy making and social science research envisions AMR in terms of 'behaviour', including practitioner antibiotic prescribing, the off-label use of antibiotics, diagnostic error, poor patient adherence to medicinal guidance, the use and mis-use of antimicrobials in agriculture, etc. Another dominant discourse emerging since the mid-1990s or so lies in the politics of hospital hygiene and declining sanitary standards. While each of these frameworks have been hotly debated, far less account has been taken of the way AMR is located spatially and architecturally in a world configured socio-materially through building layout, corridors, waiting rooms, scheduling, appointment logistics, windows, air ventilation and many of the other aspects of infrastructural design explored in this paper.

A focus on the role of the building, and spatiotemporal practices, brings to light the hidden work of staff in cystic fibrosis clinics, carefully choreographing the movement of bodies and materials to prevent cross-infection. It also illuminates tensions between the choreography of segregation and the choreography of care (Martin 2016). These tensions are prominent in the literature on cystic fibrosis, which illustrates the positive impact of segregation policies on the physical health of patients, alongside potential negative consequences for sociability and support. Our paper extends these debates to looking at the architectural design of CF clinics, and their temporal and spatial organisation. Wider discourses which aim to bring a sense of hospitality, sociability and comfort into the design of healthcare spaces clash with efforts to maintain sterility and separation. These tensions are navigated and negotiated by clinical staff at a real material level as they carefully choregraph appointments and monitor patient pathways, weighing up the importance of segregation whilst ensuring that patients are 'seen' and receive necessary care. The balance between supporting people to live well with cystic fibrosis and remain 'safe' when visiting outpatient hospitals presents ongoing dilemmas, with implications for design and care practice.

The specific case of cystic fibrosis clinics explored here also raises questions concerning the potential of building design to keep up with constantly changing discourses around AMR and cross-infection. Policies around managing cross-infection in cystic fibrosis clinics have changed rapidly over the last twenty years, yet the design of existing hospital buildings is less easily adapted. The three sites we are working with are not purpose-built CF clinics, the most recent of which was built in the early 1990s, before the widespread adoption of segregation policies for CF. The buildings therefore do not facilitate the easy flow and separation of patients. Instead staff have to work creatively with, and within, the constraints of these material environments. This has practice implications, echoing long standing calls for the design of hospital buildings that are flexible and adaptable to changing policies and practices (Weeks 1965). The need for adaptability has particular salience in the context of cystic fibrosis, and AMR more generally,

where practice is continually evolving, in tandem with the evolution of microbial life. It also concerns the 'interpretive flexibility' (Gieryn 2002) in terms of how it is that building users continually adapt their environments, in dialogue with changing policies and recommendations for mitigating cross-infection. This has implications at a local level concerning the potential for clinicians to adapt the spaces they work in, and input into their design and re-design. Attending to interpretive flexibility troubles the idea of a simple 'technological fix' (Sime 1986), and instead calls for further exploration of the way buildings and the bodies that inhabit them co-configure one another in taking account of an ever-changing and dynamic microbial ecology.

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References

Adams, A., Theodore, D., Goldenberg, E., McLaren, C., & McKeever, P. (2010). Kids in the atrium: Comparing architectural intentions and children's experiences in a pediatric hospital lobby, *Social Science & Medicine*, 70, 5, 658-667.

Akerstrom, M. (1997). Waiting - A source of hostile interaction in an emergency clinic. *Qualitative Health Research*, 7, 4, 504-520.

Al-Aloul, M., Crawley, J., Winstanley, C., Hart, C. A., Ledson, M. J., & Walshaw, M. J. (2004). Increased morbidity associated with chronic infection by an epidemic Pseudomonas aeruginosa strain in CF patients. *Thorax*, 59, 4, 334-336.

Bagnoli, A. (2009). Beyond the standard interview: the use of graphic elicitation and arts-based methods. *Qualitative Research*, 9, 5, 547–570.

Bell, S. E. (2018). Placing care: embodying architecture in hospital clinics for immigrant and refugee patients. *Sociology of Health & Illness*, 40, 2, 314-326.

Bell, S. L., Foley, R., Houghton, F., Maddrell, A., & Williams, A. M. (2018). From therapeutic landscapes to healthy spaces, places and practices: A scoping review. *Social Science & Medicine*, 196, 123-130.

Bissell, D. (2008). Comfortable bodies: sedentary affects. *Environment and Planning*, 40, 7, 1697-1712.

Braun, B. (2013). Power over life: biosecurity as biopolitics. In Dobson, A., Barker, K. & Taylor, S. L. (Eds.). *Biosecurity: The socio-politics of invasive species and infectious diseases* (pp. 59-72). Lonson: Routledge.

Bromley, E. (2012). Building patient-centredness: hospital design as an interpretive act. *Social Science & Medicine* 75, 6, 1057-1066.

Brown, N. (2019). *Immunitary Life: A Biopolitics of Immunity*. London: Palgrave MacMillan.

Brown, N., & Nettleton, S. (2017). 'There is worse to come': The biopolitics of traumatism in Antimicrobial Resistance (AMR). *The Sociological Review*, 65, 3, 493-508.

Brown, N., & Nettleton, S. (2017). Bugs in the blog: Immunitary moralism in antimicrobial resistance (AMR). *Social Theory & Health*, 15, 3, 302-322.

Brown, N., & Nettleton, S. (2018). Economic imaginaries of the Anti-biosis: between 'economies of resistance' and the 'resistance of economies'. *Nature - Palgrave Communications*, 4, 1, 123.

Buse, C., Twigg, J., Nettleton, S. and Martin, D. (2018). Dirty linen, liminal spaces and later life: Meanings of laundry in care home design and practice, *Sociological Research Online* https://doi.org/10.1177/1360780418780037

Chandler, C.I.R., Hutchinson, E., & Hutchison, C. (2016). *Addressing Antimicrobial Resistance Through Social Theory: An Anthropologically Oriented Report*. London School of Hygiene & Tropical Medicine.
http://www.lshtm.ac.uk/php/ghd/research/app/anthropologyofantimicrobialresistance.html

Cohn, E. S. (2001). From waiting to relating: Parents' experiences in the waiting room of an occupational therapy clinic. *American Journal of Occupational Therapy*, 55, 2, 167-174.

Conway, S. (2008). Segregation is good for patients with cystic fibrosis. *Journal of the Royal Society of Medicine*, 101, 1, 31-35.

Curtis, S. (2007). Therapeutic landscapes in hospital design: a qualitative assessment by staff and service users of the design of a new mental health inpatient unit. *Environment and Planning C: Government and Policy*, 25, 591-610

Cystic Fibrosis Foundation (2014). *Germs and cystic fibrosis: the facts*. Bethesda, MD: CF Foundation.

Duff, A. J. A. (2002) Psychological consequences of segregation resulting from chronic *Burkholderia cepacia* infection in adults with CF. *Thorax*, 57, 9, 756-758.

Fox, N. J. (1997). Space, sterility and surgery: circuits of hygiene in the operating theatre. *Social Science and Medicine*, 45, 5, 649-658.

Gieryn, T. F. (2002). What buildings do. *Theory and Society* 31, 35-74.

Griffiths, A. L., Armstrong, D., Carzino, R., & Robinson, P. (2004). Cystic fibrosis patients and families support cross-infection measures. *European Respiratory Journal*, 24, 3, 449-452.

Hauge, B. (2013). The air from outside: Getting to know the world through air practices. *Journal of Material Culture*, 18, 2, 171-187.

Holmdahl, T., & Lanbeck, P. (2013). Design for the post-antibiotic era: Experiences from a new building for infectious diseases in Malmö, Sweden. *HERD: Health Environments Research & Design Journal*, 6, 4, 27-52.

Jamieson, N., Fitzgerald, D., Singh-Grewal, D., Hanson, C. S., Craig, J. C., & Tong, A. (2014). Children's experiences of cystic fibrosis: a systematic review of qualitative studies. *Pediatrics*, 133, 6, 1683-697.

Jull, A. (2011). *Rethinking the Greek agora interior design and the practice of everyday public space*. Winnipeg: University of Manitoba.

Kara, H. (2015). *Creative research methods in the social sciences: a practical guide.* Bristol: Policy Press.

Kraftl, P. (2010) Geographies of architecture: the multiple lives of buildings. *Geography Compass*, 4, 402–415.

Lewis, A. (2015). Designing for an imagined user: Provision for thermal comfort in energy-efficient extra-care housing, *Energy Policy*, 84, 204-12.

Lowton, K. (2009). 'A bed in the middle of nowhere': Parents' meanings of place of death for adults with cystic fibrosis. *Social Science & Medicine*, 69, 7, 1056-1062.

Lowton, K. and Gabe, J. (2006). Cystic fibrosis adults perception and management of the risk of infection with *Burkholderia capacia* complex. *Health, Risk and Society*, 8, 4, 395-415.

Macdonald, A. (2018). Complex entanglements: design-led research for infection prevention and control training tools. DS 91: Proceedings of NordDesign 2018, Linköping, Sweden, 14th-17th August 2018.

Martin, D., Nettleton, S., Buse, C., Prior, L., & Twigg, J. (2015). Architecture and health care: a place for sociology. *Sociology of Health & Illness*, 37, 7, 1007-1022.

Mesman, J. (2009). The geography of patient safety: A topical analysis of sterility. *Social Science & Medicine*, 69, 12, 1705-1712.

Mol, A. (2002). *The Body Multiple: Ontology in Medical Practice*. Duke University Press, Durham, NC.

Ojeniyi B, Frederiksen B, Hoiby N. (2000). *Pseudomonas aeruginosa* cross-infection among patients with cystic fibrosis during a winter camp. *Pediatric Pumonology*, 29, 177–81

Panagea, S., Winstanley, C., Walshaw, M. J., Ledson, M. J., & Hart, C. A. (2005). Environmental contamination with an epidemic strain of Pseudomonas aeruginosa in a Liverpool cystic fibrosis centre, and study of its survival on dry surfaces. *Journal of Hospital Infection*, 59, 2, 102-107.

Prior, L. (1988). The architecture of the hospital: A study of spatial organization and medical knowledge. *British Journal of Sociology*, 86-113.

Prior, L. (1992) The local space of medical discourse. In Lachmund, J. and Stolberg, G. (eds) *The Social. Construction of Illness*. Stuttgart: Franz Steiner.

Roth, J. A. (1963). *Timetables: Structuring the passage of time in hospital treatment and other careers*. Indianapolis: Bobibs-Menill.

Russo, K. (2007) *The psychological impact of segregation in cystic fibrosis: a phenomenological study*. Hull: University of Hull. Doctoral thesis available at: https://hydra.hull.ac.uk/assets/hull:6998a/content

Russo, K., Donnelly, M., & Reid, A. J. (2006). Segregation—the perspectives of young patients and their parents, *Journal of Cystic Fibrosis*, 5, 2, 93-99.

Seamon, D., & Nordin, C. (1980). Marketplace as place ballet, *Landscape*, 24, 3, 35-41.

Sime, J. D. (1986). Creating places or designing spaces? *Journal of Environmental Psychology*, 6, 1, 49-63.

Smith, R. (2015). Antimicrobial resistance is a social problem requiring a social solution. *British Medical Journal*, 350.

Tummler B, Koopmann U, Grothues D, Weissbrodt H, Steinkamp G, von der Hardt H. (1991). Nosocomial acquisition of *Pseudomonas aeruginosa* by cystic fibrosis patients. *Journal of Clinical Microbiology*, 29, 1265–7

Waine, D. J., Whitehouse, J., & Honeybourne, D. (2007). Cross-infection in cystic fibrosis: the knowledge and behaviour of adult patients. *Journal of Cystic Fibrosis*, 6, 4, 262-266.

Whiteford ML, Wilkinson JD, McColl JH, Conlon FM, Michie JR, Evans TJ. (1995). Outcome of *Burkholderia cepacia* colonisation in children with cystic fibrosis following a hospital outbreak. *Thorax*, 50, 1194–8

Woolner, P., Clark, J., Hall, E., Tiplady, L., Thomas, U., & Wall, K. (2010). Pictures are necessary but not sufficient: Using a range of visual methods to engage users about school design. *Learning Environments Research*, 13, 1, 1-22.

Yaneva, A. (2008) How Buildings 'Surprise': The Renovation of the Alte Aula in Vienna, *Science Studies*, 21, 1, 8-28.

Zerubavel, E. (1979). *Patterns of Time in Hospital Life. A Sociological Perspective*. Chicago: University of Chicago Press.