Using Bandwidths to Visualise and Improve Patient Pathways

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Biography

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Abstract
As global healthcare systems struggle to manage the increasing demand for services, there is a need for better designed patient care pathways. Taking a lean perspective, we propose bandwidths as a novel approach to visualising and improving the (re)design of patient pathways. Using examples we illustrate varying degrees of complexity within the design and illustrate when lean principles might help in providing a standardised and predictable service.

Keywords: Healthcare, Lean, bandwidth, improvement, patient

This conceptual paper explores a novel way for health professionals and managers to illustrate the (re)design of patient pathways. We describe a multi-method approach that can be used to construct a bandwidth map and the potential pros and cons using this approach. Through healthcare examples we illustrate in practice how bandwidth mapping can be used to visualise the key touch points of a pathway and highlight areas for improvement.

Introduction
Globally healthcare organisations continue to struggle with managing increasing demands for their services with limited or shrinking resources. To respond to demographic pressures, a changing burden of disease, and rising patient and public expectations organisations know they have to do something different, both in the way they function and organise themselves in order to provide the level and quality of care expected by patients (Burgess and Radnor, 2012). For example, in the UK, Ham (2015) has called for closer integration of health and social care and for the NHS to have the leadership in place to deliver the highest possible standards of care within the available resources, which often means reconfiguration and organisations providing services in a more meaningful and different way.

For some time now various approaches to improvement, which originated and matured in other sectors, have been used to improve the delivery of healthcare (Brandao de Souza, 2009; Moraros et al., 2016; Williams, 2017). Although these have produced positive results, some organisations continue to struggle to make and/or sustain improvements (Burgess and Radnor, 2013). As we see a growing trend of many more patients coping with complex and multiple conditions, what is becoming apparent is the need for a more integrated approach to delivering healthcare services. Dobrzykowski et al. (2014) highlight the

importance for healthcare organizations of understanding the distinctive and contextual characteristics of healthcare when implementing and studying quality improvement. This being the case a better understanding of patient experiences is critical to being able to (co)-design and redesign care pathways that will deliver safe and reliable care. Clarity around how patient pathways are designed and operationalised is also an essential part of our understanding for improvement.

The particular focus of this paper is to explore the concept of bandwidths in visualising and understanding pathway design. We propose the use of bandwidth mapping as a way of illustrating the design of a patient pathway. Using healthcare examples we illustrate when the use of Lean might be advantageous to the design of a patient pathway. Lean is a well-established improvement approach in healthcare (e.g. Brandao de Souza, 2009; Burgess and Radnor, 2013) and has been used to streamline and often simplify services. Bandwidths are typically employed by electronics and more recently information technology. Here we explore an interesting and relevant approach in which to consider the patient touch points within a specified pathway and provide a simple visual to help identify which improvement approaches could help improve the design of the pathway. When we refer to touch points this relates to the stages of transition from referral to treatment whether in a hospital or community setting.

The specific objectives of this paper are to:

- Conceptualise how bandwidths can be used to visualise patient pathways
- Provide healthcare examples to illustrate the use of bandwidth mapping and these can be linked to lean thinking.
- Consider the pros and cons of using bandwidths to display patient pathways

The remainder of the paper is organised as follows. An overview of the key principles of Lean in healthcare is provided. The next section introduces the concept of bandwidths and using simple healthcare examples illustrate this concept can be employed in the (re)design of patient pathways. The paper culminates with a summary on how bandwidths may contribute to the improvement agenda.

Lean thinking in healthcare

Since 2001 in the UK and 2002 in the USA (Radnor and Osborne, 2013) Lean thinking has become one of the improvement methodologies that is prominent in reforming healthcare services. This popularity is confirmed by the publication of over 90 academic writings in ten different countries since its inception in 2001 (Brandao de Souza, 2009) and has been the subject of several reviews (e.g. Mazzocato et al., 2010; Poksinska, 2010; D'Andreamatteo et al. 2015; Moraros et al., 2016). This growth in interest is associated with the "double focus of Lean on customer satisfaction and employee involvement that suits the culture of most care centres". Other similarities between lean and healthcare are the focus on customers, quality, safety, and staff (Bohmer and Ferlins, 2006, p. 4). Toussaint and Gerard (2010) have translated the original lean principles (as defined by Womack and Jones, 1996) for healthcare, these being (1) focus on the patient; (2) design care around the patient; (3) identify value for the patient; (4) remove everything else (waste); (5) reduce time to treatment and the remainder of the journey. Lean thinking has been the foundation of many healthcare national improvement programmes including Productive Ward and Transforming Care. Improvements in healthcare have been shown in the reduction of waiting times (Baril et al. 2016), turnaround times (Gubb and Bevan, 2009) costs (Stonemetz et al. 2011), appointment scheduling (Luo et al, 2012) and medical errors (Gowen et al. 2012), often achieved through less resource and better process design (Silvester et al., 2004). Drotz and Poksinska (2014) expand the discussion to consider the impact implementing lean has on employees especially the roles, responsibilities and competences required to support the new ways of working.

Despite the popularity of lean, some authors believe lean implementation to be pragmatic, patchy and fragmented (e.g. Proudlove et al., 2008; Young and McClean, 2008). Burgess and Radnor's (2013) evaluation of lean in English NHS Trust found implementation was isolated rather than system-wide but over time it was expected lean would progress to more Hospital Trusts' adopting a systemic approach. Radnor et al., (2012) emphasise the key assumptions of lean and suggest without these Lean is likely to fail. Similarly, Joosten et al (2009) report how Lean in healthcare has been process-oriented and little

attention has been paid to the socio-technical aspects and 'respect-for-humans-system'. Holden (2011) whilst recognising the methodological, practical, and theoretic concerns of implementing lean, he suggests it offers significant improvement opportunities.

Given that perhaps many questions remain about Lean's effects on patient health and employees and how Lean can be best implemented in health care. It is important to understand when it is appropriate to employ lean thinking to improve healthcare services. Here we conduct a conceptual exploration of how bandwidths might be used as a way of visualising the design of patient pathways and identifying when implementing lean might be appropriate.

Use of bandwidth mapping

In the Oxford Dictionary (2016) there are numerous definitions of bandwidths, for example, when referring to telecommunications bandwidths might be described as a range of frequencies within a given band that are used for transmitting a signal. Alternatively, bandwidths can be referred to as the energy or mental capacity required to deal with a situation.

Another way bandwidths can be interpreted is by oscillating frequency. Here we draw on two principles from physics: Simple harmonic oscillation (e.g. Kelly, 2015) which refers to a repetitive movement back and forth through a central position, with equal displacement on each side; and Hooke's Law which states the extent to which an elastic material (e.g. a spring) will change size and shape under stress. For example, the greater the uncertainty (stress) the wider the bandwidth (time), alternatively if the oscillation is high (higher degree of certainty) the bandwidth becomes narrower, which reduces the time taken. By forcing the strain on the material we might find that the strain eventually leads to a breakdown (e.g. snapping of the spring). The bandwidth principle is shown in figure 1 where the spring is turned on its side.

Insert figure 1 about here

Building on Hooke's Law and the principle of oscillation we explore how this might translate to pathway design. For example, there are some care pathways which are predictable in terms of the timing and delivery of the interventions/care (e.g. elective day-case surgery). The predictability enables the care to be scheduled within a defined timeframe, which limits the strain on the team and system. This suggests that the levels of oscillation will be high (predictable and limited strain) and the bandwidth narrow (i.e. focused resource and defined time) (see figure 2). This assumes all equipment, staff and information flows are aligned to patient flow and available to deliver the necessary care for the patient in a timely manner. In other words there are no delays within the pathway an outcome that both Lean and ICPs might strive to deliver. The limited strain on the system and the predictability of the intervention and care suggests that Lean thinking has been or could be employed. The reduction of waste and non-value activities will help to identify opportunities for standardisation and increase predictability.

Before we expand our conceptual discussion further it is important to clarify our labelling for the x and y axis of a bandwidth visual as proposed in figure 2. As indicated above the y axis refers to the level of predictability within the pathway and hence the load/strain on the system/pathway. The lesser the strain the higher the reading in terms of predictability, or the greater the strain on or the uncertainty of the pathway then we would see the stretching of the bandwidth (i.e. increasing the strain/load on the pathway or system) which would reduce the reading on the y axis. The x axis can be related to the expected time required to deliver the interventions within the pathway. Here we make the assumption that an increase in uncertainty will increase the time needed to complete the interventions and /or the patient to complete their journey. For example, a more complex condition or comorbidities may well lower the oscillation and widen the bandwidth (i.e. greater range of care) due to the uncertainty around what interventions or referrals are required and when (see figure 3).

Insert figure 2 & 3 about here

Challenges are likely to occur when placing a patient with a complex condition or co-morbidities into a high frequency bandwidth. If the care pathway can be defined and specific interventions and care packages can provide a road map to the patient's care then the bandwidth can be narrowed (figure 2). If there is any uncertainty or delay in the patient receiving the intervention or elements of care then it is likely the bandwidth will become wider as the interval between the touch points (interventions) become longer (see figure 3).

Compiling a bandwidth chart

In order to compile a bandwidth chart we suggest the need for a mixed methods approach to profiling the patient journey. The first stage of compiling the chart is to conduct experience-based interviews with those involved in the pathway (e.g. patients, relatives and staff). These interviews are supplemented by observing the pathway and gathering documentation that illustrates how the pathway is designed (e.g. guidelines, protocols). These data are then used to produce a high level process map and/or a service blueprint of the patient journey (Radnor and McGuire, 2004). The process map will chart the activity whereas the blueprint will also include the various stakeholders (actors) involved in giving and receiving care. In the surgery day case example (see figure 4) the majority of patients it is a routine operation which enables the standard delivery of sub-processes (e.g. admission process) within the pathway. There is a dedicated team that delivers the care from admission through to discharge. This multi-disciplinary team is able to define the expected pathway (e.g. in the form of national guidelines, local procedures) for patients which to a large extent the information and patient flows can be standardised.

The next stage is to assess whether the activities are largely predictable and should happen within a defined timeframe. It is possible then to construct a bandwidth map which identifies the key activities within the pathway. If there is uncertainty around how and when the activity will be executed then this would be reflected in the height and width of the bandwidth as noted earlier in the description of the axis.

Some interventions are likely to take longer than others (e.g. operation and recovery) but are still within the expected timeframe (i.e. the patient is discharged by the end of the day). Clearly if improvements (e.g. reduction of duplication, delays) are made to the pathway then the bandwidth will become narrower as the frequency levels (interventions) and timeframe becomes tighter.

Insert figure 4 about here

Respiratory bandwidth example

Using the analysis of pathway data aggregated from the experiences of respiratory patients, relatives and staff we have been able to bandwidth map a high level care pathway journey (Williams et al., 2015). This does not fully capture the complexity of the journey as the full reporting of patient and relative experiences is outside the scope of this paper, but what is important for this analysis is the scoping of the generic pathway or typical patient journey and the key touchpoints when the patient interacts with the healthcare professionals. From this we can identify how bandwidths can be used as an alternative or complementary to traditional mapping approaches (such as process maps). The benefits of using the bandwidth map is to identify areas of the pathway that might lend themselves to standardisation (lean) and where more careful management and possibly skilled resource is needed to support greater flexibility and customised care. What is also beneficial is bandwidths might have a greater affinity given the use of run charts and Statistical Process Control in healthcare and more generally in service improvement.

Figure 5 shows how the key interactions/activities can be simply displayed for a respiratory pathway. The level of oscillation and predictability suggests elements of the pathway can be clearly defined or improved using the key principles of Lean (Womack and Jones, 1996). For example, the referral to a respiratory consultant is a key touch point in which the patient pathway seems to have a clear and perhaps more standardised approach. Improving the referral process will ensure that all referrals are complete and targeted at the right service. Being explicit about the referral criteria will help whoever (e.g. GP, specialist nurse, consultant) is making the referral to ensure all required information is provided. This again aids the processing of the referral and allocation to the appropriate clinic, consultant and

community team. Although the timing of interventions can differ depending on the individual patient and severity of the condition, there seems to be a clear pathway which includes various services from both the acute (hospital) and community healthcare providers. All these interventions are expected and predictable parts of the respiratory process. It is when a patient's condition worsens or an exacerbations occurs which culminates in an emergency admissions does the pathway become less predictable and can increase the strain on the pathway in relation to resources, staff, patients and relatives.

Insert figure 5 about here

We believe a bandwidth map provides an alternative way in which to visualise the trajectory of patients and start to appreciate the complexity that some conditions and/or comorbidities might bring to pathway design. The height and width of the oscillation illustrates the rate of predictability and strain (load) the pathway typically endures. For example, for a respiratory patient once a referral has been made to a respiratory consultant the patient has more knowledge about their condition, subsequently referrals are made to other services available within primary care and community services. As noted above, should the patient become unwell and admitted to hospital the pathway becomes uncertain again for a period of time.

The challenge for practitioners and pathway designers is how to identify which improvement approaches are appropriate, in what circumstances and when. Visualising patient journeys using bandwidths can help to identify the complexities of different conditions and the opportunities for improvement. Rather than using individual improvement approaches there could be synergistic benefits of having an integrated approach. Here we have taken two popular improvement approaches in healthcare and in a high frequency pathway Lean could be used to narrow the bandwidth by reducing waste, standardising processes and clearly visualising the pathway. However, what also needs to be considered is when a patient, for whatever reason, is unable to follow the expected pathway. Figure 6 provides an example to illustrate how unexpected delays or interventions might impact on the oscillation levels (increasing the strain) (e.g. no longer harmonic), increasing the time and stretching out the bandwidths. The uncertainty leads to the pathway becoming less easy to predict and control. Alternatively, this could depict a situation where a patient's pathways cross or collide, for example where a patient is admitted for elective surgery but with complexity of a long-term condition such as diabetes or respiratory disease such as Chronic Obstructive Pulmonary Disease (COPD). Figure 6 illustrates via the dotted line bandwidth map an expected pathway for a patient having day surgery, which can then be compared with the impact of the collision of pathways or complexity of comorbidities as shown by the lined bandwidth map.

Insert figure 6 about here

When we have asked patients about visualising the pathway for their condition they have requested a visual that is easily understood and provides enough detail to signpost them to the next stage of their journey. Some patients thought it was difficult to capture the likely complexity in situations when a patient is suffering from more than one condition. With a less standardised approach than perhaps Lean offers, more involvement of patients and staff is needed to understand the uncertainty that is likely to exist within the pathway. This level of involvement links well to the popular co-production of healthcare agenda (Batalden et al., 2015).

Conclusion

We propose the concept of bandwidth thinking and mapping is an appropriate way to illustrate to health professionals and other relevant stakeholders the need to consider and improve the design of pathways. It could be used as an alternative to high level process maps and/or blue printing which have become popular in healthcare improvement. The bandwidth representation is similar to a run chart which is widely used in healthcare to for temperature, heart rate and more recently in measuring improvement (Portela et al., 2015). Using an approach that is well established within healthcare may assist in multi-disciplinary engagement in the improvement agenda rather than focusing on pathway design which is often seen as a nursing phenomenon. We also see identifying the touch points within the pathway will

help to highlight where patients and relatives could be involved in the redesign of pathways again linking to the co-production agenda which is gathering credence in healthcare (Batalden et al., 2015).

The aim of this paper was to explore how the concept of bandwidth might help in our understanding and visualising of pathway design and the use of an improvement approach such as, Lean thinking. Specifically, our first objective was to access how bandwidth thinking can be used to visualise and improve patient pathways. Here we have demonstrated using illustrative healthcare examples how Lean might be helpful in redesigning pathways. We recognise there are other visual forms (e.g. process mapping, blueprinting, rich pictures) which can be used to visualise a process/system or in this instance a patient pathway. What is novel about this interpretation of bandwidth is the ability to demonstrate the advantages of being able to reduce uncertainty (e.g. standardise interventions and/or packages of care) and compress time. The representation is similar to run charts that many healthcare professionals area already familiar with. Patients have reported it helpful to have a simple visualisation of their expected trajectory which signposts them and enables them to ask questions about their care. By visualising pathways and the role of different providers, bandwidths might be one mechanism to assist in improving levels of integration and collaboration, both of which are associated with Lean (Burgess and Radnor, 2013).

Although we provide the benefits of employing bandwidth to visualising and improvement design of care pathways we must also consider the opinions of those less positive about bandwidths. For example, with bandwidths and other types of mapping there is a danger of not representing the complexity of comorbidities and conditions. Similarly, many healthcare professionals are already familiar with process mapping and therefore we would need to demonstrate clearly the pros and cons of each type of mapping and consider when best to use them either individually or collectively.

Although empirical data have been employed to help develop our conceptual thinking and identify key touch points and illustrate the design of the respiratory patient pathway, further research is required to test and validate our thinking in relation to the use of Lean and other improvement approaches with other conditions. By taking a mixed-methods approach to develop the bandwidths maps we recommend the use of experience-based interviews with patients, relatives and staff, which aligns well to co-producing health (Batalden et al., 2015) and understanding value (in terms of the first principle of Lean – see Womack and Jones, 1996).

From the discussion in this paper a number of areas for future research arise. Of particular interest is the focus of pathway research, most of this is disease or condition-focused rather than population-based. The healthcare cases are generally single disease/condition focused. Conceptually we ask questions around co-morbidity but further exploration of how Lean and care pathways can be employed within the arena of co-morbidities and the complexities these might bring would provide further insight into bandwidth mapping. Issues surrounding complexity of pathway design also require further analysis and consideration. Alternative improvement approaches such as agile and leagile (Naim and Gosling, 2011), which have been employed within the design of value streams and supply chains, could assist in creating the flexibility and customisation of pathways that occupy the low oscillating, wide (stretched) bandwidths. There is still more to do here in terms of unpacking what are some times complex approaches to pathways and improvement and using concepts from other disciplines to help visualise and possibly simplify these complexities.

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FIGURE 1.

Use of Hooke's Law for the concept of Bandwidths thinking

The greater the strain put on the spring the tighter the coils

For bandwidths and oscillations the spring is turned on its side

FIGURE 2.

An example of a highly standardised and stable pathway

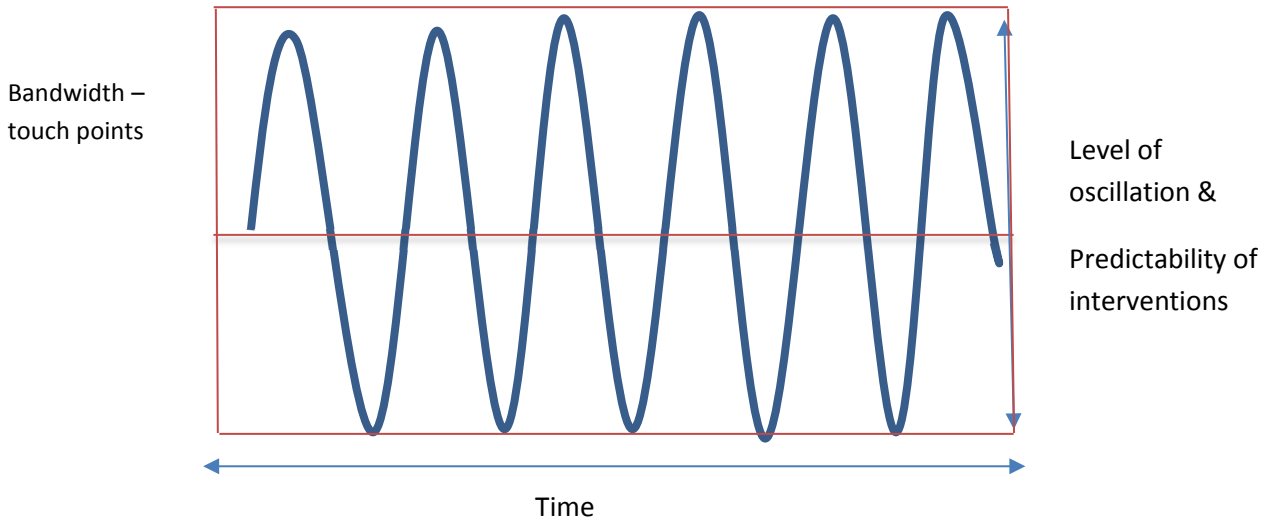


FIGURE 3.

An example of a pathway with less standardisation and certainty

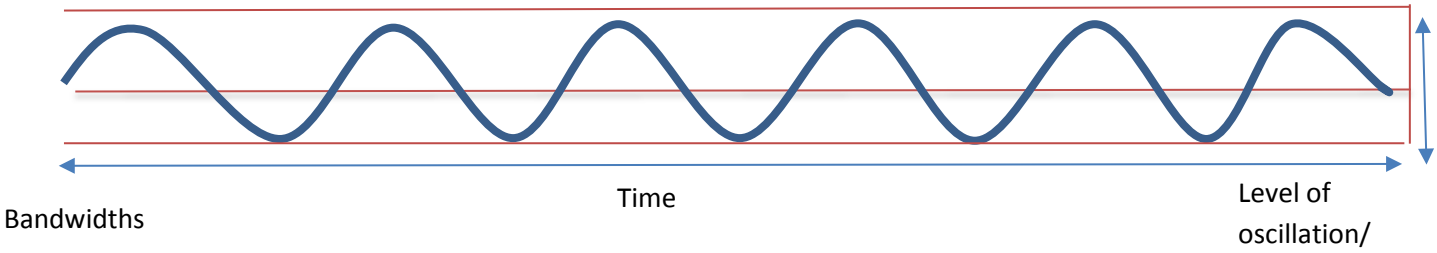


FIGURE 4.

Expected Bandwidth for Elective day-case surgery patient

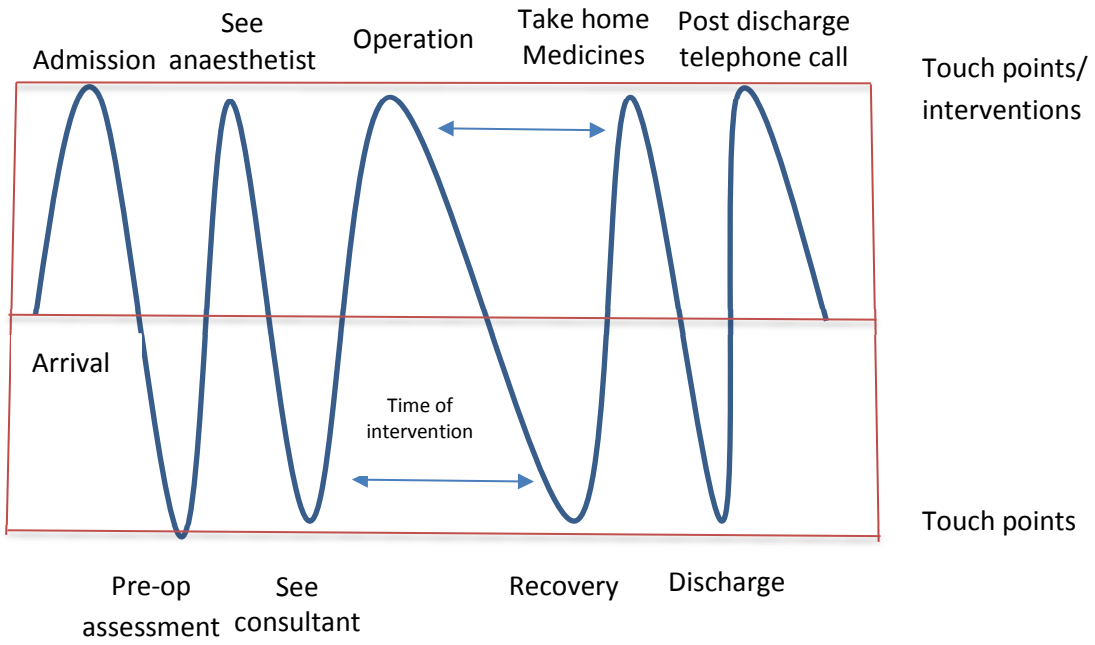


FIGURE 5.

Typical bandwidth for management of COPD

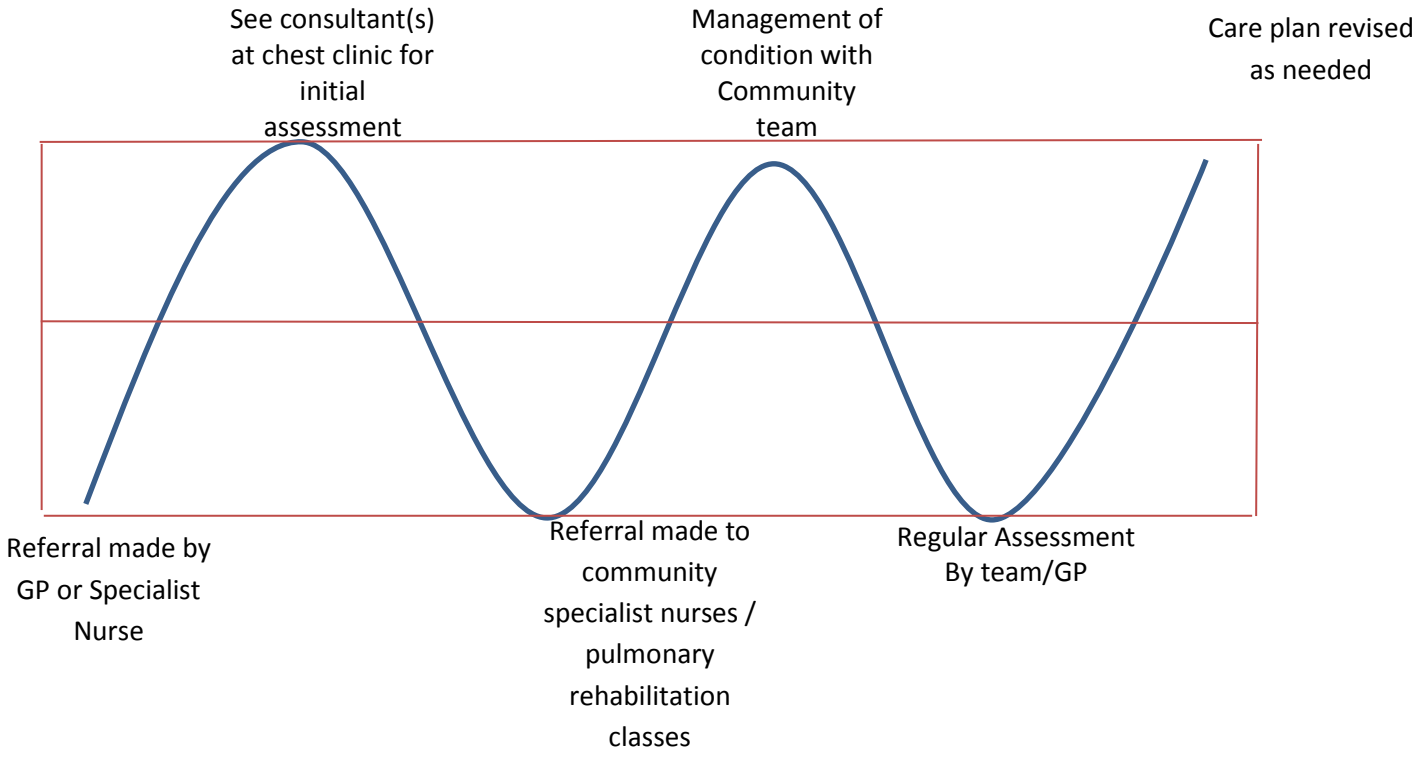
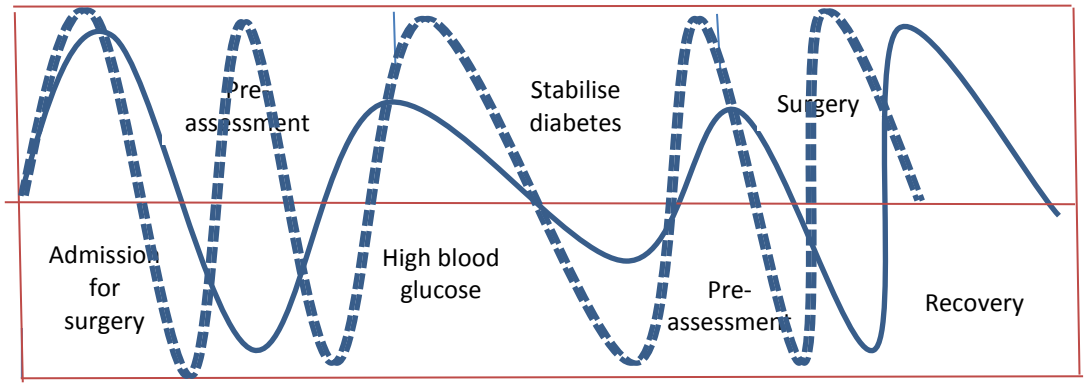


FIGURE 6.

Bandwidth illustrating unexpected delays and interventions due to a patient crossing pathways



Key: Example of bandwidth map for combined pathway for patient having day surgery with a long-term condition (Diabetes)

Example of bandwidth map for expected pathway for patient having day surgery