Supplementary file 1: Overview of the literature

Hospital volume

On the individual hospital level, hospital size has received ample attention in literature, especially in relationship with overall or relative survival as primary outcome indicator. Generally, three theoretical underlying mechanisms can be distinguished to explain the causal link in this relationship: (i) the compliance to evidence based processes of care, (ii) the level of specialization, and (iii) factors on hospital level, such as the availability of resources (Mesman et al. 2015). In practice, the existence of the volume-outcome relationship can be attributed to a combination of different explanations and contextual factors.

When focusing on breast cancer care, potential explanations for the inverse relationship between hospital volume and patient mortality include the positive influence of multidisciplinary consultations, the more frequent use of breast conservation and the choice of adjuvant chemotherapy [2].

The existing empirical literature on hospital volume and survival in breast cancer research is extensive. Gooiker et al., (2010) reviewed eight articles published between 2003 and 2007 [3]. In six studies, a significant effect in favour of high volume was found. In most recent studies the same pattern is visible when 5-year survival is used as the primary endpoint. Skinner et al., (2003) Gilligan et al., (2007) and Chen et al., (2008) & Greenup et al., (2018) all reported a positive relationship [2,4–6]. Yet, effect sizes and cut-off levels for discriminating high- and low volume differ strongly between studies which hamper external validity and stating country specific minimum volume thresholds [7]. For instance, in the study of Gilligan et al., (2007) high volume is defined as more than 40 surgeries a year in a single hospital, whereas Chen (2008) discriminates high volume above 585 surgeries. Studies with 10-year follow up as endpoint are much scarcer. Yet, the high volume and good prognosis highlight the importance of the long-term follow-up. In addition, Nomura et al., (2006) found no relationship between relative 10-year survival hospital volume [8]. Contrary, Greenup et al., (2018) with the largest study to date found that volume was an independent predictor for improved 10-year survival. In the Dutch setting, in the last study with substantial follow-up, Siesling et al., found only a small difference in survival between hospitals with a volume of 75-99 annual surgeries and hospitals with over 200 surgeries a year [9]. Vrijens et al. (2012) found better rates of application of scientific guidelines and prolonged survival in high-volume hospitals [10].

Most studies in the field of the volume-outcome relationship for breast cancer focused on survival. However, scholars have also examined hospital volume in relation to short-term outcome indicators, such as surgical margins and re-excision rates. Previous research has for instance indicated that hospital volume was a significant predictor for negative surgical margins and partially explain the volume-survival relationship [11]. In The Netherlands, no relationship was found between hospital volume and surgical margins [12]. With regards to re-excision after primary surgery, it was found that low volume hospitals were associated with a higher overall probability of re-excision within 90 days [13]. Similarly, an inverse relationship was found for surgeon volume and 90-days re-excision rates, implying that high
volume surgeons reported lower rates of re-excisions [14]. The combination of both hospital volume and surgeon volume demonstrated that women who underwent surgery in low-volume hospitals by low-volume surgeons had a significantly increased risk of re-excision [15].

Hospital competition

Additional to considering possible causes of quality differences on the individual hospital level, increasing emphasis is being placed on factors at the health system level. This includes the introduction of patient choice and competition on quality outcomes. The effects of such factors dependent on the structure of the market, for instance whether hospitals prices are liberalized or regulated [16,17]. Economic theory predicts that in markets or market segments with regulated price-setting hospitals will compete solely on quality. Currently, the NHS in the UK is an example of a hospital system without competition on prices. Consequently, when hospitals face tougher competition, the assumption is that they will increase their quality in order to attract and/or retain consumers (often referred to as consumer driven competition) or health insurers (often referred to as payer driven competition) [17]. In empirical literature, the relationship between competition and quality in settings with administered prices, showing a predominantly positive effect of increased competition on quality [16]. With regards to cancer outcomes, Aggarwal et al., (2017) reported a positive association between successful hospital competition and short-term outcomes after prostate surgery, which can also be regarded as tumours of high volume [18].

The mechanism for competition in markets where hospitals compete both on quality and price, as is the case in the US or The Netherlands, is more complex and supposes an interplay between both price and quality [17]. Economic theory then predicts that health providers place most emphasis on either price or quality, dependent of the responsiveness of demand by patients or healthcare purchasers on both elements: quality will raise if the quality elasticity of demand increases relative to the price elasticity. Quality will also increase if price increases relative to the marginal cost of quality and falls if the opposite happens [17,19,20]. Publicly available quality information is an important prerequisite: quality must be observable for either patients or purchasers. If price information is better accessible or comparable, competition mainly occurs on price instead of quality.

The effect of competition on quality in hospital markets with unregulated price-setting is less investigated. The results are rather inconsistent and often lack external validity through endogeneity limitations [16,20]. Most studies focus on acute care (CABG) in the US setting, demonstrating increased hospital competition or less concentration is associated with better outcomes [21,22].

In the Dutch setting, it was found that better quality scores were reported for bladder tumours in more competitive hospital environments [23]. It was also demonstrated that increased competition led to a larger percentage of available test outcomes within five days, as a process indicator for quality of care[24]. Additionally, the importance of observable quality information for successful hospital competition was confirmed: consumer satisfaction increased more rapidly in areas with more competition [25]. Another study found no evidence that increased exposure to price competition reduces quality
measured by readmission rates for hip-replacements [20]. Moreover, a temporary, positive impact on quality was reported. These four studies, however, did not assess the outcomes of exposure to competition on the long run.
Literature


12. Van Der Heiden-Van Der Loo M, De Munck L, Visser O, et al. Variation between hospitals in


24 Bijlsma MJ, Koning PWC. The Effect of Competition on Process and Outcome Quality of
