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Abstract

This narrative review explains the development of excess weight gain in babies and children. It takes a life course approach which includes genetics, pre-conception, pregnancy, infancy and childhood. The paper focuses on feeding behaviours, physical activity, parental influences and the wider social and environmental context. Risk factors which can cumulatively lead to excess childhood weight gain include: under- or overweight during pregnancy; the presence of diabetes during pregnancy; low or high birth weight; having obese parents; early weaning; prolonged formula feeding; rapid weight gain in the first year; disinhibited eating patterns and the consistent availability of energy dense food at home; feeding practices which are not responsive to the child's cues; insufficient sleep among preschool children; sedentary parents; low parental education; living in poor socio-economic circumstances; absence, or perceived absence, of safe play areas; parents who lack time or confidence to authoritatively parent; environments where there is poor access to affordable lower energy dense foods; and parents who do not accept that excess weight is a health problem. Recommendations for health professionals are made.

Keywords

Childhood eating behaviour, childhood obesity, infant nutrition, public health

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Introduction

There is a body of evidence which supports the view that people's health reflects an accumulation of the inter-relationships between biological, psychological, behavioural, social and environmental influences over the course of a life (DH, 2011a; Green, 2011; Marmot, 2010), and the development of obesity is no exception (DH, 2011d). In England about one-fifth of 4 and 5-year-olds are overweight or obese, and this rises to about one-third by the time they are 10 and 11 year olds (NOO, 2011). The short- and long-term physical and psycho-social health implications of being overweight are well documented (BMA, 2009; Robinson and Page, 2009), yet it is reported that health professionals lack confidence in working in this area (Rudolf, 2009; Sim and Ahmad, 2011). The English Department of Health has recently identified that the life course approach to tackling obesity has been underplayed and needs to have higher prominence within obesity prevention strategies (DH, 2011d). It has set the national ambition to achieve a downward trend in the level of excess weight in children by 2020.

If children's calorie intake from their eating is greater than energy expenditure through heat, growth, resting metabolic rate and physical activity, they will gain weight. This review does not attempt to create a complete picture of all the factors that contribute to childhood weight gain, as explained in the Foresight Tackling Obesities report (Government Office for Science, 2007). It aims to assimilate some of the key influences that work together across the early life course, with attention to genetics, pre-conception, pregnancy, infancy and childhood, and make recommendations for health professionals. It will focus on feeding, physical activity, parental (or other significant or constant adult) influences and the wider social and environmental context.

Genetic influences

Research has identified some relationship between genetics and obesity. Semmler et al. (2009) found that having lean parents seems to offer protection against children becoming overweight, regardless of socio-economic status, whereas parental obesity is a risk factor. Genes have been found to determine a child's enjoyment of physical activity and their fidgetiness, though the level of children's physical activity is generally influenced more by the environment than genes (Fisher et al., 2010). These examples show that the relationship between genes and the environment is complex because the risk of obesity is not only related to specific genotypes, but to gene-gene interactions, and gene-environment interactions (Yang et al., 2007). There are genes which relate to appetite, satiety, lipoprotein metabolism, and so forth, and there are lifestyles such as physical inactivity that disrupt the optimum expression of genes associated with metabolism. Yang et al. (2007) explain that in order to understand the genetic influences on excess weight gain, further studies are required which integrate the expertise of genetic epidemiology, functional genomics and proteomics.

Genetics only plays a minor part in ethnicity and health (Pearce et al., 2004). Ethnicity is associated with excess weight. In England, for example, obesity is more prevalent among Asian and Black children (Cronberg et al., 2010; DH, 2008; NHSIC, 2010) and in the USA more Hispanic children are obese than Black children or White children (Whitaker and Orzol, 2006). However, migration studies show that people tend to develop the lifestyles, and the associated health problems, of their new environment (IOM, 2010; WHO, 2010a). The causes of the higher rates of overweight among particular ethnic groups are more likely to be found among the risk factors that affect the rest of the population.

Pre-conception, pregnancy and infancy

Following a cohort study of children from birth to 14, Dietz (2004) found that childhood obesity is associated with high birth weight. This association was also seen by Stettler et al. (2002) who reviewed the records of 19,397 children. It is thought that babies who are exposed to high protein, glucose and insulin concentrations during pregnancy have an increased risk of having a high birth weight and of becoming an overweight or obese child (Barker, 2007). Women who are overweight or who have an excessive pregnancy weight gain are more likely to have a high birth-weight baby (BMA, 2009). The presence of diabetes adds greater risks. Yogeve and Visser (2009) explain that maternal overweight and obesity are associated with the development of gestational diabetes, which means having raised blood glucose during pregnancy in women who were previously not diabetic, and diabetes is associated with the increased risk of childhood obesity. Similarly, obese women who have previously been diagnosed with diabetes and who become pregnant are at greater risk of having an overweight or obese child. Stettler et al. (2002) propose that the apparent plasticity of a child's metabolism might be influenced by intrauterine excess nutrition causing exaggerated childhood weight gain.

Therefore the National Institute for Health and Clinical Excellence (NICE, 2010) suggest that interventions should be aimed at promoting a healthy pre-conception weight and a healthy pregnancy weight gain. However, although the NHS has pre-conception advice leaflets, accessing them has to be self-directed and most women do not seek maternity advice until they are already pregnant (Russell et al., 2010). The 12-week ante-natal assessment is often the first opportunity for midwives to advise pregnant women about healthy maternal weight gain (NICE, 2010). The prevalence of maternal obesity is rising in the UK, and it is linked to maternal death (Lewis, 2007). Yet 61 per cent of 6252 mothers in Russell et al.'s (2010) survey reported being given no opportunities to discuss their weight or dietary concerns during their pregnancy, and only 15 per cent reported being offered any advice about reducing their weight. This suggests that discussions about weight gain need to be occurring more frequently between health professionals and women who are considering pregnancy, and thereafter.

Studies show that rapid weight gain in the first few months of life is associated with an increased risk of childhood overweight and obesity (Singhal et al., 2010). For example, using data from a longitudinal study of 2103 children, Dubois and Girard (2006) confirmed that rapid weight gain between birth and five months in low-birth weight babies doubled the risk of being overweight at 4.5 years. Low birth-weight babies tend to have a rapid weight gain during the first few weeks of life (Government Office for Science, 2007) which may be due to their lack of muscle altering their sensitivity to insulin (Phillips, 1996). Rapid weight gain in early infancy would appear to permanently programme a child's metabolism by altering their sensitivity to insulin, which results in a high body fat mass. Therefore these studies suggest that as well as high birth-weight, low birth-weight can also be associated with childhood overweight and obesity.

Women who are underweight or have a low pregnancy weight gain have an increased risk of having a low birth-weight baby (BMA, 2009). This is related to a range of factors including the mother's own foetal growth, the history of her diet until pregnancy, her socio-economic status and overall health (UNICEF/WHO, 2004). Smoking during pregnancy is also a major contributing factor to low birth-weight (Bull et al., 2003), and is particularly high among pregnant teenagers (DCSF, 2009). When health professionals support healthy weight in pre-conceptual and pregnant women through physical, social and psychological support, current evidence suggests that they are also helping to prevent the unborn child being prone to excess weight gain.

Infant feeding

A number of studies have examined the relationship between breastfeeding and overweight children. Although there have been studies which concluded that breastfeeding does not influence children's weight development (Li et al., 2003; Parsons et al., 2003), the greater weight of evidence is now suggesting that it does. Armstrong and Reilly (2002) reviewed data from a cohort study of 32,200 children who were either exclusively breast-fed or bottle-fed, and found that there was a significant association between breastfeeding and reduced childhood obesity. The finding has now been confirmed by more studies which conclude that breastfeeding has a small but consistent protective affect against childhood obesity, with the association being stronger in prolonged breastfeeding (Arenz et al., 2004; Gubbels et al., 2011; Horta et al., 2007; Owen et al., 2005). It is thought that for each month of breastfeeding there is a 4 per cent reduction in the risk of childhood obesity (Singhal and Lanigan, 2007).

There have been a number of studies which have sought to explain why breastfeeding may be protective against excessive childhood weight gain. Breastfeeding may encourage breast-fed babies to self regulate their energy intake because they have control over the amount of milk they consume (Singhal and Lanigan, 2007), whereas bottle-fed babies are more likely to finish the full amount of milk offered (Li et al., 2010; Sidnell and Greenstreet, 2009). Breastfeeding has been associated with less unhealthy snacking at age 2 (Gubbels et al., 2011). Breast milk, unlike formula milk, contains leptin, a hormone that stimulates satiety, and thereby regulates appetite and suppresses overeating (BMA, 2009). Two randomized controlled trials have shown that higher protein formula milk is associated with greater body fat at 2 years old (Singhal et al., 2010). It is proposed that breast milk, which has up to 70 per cent less protein than formula milk, influences the long-term programming of insulin release and therefore inhibits rapid weight gain (Singhal and Lanigan, 2007). Early weaning, at four months, has been associated with obesity at 3 years (Hawkins et al., 2009; Huh, et al., 2011) and prolonged use of formula feeding has been associated with a higher risk of overweight (Bonuck et al., 2004). Breastfeeding might not be associated directly with body mass index, but with growth rate (Gunnarsdottir et al., 2010). Therefore, the reasons why breast feeding might be protective seem to be complex and interrelated, necessitating further research.

Other studies focus on adiposity rebound. After the first year of life children experience a loss of body fat. The regain, which occurs between 3 and 7 years, is called the adiposity rebound (Cole, 2004). Childhood growth data from Helsinki (Barker, 2007) and France (Rolland-Cachera et al., 2006) show that infants who have a low weight gain in the first year have an early rebound, and so gain weight as if by way of compensation. Early rebound tends to occur in the context of a high and increasing body mass index which increases the risk of obesity, rather than the rebound itself (Government Office for Science, 2007).

Health professionals can advise mothers that current evidence suggests that six months of breastfeeding probably helps to deter childhood weight gain because of its established health benefits, though the exact mechanisms through which this occurs are yet to be fully clarified. Initiatives to promote breast feeding are well known (DH, 2009a, 2009b; NICE, 2008; Renfrew and Hall, 2008; UNICEF, 1992, 2010), but the evidence suggests that more support is needed for teenage mothers, single mothers and mothers living in deprived circumstances (Kennedy, 2010).

Parental influences on children's eating and physical activity

Health professionals will know that providing too much energy dense food will contribute to weight gain through passive over-consumption (Prentice and Jebb, 2003). However, studies are highlighting the need to pay attention to parental feeding behaviour. For example early childhood weight gain has been associated with children watching their parents' disinhibited eating (Hood et al., 2000) and with parents explicitly encouraging their children to overeat. Parents of preschool children have been found to frequently over-estimate how much food their children require (Birch and Fisher, 1998; Dehgan et al., 2005) and to promote eating after the child has indicated that they are full (Mrdjenovic and Levitsky, 2005). For example 83 per cent of the parents of 142 toddlers encouraged their children to continue to eat after the child had indicated that they were full, either verbally or by pushing the plate away (Orell-Valente et al., 2007). Eating until uncomfortably full is thought to treble the lifetime risk of becoming obese and teaches children that overeating is normal (Denney-Wilson and Campbell, 2008).

Parents might try to restrict children's food by limiting the amount of food and the frequency with which it is offered. The danger is that food which is restricted tends to become more desirable. In one study, the children were reported as being more likely to make positive comments about restricted food and to select it (Fisher and Birch, 1999). When energy dense processed food, such as crisps and chocolate, are used in celebrations or as 'comfort food', its withdrawal can be seen by the child as a punishment, which leads the child to crave it more (Brug et al., 2008; Fisher and Birch, 2000; Hill, 2002; Levitan and Davis, 2010). Studies show that parents who strictly restrict what their children eat are more likely to have children who eat more and have a higher weight status (Brown and Ogden, 2004; Clark et al., 2007; Faith et al., 2004), though recent research suggests that this might vary according to the age of the child (Campbell et al., 2010).

Parents might exert pressure on children's eating. For example one study showed that mothers of girls who had a high fat intake in their diets were more likely to use pressure to make their daughters eat (Lee et al., 2001), and in another, mothers who used pressure as a feeding technique, were more likely to have daughters who were picky eaters and ate fewer portions of fruit and vegetables (Galloway et al., 2005). Batsell et al. (2002) asked college students to remember an experience where they were pressurized into eating an item of food that they did not want. Seventy-two per cent of the participants would still no longer eat the food that they mentioned, showing how certain child feeding techniques have the ability to impact upon food choices even after a long period of time.

Children naturally prefer sweet and salty foods, and avoid bitter and sour flavours, but they mostly develop their food eating habits through exposure and experience (Lindsay et al., 2006). Children will accept food that is frequently offered to them, especially when it is added to familiar flavours and when they see others eating it (Hill, 2002). Haire-Joshu et al. (2008) observed that obese toddlers, in their study, tended to have ready access to energy dense food at home, and that this tended to be especially true if their parents were overweight or obese (Manios et al., 2010). Therefore, parental food related attitudes and behaviours, healthy or less healthy, will greatly influence children's attitudes and choices (Gibson et al., 1998; Klesges et al., 1991; Vereecken and Maes, 2010; Wardle, 1995), and children themselves are aware that adults exert control over their eating (Robinson, 2000). Parents report feeling a lack of self-efficacy in their abilities to promote healthy eating, citing a lack of time, which causes a reliance upon energy dense fast food, money constraints, conflicting family preferences and a fear of seeking help for fear of being blamed for their child's overweight (Pockock et al., 2009; Sonnevile et al., 2009).

The evidence suggests that health professionals need to observe and discuss parental feeding practices as well as food content. Parents need to be aware of how their own attitudes and behaviour will influence their child's weight. This includes: taking cues from their children about when they have had sufficient to eat; moderating calorie dense foods without completely banning them, and avoiding using them as a reward or for comfort; repeatedly encouraging new tastes in small quantities, but not allowing them to become the centre of a battle-ground; and role modelling healthier eating when possible. This can be a very difficult balancing act (Haugstvedt et al., 2011) for which Rudolf (2009) recommends a whole-family approach to healthier eating, whereby parents take an authoritative-responsive approach to feeding children. Authoritative parenting is characterized by providing supervision, having expectations of high levels of maturity from children, being sensitive to the children and providing support for their needs (Gutman et al., 2009). Health professionals need to handle these highly personal aspects of people's lives sensitively, gently helping parents to be able to take control, whilst also being sensitive to cues from their children.

Children's physical activity is difficult to measure as it is largely reliant on parents who report their children's behaviour, and even pedometers are dependent on children being willing to wear them (Cooper and Page, 2010). Parental perceptions also play their part. Following a neighbourhood survey of 6821 households, Jones et al. (2009) found that families living in deprived areas perceived greater barriers to accessing green spaces regardless of their distance, compared to other families. As a consequence, these families made less use of parks and woodland. Children's activity is often associated with parental activity (The NHS Information Centre, 2011; Pickup and Gunning, 2009). Parents who support their children, in the form of encouragement and involvement, can positively influence their child's physical activity levels, and this is seen more prominently among parents who are themselves physically active (Welk et al., 2003; Zecevic et al., 2010). In the Framingham Children's Study, the young children whose parents were both physically active were more than five times more likely to be active than children with parents who were not physically active (Hood et al., 2000). It is noteworthy that games such as Wii Fit seem to help because children associate them with fun rather than intentional exercise (Rice et al., 2008).

In addition to promoting children's physical activity, attention is now turning towards the rising levels of children's sedentary behaviour and its association with childhood overweight and obesity (WHO, 2010b). Sedentary activity for more than four hours a day has been reported in 49 per cent of obese children, 44 per cent of overweight children and 36 per cent of children who were within a healthy weight range (The NHS Information Centre, 2011). Whether physical inactivity causes weight gain or whether excess weight hampers engagement in activity is unclear. Spurrier et al. (2008) found that preschool children who owned electronic television games, or had a television in their bedroom, had less physical activity and were more sedentary than those who did not. However, children who watch television more might be more sedentary in general (CCM, 2011). Greater television watching in the evening can reduce the amount of children's sleep, and less sleep is also a risk factor for obesity (CCM, 2011; Rudolf, 2009). Studies, such as Kipping et al. (2008) have found that making small reductions in children's sedentary behaviour seems to result in the establishment of long-term more active behaviour, and have led to recommendations that parents should be encouraged to reduce the amount of time that their children spend watching television or playing computer games (CCM, 2011; Government Office for Science, 2007; Kamath et al., 2008; NICE, 2006). Therefore, health professionals might find it more fruitful to focus their advice on the whole family by suggesting more physical activity through fun games and reducing sedentary behaviour.

The context of children's eating and physical activity

The *Foresight Tackling Obesities* report (Government Office for Science, 2007) drew up an obesity system map which seeks to show that child obesity is not only the product of biological and psychosocial factors, but of whole societal factors which include the media, the economy and the physical environment. Perhaps it is not surprising that some parents believe that their child's size is their child's destiny rather than being due to modifiable behaviours (Goodell et al., 2008), because there is an element of truth in it. One qualitative study (Goodell et al., 2008) found that parents were aware of the high calorie content of food, but were not willing to limit their children's access to it because they did not believe that this would prevent excess weight gain. They were only willing to do so if their child was clinically obese. Also, the parents did not believe that excess weight gain could negatively affect their child's health. A number of studies have shown that parents fail to see their child as overweight (Baughcum et al., 2000; Jain et al., 2001; Jones et al., 2008). For example Jeffery et al. (2005) asked parents to rank how under- or overweight they thought their child was and how concerned they were about their child's weight status. One-third of parents with an obese child thought that their child's weight status was about right. Eighty-six per cent of parents with an overweight child said that they were unconcerned about their child's weight status. The authors suggest that parents might not identify that their child is carrying excess weight because it has become the norm within society.

Children from poorer families are more likely to be overweight or obese compared to the more affluent (Marmot, 2010; Semmler et al., 2009; Stamatakis, et al., 2010). Lower socio-economic status is associated with low levels of parental education, and both are associated with child obesity (Dannermann et al., 2011; Lamerz et al., 2005; Young-Gyu, 2009). Low family income is associated with children eating fewer portions of fruit and vegetables per day (Ogunbadejo, 2009). The decline of small shops in urban and deprived areas due to the expansion of out-of-town supermarkets has limited people's access to fruit and vegetables through travel costs, carrying heavy shopping and price (White, 2007). Improved manufacturing processes have resulted in the easy availability of cheap snack and ready-made meals, which tend to be high in calories (White, 2007). Four times as much is spent on advertising these energy dense 'fast' foods than low calorie fruit and vegetables (Lake and Midgley, 2010) and this has been directly linked to children's increased consumption of these foods and to obesity (CCM, 2011; Kelly et al., 2010). In addition, marketing food shaped as fun items and decorated with cartoons also encourages consumption and subsequent weight gain (Elliott, 2008).

Obesity rates in young children are higher in urban than rural areas (Jones and Panter, 2010; The NHS Information Centre, 2011). Although urban areas have high concentrations of sports centres and play gyms, the local residents often do not have the finances to access them. Busy roads and a lack of pavements discourage parents from allowing their young children to walk, preferring to push them in prams or use vehicle transport (Sallis and Glanz, 2006). Dwyer et al. (2008) carried out a qualitative study which found that parents' fear of danger from excessive road traffic in residential areas was an overwhelming factor in causing them to restrict their children's physical activity opportunities. They preferred to keep them indoors and safe. Rahman et al. (2011) reviewed studies about the built environment and observed that neighbourhoods comprising houses, shops and recreational facilities with wide well-connected pavements, offered the greatest opportunity for physical activity among children. It is for these reasons that NICE (2009) recommended that pedestrian safety needs to be improved in urban areas through lowering speed limits and ensuring safe crossing points.

Sallis et al. (2000) found that children who had access to local recreational facilities, such as playgrounds and gardens, were more physically active than those who did not. They discovered that spending time outside correlated strongly with a child's physical activity and, without safe play, children spent more time indoors watching television. This finding was also observed by Spurrier et al. (2008) who visited 280 homes of preschoolers and found that having access to a garden and outdoor play equipment was associated with more physical activity. However, the evidence is inconsistent. For example, Trost et al. (2003) observed the physical activity habits of 245 preschool children and found that access to outdoor toys and visits to parks made no significant difference to the children's physical activity levels. Brug et al. (2008) observed that, within the same neighbourhood and local facilities, children from lower socio-economic groups and Black and minority ethnic families, engaged in less physical activity than others. Although the authors acknowledge that the evidence was weak due to poorly designed studies, they conclude that socio-cultural factors might be more important than access to physical facilities.

There is global concern about child overweight and obesity, and widespread recognition that in addition to the action taken by individuals and communities, some of the underlying causes can only be addressed by governments and industry working at national and international level. The World Health Organization advocates a comprehensive regional and national inter-sectoral, population-based approach to child obesity (WHO, 2010c). There are global (WHO, 2010b, 2010d) and regional strategies about food (WHO, 2008) and physical activity (Cavill et al., 2006; Commission of the European Communities, 2007) that are guiding national governments to action. Countries such as Denmark, Australia, Canada and Romania are taxing foods and drinks that are high in fat and sugar (Nicholls et al., 2011; Timmins, 2011). The English Department of Health is taking forward the Responsibility Deal which seeks pledges from the food and drink industry to reduce the nation's calorie intake, emphasizes the role of local government to address town planning and healthier lifestyles, and offers to provide national support for more research to guide professional practice (DH, 2010a, 2010b, 2011b, 2011c, 2011d; NICE, 2011).

Conclusion

This review has shown that along the early life course, from pre-conception to childhood, there are a number of risk factors that cumulatively lead to child overweight and obesity. While the deeper underlying causes, such as the type and price of food and town planning, are matters for industry and government, there are many risk factors to which health professionals need to be alert. Several of these in combination, rather than any one or two alone, are cause for concern. The below table shows the risk factors for excess weight gain and recommendations for health professionals.

Table I. Risk factors for excess weight gain and recommendations for health professionals

Risk factors for excess weight gain in babies and children	Recommendations for health professionals
Overweight or underweight during pregnancy. High or low birth weight.	Encourage a healthy pre-conception and pregnancy weight and smoking cessation for all.
Presence of diabetes during pregnancy.	Explain how the presence of diabetes is a particular risk factor during pregnancy.
Obese parents.	Note whether a child has lean or obese parents.
<i>(continued)</i>	

Table I. (continued)	
Risk factors for excess weight gain in babies and children	Recommendations for health professionals
Teenage and/or single mothers and those living in deprived circumstances whomight need support with breastfeeding.	Support mothers with breastfeeding up to six months, with particular attentionto teenage or single mothers.
Early weaning and prolonged formula feeding.	Support breast-friendly initiatives.
Rapid weight gain in first year.	Note rapid weight gain during the first year.
Parents who perceive that an overweight child is a healthy weight. Parents whodon't believe that excess weight can be a health risk.	Provide education about healthy weight for age and sex.
Parents who eat in a disinhibited way and a family eating pattern ofdisinhibited eating. Inactive, sedentary parents.	Encourage a whole-family approach towards reducing disinhibited eating andreducing sedentary behaviour.
Homes where there is a constant supply of energy dense food.	Provide education about energy dense foods and alternatives, being mindful ofcost, practicality and availability.
Parents who lack time and/or confidence in themselves to authoritatively parent.Parents who overly restrict their children's food or pressurize children intoeating, perhaps insufficiently responsive to cues from children.	Provide support and guidance about authoritative parenting andauthoritative-responsive feeding.
Pre-school children having insufficient hours of sleep, possibly associated withhigher or later hours of watching television.	Emphasise the importance of sleep, especially for pre-schoolers.
Low parental education. Families of lower income.	Be aware that low parental education and living in poor socio-economiccircumstances are risk factors for childhood obesity, and that therefore thesefamilies might need to be given particular attention.
Families who live in urban areas without affordable and safe play areas.Families who are unaware of appropriate space for play and activity.	Research the local environment to identify affordable and safe play areas andsources of good value non-energy dense food. Lend support to initiatives to increasethe opportunities for affordable, safe play and affordable sources of non-energydense food.
Families who live in areas where there is poor availability of affordable foodof lower energy density such as fruit and vegetables.	Research the local environment to identify affordable sources of good valuenon-energy dense food. Lend support to initiatives to increase the opportunities foraffordable sources of non-energy dense food.
<i>(continued)</i>	

Table I. (continued)	
Risk factors for excess weight gain in babies and children	Recommendations for health professionals
	Take responsibility for own professional development by seeking out guidance from local nutritionists, dieticians, health improvement and public health practitioners.
	Check that educational opportunities, such as antenatal classes and one-to-one consultations, are regularly updated, underpinned by the latest evidence and tailored towards local, family or individual needs.

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