# Intertemporal Decision-Making and Health Behavior: Mechanisms and Influencing Factors

**Authors:** Wu Xiaoju, Chen Junfang, Fu Jiahui, Li Shu, Liang Zhuyuan, Liang Zhuyuan

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## Abstract

Intertemporal decision-making in the health domain bears upon the health and well-being of individuals and the nation. Currently, academic research in this area remains largely at the stage of drawing upon theoretical models and methodological approaches from the traditional monetary domain. However, health intertemporal decision-making exhibits domain-specific characteristics, and the adoption of monetary domain theories and methods has resulted in considerable inconsistency in research methodologies and findings within this field. The behavioral consequences of health intertemporal decision-making constitute a primary focus of the domain, with most studies reporting that individuals' low time discount rates and high future time orientation are positively associated with health-protective behaviors and negatively associated with health risk behaviors. The field also investigates the mechanisms underlying health intertemporal decision-making, including core features of the decision object and decision subject, among other factors. Future research urgently needs to develop intertemporal decision-making models and research paradigms tailored to the health domain, elucidate the relationship between health behaviors and intertemporal decision-making preferences, thoroughly examine the intrinsic choice mechanisms of health intertemporal decision-making, and undertake greater efforts and explorations in the application of health behavior interventions and healthcare policies.

## Full Text

## Time Preferences for Health and Health Behavior: Mechanisms and Influencing Factors

**WU Xiao-Ju[1],[2], CHEN Jun-Fang[1],[2], FU Jia-Hui[1],[2], LI Shu[1],[2], LIANG Zhu-Yuan[1],[2]**

[1]CAS Key Laboratory of Behavioral Science, Institute of Psychology, Chinese Academy of Sciences, Beijing 100101, China
[2]Department of Psychology, University of Chinese Academy of Sciences, Beijing 100049, China

**Abstract**

Time preference for health is omnipresent and important at both individual and national levels. For a long time, research in this field has been limited to following intertemporal choice models and methods in the traditional monetary domain of time preference studies. Given the domain-specificity of time preference in the health domain, these indiscriminately applied theoretical models have led to inconsistent measures and results in the field. In the past few decades, researchers in this field have focused on the behavioral consequences of time preference for health. Most studies reported that lower temporal discount rates and higher future time perspectives are positively related to health protection behaviors and negatively related to health risk behaviors. Researchers also found that features of both decision-making objects and decision makers are key impact factors for time preference for health. Future studies should develop theoretical models and measurements that are more suitable to the time preferences for health domain, identify the relationship between healthy behaviors and time preference, and investigate the mechanism underlying the decision-making process. Future researchers should also explore interventions for health behaviors and their application to formulation of healthcare policies.

**Keywords:** intertemporal decision making; health behavior; domain specificity; time perspective

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Intertemporal decision making refers to trade-offs between costs and benefits occurring at different time points—particularly between present and future outcomes (Liang & Liu, 2011; Frederick, Loewenstein, & O' donoghue, 2002). Many decisions in life involve intertemporal choices, such as deciding whether to save money (trading off current consumption against future savings) or whether to exercise (trading off immediate leisure against time and effort invested for future health). Intertemporal decision making is closely related to individual welfare and national well-being, and has been a major research focus in behavioral decision making and related fields for decades.

Intertemporal decisions can occur in multiple domains, including money, health, environment, and society. Among these, intertemporal decision making in the health domain (hereinafter referred to as health intertemporal decision making) is particularly important. Health intertemporal decision making refers to decisions that require trade-offs between short-term costs and long-term health benefits (Chapman, 1996; Ortendahl & Fries, 2005). Short-term costs may be psychological (such as giving up pleasure or enduring discomfort), financial, or other non-financial costs (such as time and energy). Long-term health benefits

involve obtaining potential advantages in reducing future disease morbidity and mortality rates (Fuchs, 1982). In real life, health intertemporal decisions can be divided into two types: at the individual level, they involve trade-offs between short-term non-health costs and long-term health benefits, such as an individual' s weighing of immediate pleasure against future health gains, which influences their decision to start or maintain healthy habits (e.g., exercising, quitting smoking, regular diet) (Daugherty & Brase, 2010). At the societal level, they involve trade-offs between short-term and long-term health, such as people' s general preference for present health over future health, leading to discounting of future health benefits in healthcare economic evaluations (Gafni, 1994, 1995; Van der Pol & Cairns, 2008). Most health behaviors involve health intertemporal decision making, though some—such as seatbelt use—are more related to the probability of health outcomes rather than trade-offs between short-term costs and long-term health benefits, and thus do not primarily constitute health intertemporal decisions.

Since the 1980s, scholars have begun to focus on health intertemporal decision making, initially examining whether individuals' general intertemporal decision preferences affect health-related behaviors. As early as 1982, Fuchs linked intertemporal decision preferences with health behaviors, finding a weak connection. Since 2000, interest in this relationship has surged (Amlung, Vedelago, Acker, Balodis, & MacKillop, 2017; Barlow, McKee, Reeves, Galea, & Stuckler, 2017; Barlow, Reeves, McKee, Galea, & Stuckler, 2016; Van & Irvine, 2018). However, most of these studies measured intertemporal decision preferences using monetary outcomes rather than health outcomes. This raises a theoretical question: whether intertemporal decision making for health and money is homogeneous. This issue has been discussed by scholars since the 1990s (Attema, Bleichrodt, L' haridon, Peretti-Watel, & Seror, 2018; Chapman, 1996, 2002; Chapman & Elstein, 1995). Meanwhile, to understand differences in health intertemporal decision preferences across individuals or conditions, researchers have also examined influencing mechanisms, considering factors such as attributes of decision options (Mahboub-Ahari, Pourreza, Sari, Sheldon, & Moeeni, 2019; Ortendahl & Fries, 2005) and individual difference factors like health status and socioeconomic status (Takagi, Kondo, Takada., & Hashimot, 2016; Weller, Cook, Avsar, & Cox, 2008).

To date, research on health intertemporal decision making has grown substantially in quantity and output. However, broadly speaking, the field has yet to reach consensus on theoretical frameworks, empirical methods, and research findings. Therefore, this paper reviews relevant research on health intertemporal decision making, summarizes contradictions and problems in previous studies, and aims to provide new directions for future research.

## 2. Theoretical Foundations of Health Intertemporal Decision Making

Classic theories of intertemporal decision making originated from research in the monetary domain. In intertemporal decisions, people consistently tend to assign lower weights to future gains and losses compared to current or near-term outcomes. Therefore, researchers commonly use temporal discounting rates as an indicator to measure preferences in intertemporal decision making—the rate of change in the value of future outcomes after a standard time period (Liang & Liu, 2011). A high temporal discounting rate means an individual focuses more on present outcomes and relatively underestimates future outcomes (Frederick et al., 2002). In 1937, economist Samuelson proposed the discounted-utility model (DU) based on rational assumptions to explain temporal discounting. The DU model assumes that people discount the utility of outcomes at different future time points using an exponential function with a constant positive rate r (the temporal discounting rate). Since the 1980s, researchers have proposed various hyperbolic or quasi-hyperbolic discounting models to explain multiple anomalies that violate DU theory (Laibson, 1997; Loewenstein & Prelec, 1992; Mazur, 1984). These models assume that temporal discounting rates differ across time points (a, b). In the twenty-first century, some researchers have departed from the mainstream theoretical development path and proposed heuristic models that do not start from discounting calculations, such as the Attribute-comparison model (Read, 2001), Similarity model (Leland, 2010), and Equate-to-Differentiate model (Li, 2004).

Theoretical research on health intertemporal decision making primarily references theoretical models from the monetary domain to test their rationality and applicability in health. Most studies have found that intertemporal decision models based on temporal discounting do not adequately describe individuals' time preferences for health outcomes (Bleichrodt & Gafni, 1996; Bleichrodt & Johannesson, 2001; Mahboub-Ahari et al., 2019; Redelmeier & Heller, 1993; Van der Pol & Cairns, 2011). Regarding the discounted-utility model, studies have found that some individuals have temporal discounting rates below 0.00, and that individuals discount further delayed health outcomes less than initially delayed ones. This challenges the DU model' s assumption of a positive and constant temporal discounting rate (Bleichrodt, Gao, & Rohde, 2016; Bleichrodt & Johannesson, 2001; Mahboub-Ahari et al., 2019; Redelmeier & Heller, 1993). A real-world example is when someone plans to start exercising next week, but when next week arrives, they may not start and instead postpone the plan to the following week. Compared to the discounted-utility model, although proportional discounting models and hyperbolic discounting models assume different temporal discounting rates across time points and are more suitable for describing individuals' intertemporal preferences for health outcomes (Bleichrodt & Gafni, 1996; Bleichrodt & Johannesson, 2001; Robberstad & Cairn, 2007), as Bleichrodt (2016) and colleagues' empirical research shows, these models are not suitable for describing behavior where individuals become increasingly im-

patient with longer delays (discounting rates increase with delay), indicating limitations.

From the above, it is evident that intertemporal decision models developed in the monetary domain may not adequately describe individuals' intertemporal preferences for health outcomes. Research on domain specificity in health intertemporal decision making provides further evidence for this issue.

## 3. Domain Specificity of Health Intertemporal Decision Making

As seen from the theoretical development trajectory of intertemporal decision making, most theories assume that individuals use the same model for intertemporal decisions across different stimuli. If this assumption holds, people' s intertemporal decision preferences for health and money should be the same, making specialized research on health intertemporal decision making unnecessary. Therefore, since the 1990s, numerous studies have examined the domain specificity of health intertemporal decision making from a theoretical construction perspective.

Some studies have found similarities between health and monetary intertemporal decisions: their temporal discounting rates tend to be similar (Fredslund, Mørkbak, & Gyrd-Hansen, 2018), and various decision biases similar to those in the monetary domain exist in health intertemporal decisions, such as delay effect, magnitude effect, and sign effect (Mahboub-Ahari et al., 2019; Ortendahl & Fries, 2005). However, more studies report differences between the two domains, indicating that health intertemporal decision making has domain specificity (Attema et al., 2018; Chapman, 1996, 2002; Chapman & Elstein, 1995).

First, people' s temporal discounting rates for health often differ from those for money. Some studies find that temporal discounting rates are lower in the health domain than in the monetary domain (Attema et al., 2018; Meerding, Bonsel, Brouwer, Stuifbergen, & Essink-Bot, 2010), while a few studies find the opposite (Chapman & Elstein, 1995). Second, temporal discounting rates for health and money are weakly correlated and independent. Chapman and Elstein (1995) found that the correlation between health and monetary domains was lower than correlations within each domain. Finally, health and monetary intertemporal decisions differ in some biases. For example, in sequence effects, people generally prefer gradually improving options in the monetary domain but prefer "bitter first, sweet later" sequences in the health domain (Gafni, 1995). In delay effects, the effect is larger (Bleichrodt et al., 2016) or smaller (Galizzi, Miraldo, Stavropoulou, & Van der Pol, 2016) in the health domain than in the monetary domain. In sign effects, temporal discounting rates for health gains are lower than for monetary gains, but no significant difference exists between the two domains in loss situations (Berry, Nickerson, & Odum, 2017).

Domain specificity in health intertemporal decision making may stem from differences between health and money in multiple characteristics, such as utility

and value, tradability, temporal continuity, and uncertainty. First, early scholars proposed based on the discounted-utility model's computational assumptions that domain specificity might originate from differences in utility and value between health and money. However, after matching utility functions to account for these differences, domain specificity remained (Chapman, 2003). Second, unlike money, health has the characteristic of being non-tradable (Chapman, 2002; Attema, 2011). Therefore, some researchers hypothesized that domain specificity might partially result from decision-makers' default assumption that health cannot be traded with money. When they forcibly created tradable choice situations for health, they found consistency between health and monetary temporal discounting rates increased, supporting their hypothesis (Chapman, 2002). Third, health outcomes mostly require a continuous period to achieve, whereas monetary outcomes can occur at a single time point (Bleichrodt & Johannesson, 2001). However, people' s preferences differ between single-time-point outcomes and sequential outcomes—they may show impatience for single-time outcomes but preference for the future in continuous outcomes (Loewenstein & Prelec, 1992). Finally, future health outcomes may be more uncertain than future monetary outcomes. Some research suggests that delay effects occur because present outcomes are certain while future outcomes are uncertain (Andersen, Girolamo, Harrison, & Lau, 2014). It can be inferred that if future health outcomes have greater uncertainty, biases in delay effects between money and health may stem from differences in uncertainty, though no relevant empirical evidence has been seen yet.

These studies suggest that the psychological and behavioral mechanisms of health and monetary intertemporal decisions may have essential differences. Equating health intertemporal decision making with monetary intertemporal decision making without distinction may lead to distortion or misunderstanding of the nature of health intertemporal decision making.

## 4. Research Methods for Health Intertemporal Decision Preferences

For a long time, research methods for health intertemporal decision preferences can be divided into two categories: stated preference methods and revealed preference methods. These methods have significantly different implicit assumptions and applicable scopes.

Stated preference methods mainly follow traditional time trade-off methods from the monetary domain: they derive individuals' "indifference points" for outcomes at different time points through participants' choices, then calculate temporal discounting rates based on intertemporal decision models. Due to operational convenience, stated preference methods have been favored in empirical research and remain the primary method for studying health intertemporal decision preferences. Specifically, these methods mainly use closed-ended choice tasks and open-ended matching task paradigms.

Choice task paradigms typically present single or continuous discrete options, requiring participants to choose between two health outcomes at different time points with different magnitudes (Gafni & Torrance, 1984; Jonker, Donkers, De Bekker-Grob, & Stolk, 2018; Van der Pol & Cairns, 2001). For example, in a specific chronic disease scenario, participants are presented with two treatment options: Option 1 provides disease relief for a period starting now; Option 2 provides disease relief for x time periods starting at time point t. By varying x or t to find the indifference point, researchers determine participants' time preferences for health gains (MacKeigan, Larson, Draugalis, Bootman, & Burns, 1993; Van der Pol & Cairns, 2001). Matching task paradigms generally require participants to report outcomes at one time point that are subjectively equivalent to outcomes at another delayed time point. For example, "How many days of illness now is equivalent to 30 days of illness one year later?" By varying delay time and health outcome magnitude, researchers determine temporal discounting rates for different delays and health outcomes (Chapman, 2002; Mahboub-Ahari et al., 2019; Robberstad, 2005). Both tasks require participants to imagine future health events, which is often limited by personal experience and other factors, making it difficult to obtain precise health intertemporal preferences (Van der Pol & Cairns, 2001).

Revealed preference methods primarily observe individuals' actual behavioral performance in contexts related to time preferences to measure health intertemporal decision preferences. For example, individuals' performance in health insurance and medical examination behaviors represents their health intertemporal preferences, with high insurance rates and examination rates indicating future-oriented health preferences (Wang & Sloan, 2018). However, due to difficulty in obtaining relevant behavioral data and confounding factors such as socioeconomic status, this method is not widely used (Stavem, Kristiansen, & Olsen, 2002).

The health intertemporal decision making field has also used standard gamble questions as a special method to study health intertemporal decision preferences. Standard gamble questions borrow classic methods from risk preference measurement, incorporating risk (uncertainty) as a unique factor in health intertemporal decisions, reflecting trade-offs between quality of life (Q) and survival duration (T) (Gafni, 1994). The classic paradigm requires participants to choose between two alternatives: Option 1 is a treatment with two possible outcomes—recovery and living T more years (probability p) or immediate death (probability 1-p); Option 2 is living T years in disease state (i). By varying probability p to find participants' indifference point for disease state i, researchers determine preferences for quality of life (Q) versus survival duration (T) (Gafni, 1994; Gyrd-Hansen, 2002).

Notably, due to difficulty in developing appropriate measurement tools for health intertemporal decision behaviors, research often measures individuals' general intertemporal decision preferences or time perspective, indirectly assessing health intertemporal decision preferences by examining their relationship

with health behaviors. General intertemporal decision preferences mostly follow monetary domain measurement paradigms, using choice tasks and matching tasks (Chapman & Coups, 1999; Sofis, Carrillo, & Jarmolowicz, 2017). Time perspective, reflecting individuals' consistent views of past, present, and future, represents general intertemporal decision preferences to some extent (Henson, Carey, Carey, & Maisto, 2006) and is also widely used. Time perspective measurement tools mainly consist of two self-report scales: the Zimbardo Time Perspective Inventory (ZTPI) and the Consideration of Future Consequences Scale (CFCS). Both assess individuals' consideration of current and future consequences but from different angles. ZTPI divides time perspective into five dimensions (past positive, past negative, present hedonistic, present fatalistic, and future), evaluating past, present, and future time views (Zimbardo & Boyd, 1999). CFCS directly assesses the continuous time view between present and future (Strathman, Gleicher, Boninger, & Edwards, 1994).

Current research methods for health intertemporal decision preferences have several significant problems. At the theoretical level, mainstream stated preference methods rely on the discounted-utility model from the monetary domain, which may not accurately describe preferences for health outcomes. The discounted-utility model assumes a constant temporal discounting rate, whereas health domain discounting rates are more likely variable, but current choice and matching tasks cannot measure variable discounting rates (Stavem et al., 2002). At the practical level: (1) Different research methods may cause inconsistent preference results. Temporal preference values under standard gamble questions are typically much higher than those estimated by stated preference methods (Gyrd-Hansen, 2002). Between the two stated preference methods, temporal discounting rates in choice tasks are lower than in matching tasks (Van der Pol & Cairns, 2001). (2) Most existing research paradigms have low ecological validity and cannot accurately measure health intertemporal decision preferences. To estimate temporal discounting rates for health using discounting functions, most studies implicitly assume health outcomes occur at a single time point, ignoring that health outcomes require a continuous period to achieve (Bleichrodt & Johannesson, 2001). (3) Existing research paradigms only consider single health outcomes in pure gain or pure loss situations and cannot be applied to mixed gain-loss health decision contexts. Therefore, future research needs to comprehensively consider these issues and develop measurement tools and methods suitable for health intertemporal decision preferences.

## 5. Behavioral Consequences of Health Intertemporal Decision Making

One research approach in the health intertemporal decision making field examines the relationship between individuals' health behaviors and general intertemporal decision preferences/time perspective to explore the behavioral consequences of health intertemporal preferences. In recent years, studies have begun exploring the relationship between health behaviors and intertemporal

preferences/time perspective, but different studies focus on different specific health behaviors, making unified comparison difficult. Therefore, following previous classifications of health behaviors (McEachan, Lawton, & Conner, 2010), we categorize health behaviors containing intertemporal decision components into health protection behaviors and health risk behaviors based on whether they are beneficial or harmful to health. We summarize the relationships between these behaviors and intertemporal decision preferences/time perspective reported in previous studies (see Table 1 and Table 2 ).

In summary, after controlling for various potential confounding factors, most studies find that intertemporal decision preferences are indeed associated with health behaviors. On one hand, low temporal discounting rates/high future time orientation are positively correlated with health protection behaviors. Individuals with low discounting rates and high future orientation have good lifestyle habits (e.g., regular exercise, healthy diet) (Adams, 2009; Gellert, Ziegelmann, Lippke, & Schwarzer, 2012; Griva, Tseferidi, & Anagnostopoulos, 2015; Hunter et al., 2018; Kosteas, 2015; LeComte, Sofis, & Jarmolowicz, 2020; Mahon, Yarcheski, & Yarcheski, 2000; Snider, DeHart, Epstein, & Bickel, 2019), more environmental risk avoidance behaviors (e.g., sun protection) (Mahon et al., 2000), preventive health behaviors (e.g., health check-ups, flu vaccination, medical adherence) (Axon, Bradford, & Egan, 2009; Bradford, 2010; Mahon et al., 2000; Sheffer et al., 2018; Snider et al., 2019), and dangerous situation avoidance behaviors (e.g., safe sex, seatbelt use, helmet use) (Henson et al., 2006; Mahon et al., 2000). On the other hand, low temporal discounting rates/high future time orientation are negatively correlated with health risk behaviors. Individuals with high discounting rates and low future orientation exhibit more smoking (Fuchs, 1982; Sheffer et al., 2018; Takagi et al., 2016), alcohol abuse (Henson et al., 2006; Sheffer et al., 2018; Takagi et al., 2016), unsafe sex (Henson et al., 2006), lack of sun protection (Sheffer et al., 2018), drug use (Kim-Spoon, Farley, Holmes, Longo, & McCullough, 2014; Snider et al., 2019), and other health risk behaviors.

Meanwhile, some studies find no association between individuals' intertemporal decision preferences and health behaviors. For example, vaccination acceptance is weakly correlated with monetary intertemporal preferences and not associated with health intertemporal preferences (Chapman & Coups, 1999). Among hypertensive patients, a 1% increase in temporal discounting rates did not change dietary or exercise habits (Axon et al., 2009). Future time orientation is not significantly related to exercise (Gulley, 2013; Gulley & Boggs, 2014; Guthrie, Butler, & Ward, 2009), healthy diet (Sheffer et al., 2018), safe driving (Henson et al., 2006; Snider et al., 2019), or smoking (Griva et al., 2015; Guthrie et al., 2009).

Thus, most studies support that health behaviors are behavioral consequences of health intertemporal decision preferences. However, it is worth noting that different studies use different samples and methods, and do not carefully distinguish between different health behaviors. Generally treating health behaviors as

consequences of health intertemporal preferences may be problematic. We argue that the mixed and even contradictory results may stem from ignoring the specificity of health intertemporal decision making. Even when clearly distinguishing behaviors that belong to the category of health intertemporal decisions, domain specificity may still exist within the health domain itself. Preferences reflected by different health behaviors may not be homogeneous. For example, exercise and healthy diet behaviors may reflect preferences for long-term health, while health check-ups and medical adherence may reflect preferences for short-term health. However, the issue of inconsistent preferences within health intertemporal decision behaviors has not received due attention and warrants further investigation in future research.

## 6. Influencing Factors of Health Intertemporal Decision Making

Health intertemporal decision making has many special attributes that differ from money or other domains. Therefore, preferences for paying short-term costs to obtain long-term health benefits, or avoiding costs for future health benefits, at both individual and societal levels may be influenced by unique factors. Examining key factors that influence individual health intertemporal decision preferences has become an indispensable step in exploring the psychological mechanisms of health intertemporal decision making. Current research has mainly explored potential influencing factors from the perspectives of decision objects and decision makers.

### 6.1.1 Decision Objects: Self vs. Others/Societal Health

Health intertemporal decision objects mainly involve one' s own health and others' /societal health. Whether decision makers have consistent preferences for different objects remains inconclusive. On one hand, some studies report that people' s intertemporal preferences for their own health differ from those for others' /societal health (Ahari, Pourreza, Sari, Foroushani, & Heydari, 2014; Chapman, 2002; Mahboub-Ahari et al., 2019). Some evidence shows that individuals have lower temporal discounting rates for others' /societal health than for their own health (Chapman, 2002). For example, policymakers are more cautious from a societal perspective and discount future health less than individual decision makers. Meanwhile, some evidence shows the opposite pattern –higher discounting rates for others' /societal health than for one' s own health (Ahari, Pourreza, Sari, Foroushani, & Heydari, 2014; Mahboub-Ahari et al., 2019). Moreover, individual health intertemporal preferences are more influenced by demographic factors than societal health intertemporal preferences (Van der Pol & Cairns, 2001). On the other hand, some studies find that people' s intertemporal preferences for their own health are roughly the same as for societal health (Gyrd-Hansen, 2002; Irvine, Van der Pol, & Phimister, 2019; Robberstad, 2005; Van der Pol & Cairns, 2008). For example, doctors show no significant difference in temporal discounting rates when making intertemporal

choices for their own health versus their patients' health (Irvine, Van der Pol, & Phimister, 2019). Future research still needs more effective empirical evidence to clarify the relationship between personal and societal health intertemporal preferences.

### 6.1.2 Attributes of Decision Options

Similar to the monetary domain, health intertemporal decision making is influenced by various attributes of decision options (decision valence, delay time, health outcomes), manifesting as sign effects, delay effects, and magnitude effects (Bleichrodt et al., 2016; Mahboub-Ahari et al., 2019; Ortendahl & Fries, 2005). First, decision valence affects health intertemporal preferences—temporal discounting rates in loss frames are often lower than in gain frames (Chapman, 1996; Chapman & Elstein, 1995; MacKeigan et al., 1993). This effect can be used for health interventions. For example, preventive health behaviors belong to gain frames, while detection health behaviors belong to loss frames (Li & Chapman, 2013). If preventive health decisions are framed as loss frames, their temporal discounting rates can be reduced (Ortendahl & Fries, 2005). Second, the length of delay time may cause changes in health intertemporal decision preferences—discounting rates for shorter delays are often greater than for longer delays (Chapman, 1996; Chapman & Elstein, 1995; Olsen, 1993; Robberstad & Cairns, 2007). Third, health outcome magnitude also affects health intertemporal decision preferences—larger health outcomes have smaller discounting rates than smaller health outcomes (Chapman, 1996; Chapman & Elstein, 1995; Robberstad, 2005; Robberstad & Cairns, 2007). Additionally, various decision option attributes have interactive effects on health intertemporal choices. For example, in gain domains, temporal discounting rates are relatively consistent across different health outcome magnitudes, but in loss domains, larger health outcomes have higher discounting rates while smaller health outcomes have lower rates, even showing negative discounting (MacKeigan et al., 1993).

Notably, as mentioned earlier, the health domain has characteristics different from the monetary domain, and health and monetary intertemporal decisions differ in some decision biases. However, current research on how decision attributes affect health intertemporal decision making still borrows theories and methods from the monetary domain, and their validity and applicability in the health domain need further examination.

## 6.2 Individual Difference Factors

Health intertemporal preferences are influenced not only by decision objects and option attributes but also show obvious individual differences. Existing research has mainly explored how health status, socioeconomic status, personality, time perspective, and other factors affect health intertemporal preferences.

**6.2.1 Health Status** Individuals' physical health status affects their health intertemporal decision preferences—this seems intuitive and self-evident, but

conclusions from numerous related studies are not entirely consistent.

Most studies confirm this effect, which mainly appears in general health status. Since Body Mass Index (BMI) is commonly used to measure general physical condition, these studies mostly use BMI as a health status indicator to explore its impact on health intertemporal preferences. Early research found no association between BMI and health intertemporal preferences (Kirby et al., 2002), but some recent studies have different findings. For example, BMI is significantly positively correlated with impulsivity levels and temporal discounting rates (Cavaliere, De Marchi, & Banterle, 2014; Rieger, 2015; Zhang & Rashad, 2008). Adult subjects without coronary heart disease history show lower correlation between BMI and low discounting tendency (Garza, Harris, & Bolding, 2013). Obese female students (using BMI as indicator) have higher temporal discounting rates than healthy-weight students (Weller et al., 2008). Additionally, since subjective health status and age are closely related to general health status, some studies use self-reported health status and age as general health indicators and find effects on health intertemporal decision making. For example, respondents' temporal discounting rates increase with age, and respondents who self-report fair or poor (rather than good) health status tend to have lower discounting rates (Van der Pol & Cairns, 2001). People with illness experience and older adults prefer options beneficial to long-term health (Lawless, Drichoutis, & Nayga, 2013).

This effect also appears under extreme health conditions. One study of residents in a high morbidity and mortality area (a community in South Africa) found a U-shaped relationship between extreme physical health status and temporal discounting rates—individuals in very unhealthy and very healthy conditions both have high discounting rates (Chao, Szrek, Pereira, & Pauly, 2009). Discounting rates for saving lives (mortality) are higher than for improving health (morbidity) (Olsen, 1993). Temporal discounting rates differ across disease contexts (Ganiats et al., 2000; Redelmeier & Heller, 1993): blind patients often have lower discounting rates than colostomy or depression patients (Redelmeier & Heller, 1993); different populations show different discounting rates across five specific disease contexts—chickenpox (negative discounting), Parkinson' s disease (positive discounting), tropical diseases (positive discounting), migraine (high positive discounting), and sterilization (moderate positive discounting) (Ganiats et al., 2000).

However, a few studies do not support the effect of health status on health intertemporal decision making. One study of real patients (with chronic obstructive pulmonary disease) only confirmed the effect of age on health intertemporal preferences but found no effect of disease severity (Stavem et al., 2002). Another study reported that individuals' subjective health status does not affect their health intertemporal decision preferences (Robberstad, 2005), and health intertemporal decision preferences have no significant relationship with age, BMI, or physical exercise (Chao et al., 2009; Stahl & Patrick, 2012).

From the above studies, it is clear that current research uses inconsistent indica-

tors for general health status and confounds other factors, making it impossible to fully clarify the impact of general health status on health intertemporal preferences. Moreover, research on health intertemporal preferences under extreme health conditions or different disease states remains incomplete. Investigating health intertemporal preferences across various disease states is an important direction for future research.

**6.2.2 Socioeconomic Status and Other Variables** Societal economic and development levels are inseparable from national health. This relationship manifests at the individual level as an association between socioeconomic status and health intertemporal decision making. For example, individuals with higher education levels prefer options beneficial to long-term health (Fredslund et al., 2018; Guthrie et al., 2009; Lawless et al., 2013). Among UK elderly samples, older adults with high socioeconomic status have higher future time orientation, less smoking behavior, and higher physical exercise frequency than those with low socioeconomic status (Adams, 2009). However, this relationship may be more complex: one study found that education level is associated with unhealthy behaviors such as smoking, alcohol abuse, and BMI, but temporal discounting rates do not mediate the relationship between education level and health behaviors (Takagi et al., 2016). Another similar study found that time perspective is closely related to socioeconomic status and self-reported health status but not to health behaviors such as obesity, smoking, or exercise (Guthrie et al., 2009).

Other important individual difference factors such as gender, personality traits, and time perspective (see Tables 1 and 2) may also affect health intertemporal preferences. For example, compared to men, women tend to discount health outcomes more and prefer immediate health (Fredslund et al., 2018). Personality traits of conscientiousness, neuroticism, and openness are related to exercise willingness and behavior (Villaron et al., 2017). A meta-analysis reported significant effects of time perspective on health outcomes (Andre, Vianen, Peetsma, & Oort, 2018). However, related research remains limited.

## 7. Future Research Directions

In summary, contrary to its importance in real life, many relevant topics in the health intertemporal decision making field have been superficially addressed or not yet touched upon by academia. Future researchers and practitioners may consider the following directions.

First, future research should 致力于理论框架的界定，区分并细化健康行为与跨期决策偏好的关系. Although many health behaviors reflect individuals' intertemporal preferences, not all health behaviors include intertemporal decision components. Therefore, starting from the basic attributes of intertemporal decision making, distinguishing health intertemporal decision behaviors from other health behaviors, and clearly defining the extension of health intertemporal decision making is an important prerequisite for expanding this field. This paper has attempted to categorize health behaviors containing intertemporal decision components

into health protection behaviors and health risk behaviors based on whether they are beneficial or harmful to health. However, this classification does not include another important attribute of health intertemporal decisions: the timing of health outcomes. Recent research shows that different health behaviors differ in "outcome timing"characteristics—some produce immediate health effects while others take a long time to show effects (McEachan, Lawton, & Conner, 2010; Nudelman & Shiloh, 2016, 2018). Therefore, future research needs to fully consider domain specificity in health intertemporal decision making, especially sub-domain specificity, distinguishing health intertemporal preferences represented by different health behaviors to better utilize foundational intertemporal decision theories to explore the nature of health intertemporal decision making.

Second, future research should focus on health's unique attributes to develop theoretical models and measurement paradigms suitable for health intertemporal decision making. Currently, the health domain mainly references theories and methods from the monetary domain, which are not entirely applicable to health. Because the health domain differs from the monetary domain—health outcomes are uncertain and risky, mostly require a continuous period to achieve (Bleichrodt & Johannesson, 2001), and health decisions are mostly mixed gain-loss scenarios where health gains require paying other costs—future research should consider not only health gains but also cost/price, uncertainty, temporal continuity, and other characteristics of health outcomes. Future studies should develop theoretical models suitable for health intertemporal decision making, focusing on exploring unique psychological and behavioral mechanisms in health domain intertemporal decisions, while developing ecologically valid measurement tools to study health contexts and intertemporal choice problems that reflect real life.

Third, future research should focus on decision-making processes to deeply explore the internal choice mechanisms of health intertemporal decision making. Current research in the health intertemporal decision making field mostly uses behavioral outcomes as decision preference measurement indicators, neglecting information about people' s health decision-making processes and making it difficult to understand the reasons behind health intertemporal preferences. In recent years, process-tracing methods such as eye-tracking technology have been widely used in decision-making research. These methods can naturally and non-invasively record participants' decision-making processes without special restrictions or requirements on experimental tasks or subjects, and collect diverse information (Ashby & Rakow, 2016; Smith & Krajbich, 2018; Van der Laan, Hooge, De Ridder, Viergever, & Smeets, 2015), making them effective methods for studying complex cognitive processes in decision making. Future research could adopt process-tracing methods such as eye-tracking technology to further explore the internal choice mechanisms of health intertemporal decision making, helping us better understand and promote health intertemporal decisions.

Finally, future research should conduct more attempts and explorations in health behavior interventions and healthcare policy applications. At the individual level, health behaviors can be improved by reducing temporal

discounting rates or enhancing future time orientation (Rung, & Madden, 2018; Rung, Peck, Hinnenkamp, Preston., & Madden, 2019). For example, through regular education and activities, increasing individuals' awareness and consideration of the long-term effects of their physical activity can promote increased physical activity (Hall & Fong, 2003). Or by leveraging discounting biases in the health domain to encourage future-oriented health behaviors—for instance, delaying regular snack vending machine delivery by 25 seconds compared to healthy snack vending machines can postpone unhealthy food intake and increase the proportion of healthy food purchases (Appelhans et al., 2018). At the healthcare policy level, substantial evidence has shown that the fixed temporal discounting rates used in existing healthcare policies may be overly simplistic. Future research should conduct classified and detailed studies on health intertemporal decision making across different populations and healthcare contexts, applying appropriate temporal discounting rates to different populations or disease patients to provide scientifically reliable bases for healthcare policy formulation.

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*Note: Figure translations are in progress. See original paper for figures.*