Hypothesis/Commentary

Cancer Epidemiology, Biomarkers & Prevention

Time to Get Serious About Skin Cancer Prevention

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Abstract

In this commentary, we discuss the skin cancer epidemic in the United States and provide data to indicate that the United States public is not protecting itself from ultraviolet radiation, the primary risk factor for melanoma, and nonmelanoma skin cancer. In our opinion, skin cancer control in this country may be hindered by uncertainty about the effectiveness of sun protection strategies, inconsistent messages about the relative effectiveness of sun protection measures by federal and national organizations, and conventional research approaches that have identified few effective sun protection interventions for adults and targeted individuals for behavior change without considering the environmental context. A policy and research agenda is put forth to remedy the apparent insufficiencies in the current approach to skin cancer prevention in the United States. *Cancer Epidemiol Biomarkers Prev; 21(11); 1893–901. ©2012 AACR.*

Skin Cancer is Epidemic in the United States

At a time when incidence is declining for all major cancers in men and women in the United States, the long-recognized epidemic of skin cancer persists (1). Since 1992, melanoma incidence in the United States has risen 1.8% to 4.6% per year, affecting men and women of all ages; an increase in incidence of nonmelanoma skin cancer has also been documented nationally and internationally (2–5). This pattern is especially frustrating because, compared with other cancers trending upward (pancreas and kidney cancer in men and women, thyroid cancer in women, liver cancer in men), skin cancer is preventable. Both solar and artificial sources of ultraviolet (UV) radiation are established causes of skin cancer (6, 7). The relationship of UV radiation to the development of skin cancer differs for melanoma and nonmelanoma skin cancer and depends on the interplay of genetic susceptibility, the intermittent or chronic nature of time spent in the sun, and lifetime acquisition of sunburns (8, 9). Nevertheless, UV radiation is estimated to account for 50% to 90% of melanoma or basal cell skin cancer and 50% to 70% of squamous cell skin cancers worldwide (10). Thus, effective protection of the skin from UV radiation would prevent a substantial amount of melanoma and nonmelanoma skin cancer, saving 10 to 15 years of potential life lost per skin cancer death, and annual costs of $29 to $39 million in morbidity and $1 to $3.3 billion in mortality, depending on the type of skin cancer (11).

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The skin cancer epidemic continues because the United States population is not protecting itself from the harmful effects of UV radiation. Since 2000, national trends indicate inconsequential changes in use of shade, sunscreen, or shirts with long sleeves; less than 5% of the population reported use of all 3 strategies in 2010 (Fig. 1A; ref. 12). As a consequence, sunburn prevalence, a marker of nonadherence to sun protection recommendations, has not changed over time (Fig. 1B). Although indoor tanning use in the United States population declined from 15% in 2008 to 6% in 2010, it is 5 times more common among young white women and is also likely contributing to increasing skin cancer rates in that group (13, 14). In a recent review of published reports from state and national surveys on sunburn prevalence, sun protection, and indoor tanning behaviors among adults, the authors concluded that these observations reflect not so much a failure of national efforts to improve sun protection, but rather a consequence of little national investment to support frequent, sustained, and coordinated sun protection programs (15). We agree with this assessment, and expand here on reasons that may hinder skin cancer control efforts in the United States, focusing on protection from solar UV radiation.

The Uncertain Effectiveness of Sun Protection Methods

Ideally, credible sun protection recommendations are based on strong scientific evidence. However, widely accepted sun protection strategies—clothing and hats, sun avoidance via shade or timing, or sunscreen—offer variable effectiveness for reducing exposure to UV radiation, whereas research on their efficacy to prevent skin cancer is fairly sparse. Severe sunburns, which increase melanoma risk, are less commonly reported by persons who regularly choose clothing, hats, shade, or midday sun avoidance compared with persons who do not (16, 17). However, shade structures are known to only partially

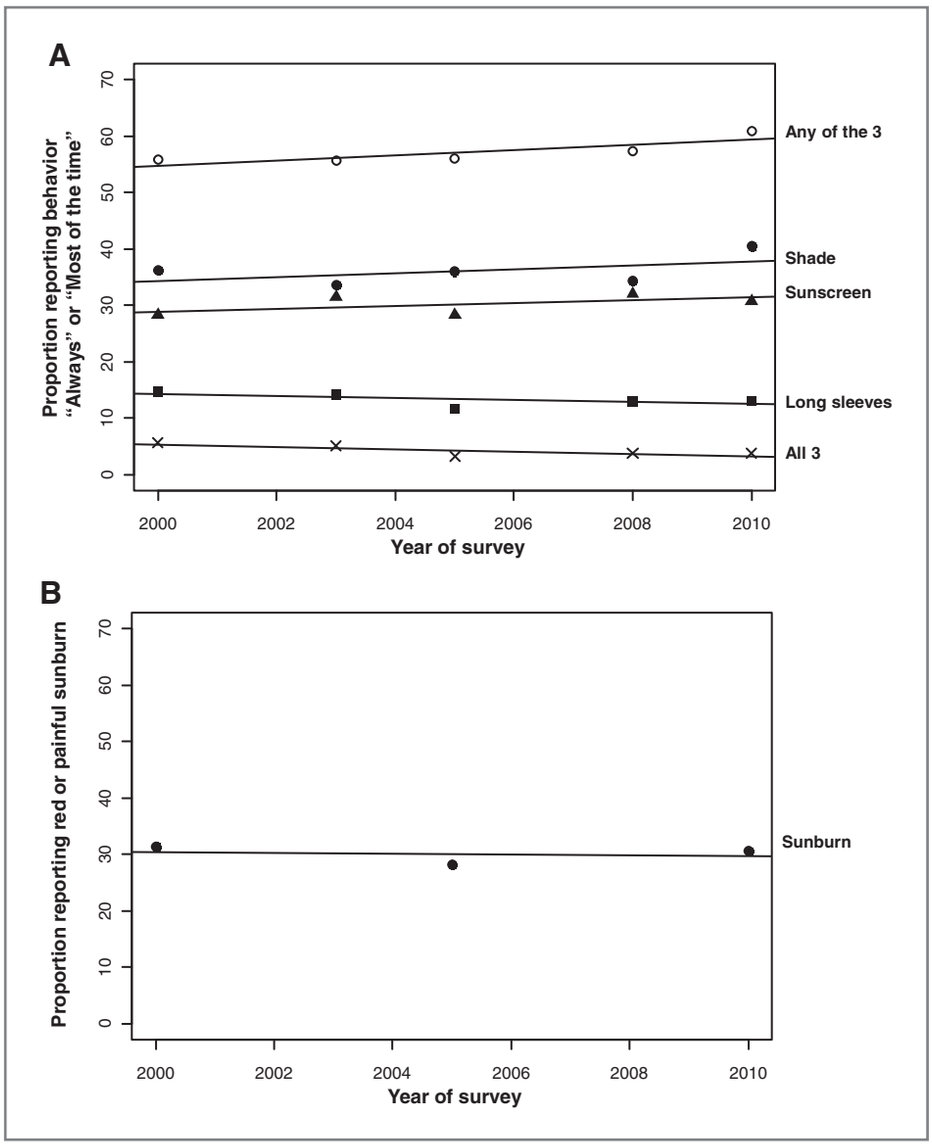

Figure 1. Sun protection practices and prevalence of sunburn among adults in the United States, National Health Interview Survey, 2000 to 2010. Data from the National Health Information Survey, age-adjusted to the 2000 standard using age groups: 18–24, 25–34, 35–44, 45–64, 65+ years. A, percentage of adults 18 and older who report they always or most of the time: seek shade, use sunscreen with SPF $\geq$ 15, wear a long-sleeve shirt, one these practices or all 3 practices. A question about hats was asked in all years, however, the wording and order changed over time, which resulted in inaccurate estimates of behavior and therefore those data are not reported here (99). B, percentage of adults 18 and older who report a sunburn in the past 12 months (with "sunburn" being defined as even a small part of skin turned red or hurt for 12+ hours, including burns from sunlamps and other indoor tanning devices).

block UV radiation, depending on location underneath and size of the shade apparatus and the amount of surface reflectance (18). Sun protection from hats depends on how wide the brim is and to what extent the ears, neck, and face are covered (19). The UV protection factor of clothing varies by type of garment, its fabric, weave and color, and number of washings (20). Research on clothing or shade and melanoma prevention is limited, although a few reports suggest melanoma risk is affected by whether the tumor site was exposed or covered during outside work, whether the trunk was exposed or covered by swimwear, and whether methods such as use of clothing or staying in the shade were frequently used in the 2 decades before melanoma diagnosis (21–23).

In contrast to clothing selection and sun avoidance, use of sunscreen allows direct sun exposure to the skin by lessening sunburn risk. In fact, sunscreen has been associated with intentional sun exposure and greater amounts of UV radiation to the skin (24). For maximum sunburn protection, the timing of sunscreen application before sun exposure, the amount of sunscreen applied, and the frequency of sunscreen reapplication are important factors. Determination of the sun protection factor (SPF) of a sunscreen product is based on applying 2 mg/cm^2, but individuals typically apply less than half this amount (25). Under these conditions, sunscreen with an SPF of 15 is reduced to about 5, the same level of protection as a suntan (26). Application of sunscreen is recommended about 30 minutes before going in the sun with reapplication at least every 2 hours, or more frequently if sunscreen is washed, sweated, or toweled off (27–29). Studies that assessed how well these sunscreen directions are followed indicate low compliance (Table 1; ref. 23, 30). Finally, it is important to note that SPF only describes level of protection from UVB,

Table 1. Proportion of controls ($n = 1101$), ages 25 to 59 years, in a population-based case–control study (23) who reported adequate use of sunscreen in the past decade by age at interview

		Age at interview (years)			
Sunscreen pattern	**Total**	**<30**	**30–39**	**40–49**	**50–59**
% reporting...					
Almost always use sunscreen with SPF 15 or greater	56.9	50.0	54.4	60.2	56.1
Apply thick coating of sunscreen	9.3	8.8	10.9	9.9	8.1
Covered all or most of skin with sunscreen	63.9	54.4	62.2	70.2	60.4
Almost always reapplied sunscreen after 2 hours	10.1	7.4	10.9	11.2	9.2
Almost always used even when not planning to be in the sun	6.6	5.9	5.7	7.6	6.1

not UVA. U.S. Food and Drug Administration just issued standards for UVA protection in sunscreen in 2011 (31), so many sunscreen products, even those labeled as broad spectrum, have not provided adequate UV protection.

The inadequate use of sunscreen is one explanation for the lack of an association between sunscreen and melanoma in case–control studies (32, 33). Only 1 randomized controlled trial has tested the efficacy of sunscreen for preventing skin cancer. In that study, daily application of sunscreen to head, neck, and arms compared with usual sunscreen practice resulted in decreased incidence of squamous, but not basal cell, carcinoma of the skin (34, 35). Ten years after trial completion, 11 melanomas were diagnosed among individuals assigned to the intervention versus 22 melanomas among those in the comparison condition (35). The routine use of sunscreen was also associated with decreased risk of melanoma in a recent case–control study (23), providing some support for making sunscreen use a daily habit to reduce skin cancer risk regardless of planned outdoor activities.

Disagreement about Skin Cancer Prevention Recommendations

On the basis of the available evidence and expert opinion, skin cancer recommendations from the International Agency for Research on Cancer (IARC) include protective clothing that covers arms, legs and trunk, hats that sufficiently shade the entire head, shade, avoidance of sun during peak exposure hours, and sunscreen, *in that order* (emphasis added), with the additional qualifier that sunscreen not be the first nor sole method selected (36). Against this backdrop, a comparison of skin cancer prevention recommendations from 4 federal agencies or national organizations is informative regarding the challenges of promoting sun safety messages to the United States public (Table 2). Altogether, 14 different messages are communicated; none follow the order presented by IARC. Although all groups urge avoidance of indoor tanning, they only agree on 2 sun protection recommendations: wear protective clothing (or "cover up") and use sunscreen. Sunscreen recommendations run from simple (see American Cancer Society) to complex (see American Academy of Dermatology); the notion that sunscreen should be used only in combination with other strategies is largely missing. For detailed instructions about proper use of sunscreen (e.g., amount, timing, and reapplication), further investigation of the Web sites is required.

The apparent discord among groups is also reflected in evidence-based recommendations issued by the Task Force on Community Preventive Services in 2003 (37). Even though its systematic review of intervention research for sun protection identified effective strategies to improve sunscreen use (38), the Task Force did not issue any sunscreen-specific recommendations on the basis that sunscreen alone was inadequate for sun protection. Regardless of the inconsistency by national groups in their sun protection recommendations, the media emphasizes sunscreen as the preferred approach to sun protection (39, 40). The dominance of sunscreen more than other sun protection strategies in the media is undoubtedly reinforced by the advertising expenditures for sunscreen by the skin care industry, estimated to be US $75 million in 2011 (41). Not surprisingly, when the United States public is asked about ways to prevent skin cancer, 72% volunteer sunscreen but only 63% suggest sun avoidance and 46% offer clothing or hats (42).

Conventional Research Approaches Yield Few Options for Adult Sun Protection

Adults are exposed to UV radiation throughout their lifetime (43), sunburns confer increased risk of melanoma regardless of age received (44), and sustainability of childhood sun protection behaviors into adulthood has not been documented. In addition, adults are monitored for progress in sun protection behavior. Yet, 2 systematic reviews of intervention research to guide implementation of effective sun protection found few strategies to recommend for the adult population (38, 45). From a review of reports published through 2002 (38), the Task Force for Community Preventive Services found "sufficient evidence" from randomized controlled trials to recommend "educational and policy" interventions implemented primarily at pools or beaches for just 1 sun protective action, "covering up." A recent review for the U.S. Preventive Services Task Force of behavioral counseling trials published through 2008 did not find evidence to recommend

Table 2. Skin cancer prevention recommendations from 4 federal agencies or national organizations in the United States

Agency	Recommendations
Environmental Protection Agency (EPA) http://www.epa.gov/sunwise/actionsteps.html	• Do not burn • Avoid sun tanning and tanning beds • Generously apply sunscreen with SPF 15 or higher and both UVA and UBV protection • Wear protective clothing • Seek shade • Use extra caution near water, snow, and sand • Check the UV index • Get vitamin D safely
Centers for Disease Control (CDC) http://www.cdc.gov/cancer/skin/basic_info/prevention.htm	• Seek shade, especially during midday hours • Wear clothing to protect exposed skin • Wear a hat with a wide brim to shade the face, head, ears, and neck • Wear sunglasses that wrap around and block as close to 100% of both UVA and UVB rays as possible • Use sunscreen with sun protective factor (SPF) 15 or higher, and both UVA and UVB protection • Avoid indoor tanning
American Academy of Dermatology http://www.aad.org/skin-care-and-safety/skin-cancer-prevention/be-sun-smart	• Generously apply a broad-spectrum, water-resistant sunscreen with a SPF of 30 or more to all exposed skin • Wear protective clothing • Seek shade • Use extra caution near water, snow, and sand • Get vitamin D safely • Avoid tanning beds • Check your birthday suit on your birthday
American Cancer Society http://www.cancer.org/Cancer/CancerCauses/SunandUVExposure/SkinCancerPreventionandEarlyDetection/skin-cancer-prevention-and-early-detection-u-v-protection	• Cover up • Use sunscreen • Wear a hat • Wear sunglasses that block UV rays • Limit direct sun exposure during midday • Avoid tanning beds and sunlamps • Protect children from the sun • Get vitamin D through diet and vitamin supplements

this approach for adults after age 24 (45, 46). Pointing a way forward in skin cancer prevention research, the Task Force for Community Preventive Services documented several gaps and challenges for research on sun protection (38). In particular, studies measured changes in knowledge and attitudes but few assessed behavioral and health outcomes (e.g., sunburn), relied on change in a composite score of sun protection behaviors making it difficult to determine if the intervention was effective for a specific behavior, and examined only short-term changes so were unable to guide actions to sustain the desired behavior.

The Need for a Comprehensive Approach to Skin Cancer Prevention

Although the evidence was limited, the Task Force for Community Preventive Services was especially positive about the potential of "comprehensive, community-wide interventions" to improve sun protection behavior to decrease skin cancer risk (38). Today, a comprehensive approach is increasingly recognized as essential to improve and sustain population level health promotion efforts (47, 48). Its utility has been shown through success in tobacco control and it is being applied to understand the complexities of health disparities (49, 50). A comprehensive, or multilevel, approach tackles a public health problem from multiple perspectives and draws on the interactions between the individual, his or her relationships with others, and the environment (47, 51). As noted by the Task Force, research to test a multilevel approach to improve adoption of sun protection has seldom been attempted. We reviewed an additional 17 randomized controlled trials that tested interventions to change sun protection behavior in adults, published and available on

PubMed since that systematic review (52–68). From these, we identified only 2 that appeared to purposefully take a multilevel approach to intervention design and testing, with promising results (54, 60). In a study of U.S. postal workers, participants who worked in intervention post offices were educated about sun safety, provided accessories (e.g., key chains with sun safety messages), exposed to posters to cue action, and offered free hats and free sunscreen in locker rooms (60). This resulted in higher use of sunscreen and wide brimmed hats than among workers in nonintervention post offices. Importantly, this study has shown a persistent intervention effect through 2 years of observation. In a study at ski resorts, the intervention included signage to inform staff about skin cancer risks and remind them to use sun protection, techniques to encourage coworkers to discuss sun safety with each other and with guests, and supervisor-delivered instruction to staff on how to take precautions against the sun. Oddly, self-reported sun protection did not differ between groups, however, workers at intervention ski resorts reported significantly fewer sunburns than those at nonintervention ski resorts (54). And in resorts where the intervention was more fully implemented, even greater reductions in worker sunburns were reported, calling attention to an environment that keeps sun protection front and center in the target population.

Lessons from Australia

A wide gap exists between the multilevel research shown to improve sun protection and reduce sunburns among outdoor workers to research that informs about the most effective ways to make sun protection a routine practice among adults. In the absence of this evidence base, the experience in Australia (69), which began more than 30 years ago, illustrates that comprehensive skin cancer control is achievable. Initially, public health campaigns focused on increasing individual awareness for early recognition of skin changes indicative of melanoma but later promoted sun safety through Slip, Slop, Slap, and SunSmart programs. These public messages were reinforced by availability of sunscreen tax-free, sun protection policies in schools and daycare centers, and support for shade structures and tree-planting in public places. At the same time, national standards were put in place to regulate shade cloth quality, SPF for sunscreen, UV standards for eyewear, limits on occupational UV exposure, and UV labeling for sun protective clothing (70). Population surveys from 1987–1989 to 2001–2002 in Victoria show increases in the proportion who reported not liking to get a suntan and in use of hats and sunscreen, with concomitant decreases in the amount of time spent outdoors and amount of the body exposed to UV radiation (71). Notably, self-reported sunburns declined nearly 50% by 2001 to 2002, and now, melanoma incidence has stabilized and mortality rates have declined, particularly among younger individuals (72, 73). Despite the implementation and maintenance of a comprehensive approach for skin cancer prevention, Australia still finds room for improvement, including the need for continued promotion of individual behavior change and policy adoption (74–76). The sustainability of these gains also clearly requires continued infusion of resources, as evidenced by declines in negative attitudes toward desiring a tan when funding for sun protection programs in Victoria waned (77).

A New Agenda for Skin Cancer Prevention Policy and Research

To make progress against skin cancer, a change in research priorities and policies is urgently needed. In our opinion, it is time to align U.S. sun protection recommendations with what is known about their relative effectiveness to prevent skin cancer, as IARC has done. If the American Cancer Society, the American Academy of Dermatology, the Centers for Disease Control and Prevention, and the Environmental Protection Agency agreed to recommendations more consistent with those from IARC and then spoke with 1 voice to the public to promote their recommendations, we could begin to change the public's perception that sunscreen is the primary way to protect skin from the sun. [For a discussion on designing effective health communication interventions, please see reviews by Wakefield and colleagues, 2010 (78) and Snyder, 2007 (79)]. And when sunscreen is selected in combination with other sun protection measures, then the public needs detailed and specific information about how to apply it for maximum protection. The new federal rules for sunscreen labeling are a start in this direction, but whether sunscreen users will heed the information remains to be seen. Surveillance strategies should also be improved. Currently, the Behavioral Risk Factor Surveillance System does not routinely gather data about prevalence of sunburns or sun protection behavior. Although the National Health Interview Survey assesses some of the desired sun protection behaviors, data are collected only every other year and are only available nationally, hampering efforts to address skin cancer at the local and state levels. In addition, the information that is collected would be more useful to inform progress, or lack thereof, if the questions reflected the recommendations, including the adequacy of sunscreen use or sunscreen combined with other protective actions. Finally, monitoring positive attitudes toward tanned skin would help to know if policy actions are enhancing awareness and changing norms in the population.

With agreement about recommendations by national policy-setting bodies, and with acknowledgement of the need for new research approaches (e.g., multilevel), the research community could begin to conduct research to identify how best to encourage individuals to adopt and maintain sun protection behavior. Because sun protection methods vary with regard to convenience, acceptability and cost, and conflict with social norms attached to the appearance of tanned skin (e.g., a marker of health or

beauty), research is needed to determine messages specific to each type of desired sun protection action that resonate with the public and increase readiness and willingness to change behavior. At the same time, researchers need to be mindful that sun protection may interfere with potential health benefits of outdoor physical activity and skin synthesis of vitamin D (80–83). Many different intervention components have been evaluated, for example, signage, supervisor-delivered messages, peer discussion, sun protection equipment, and text messaging. But which are optimal, how many are needed, and whether they work for every sun protective behavior are important research questions. Borrowing from engineering, techniques such as the multiphase optimization strategy (84) could be used to examine the effect of each component on promoting sun protection behaviors to identify only those that are essential to the goals. Empirical evidence is needed to understand the decision-making process to engage in sun protection, the factors which lead to long-term sustainability of sun protection behavior, and the characteristics of the environment that best support the behavior. We also need to further document the socioeconomical and racial-ethnic disparity in sun protection behaviors and skin cancer (85–89).

Limited research and the Australian experience support a multilevel approach to impress upon individuals the need for sun protection and to provide a supportive environment that is conducive to sun protection behavior. Funding constraints and availability of sufficient number of independent communities (however defined) make it difficult to apply rigorous study designs to show the efficacy of a multilevel approach. Alternatives to the randomized controlled trial proposed in other health contexts could be applied to sun protection, such as practical trials (90), rapid learning systems (91), or multiple baseline designs (92). The recent application of systems science in health research provides an opportunity to estimate the effect of multilevel interventions before testing and implementation. For example, through system dynamics modeling (93, 94), the effects of different intervention components at multiple levels of influence could be simulated to enable selection of the most appropriate intervention for a specific level. We also need to better understand how to implement evidence-based interventions in real world settings, information that is currently limited for skin cancer prevention (95, 96). For these questions, we can draw from the science of dissemination and implementation, which emphasizes consideration of how an intervention will be translated into practice as part of its initial development and testing (97).

Time to Get Serious About Skin Cancer

In 1999, a call was issued for a national policy on sun protection (98). Not only did the call go unheeded, but trends in sun protection behavior and sunburn have barely budged. As a consequence of our inaction, more Americans have suffered a diagnosis of skin cancer and many have died. The Australian example shows that changing the skin cancer epidemic is possible but must be tackled on several different fronts simultaneously, with individuals and communities, and over the long term on a continuous basis. Within this framework, research is needed to determine the most efficient, effective, and synergistic approaches to achieve meaningful and lasting prevention and control of skin cancer. Public and political support for skin cancer prevention in Australia was driven by the high rates of melanoma affecting its population. Among the formidable challenges to skin cancer control in the United States are doubts about skin cancer as a significant health issue, insufficient funding for research, dissemination and implementation, skepticism toward alternative research approaches, a fragmented public and private health system, and lack of political will to take necessary actions. Still, given the progress that we have made toward reducing the burden of common cancers in this country, now is the time to get serious about the cancer that afflicts more Americans than all other cancers combined.

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No potential conflicts of interest were disclosed.

Authors' Contributions

Conception and design: D. Lazovich, K. Choi
Development of methodology: D. Lazovich, K. Choi
Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): D. Lazovich, K. Choi, R.I. Vogel
Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): D. Lazovich, K. Choi, R.I. Vogel
Writing, review, and/or revision of the manuscript: D. Lazovich, K. Choi, R.I. Vogel
Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): D. Lazovich, K. Choi
Study supervision: D. Lazovich

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